FINAL ENVIRONMENTAL ASSESSMENT

CONSTRUCTION OF EVAPOTRANSPIRATION TOWER

ARNOLD AIR FORCE BASE, TENNESSEE

PREPARED FOR:
DEPARTMENT OF THE AIR FORCE
ARNOLD AIR FORCE BASE, TENNESSEE

CH2MHILL

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Finding of No Significant Impact:
Proposed Construction of An Evapotranspiration Tower Arnold Air Force Base, TN

Arnold Air Force Base (AFB) has prepared an Environmental Assessment (EA) that evaluates the potential environmental and socioeconomic impacts associated with construction of an Evapotranspiration Tower.

Arnold Engineering Development Center (AEDC) and the US Geological Survey (USGS) Water Resource Division are collaborating on a 4-year project to support the Base's ecosystem management efforts by increasing knowledge of the relationships among vegetation, climate, soils, and water balance. The project requires quantification of evapotranspiration (ET) demand from the land/vegetation system to calibrate water budget models relating hydrologic inputs and outputs to wetland and stream function.

Description of the Proposed Action (Preferred Alternative)

Under the Proposed Action, AEDC and the USGS would construct and operate a 140-foot tall ET tower approximately 4,000 feet north of the Base Fire Tower in the Barrens restoration area. The proposed tower would sit on a 4-foot by 4-foot (16-square-foot) steel-reinforced concrete pad within a chain link enclosure topped with barbed wire and a locked gate. The foundation pad would be 4 feet thick. Guy wires would be spaced at 120-degree angular increments and attached to the tower at heights of 35, 70, 105, and 140 feet. Guy wires would be attached to three 12,000-pound capacity steel anchors set in reinforced concrete pads with minimum dimensions of 1.5-foot diameter and 4-foot depth. Each of the three anchors would be located 90 feet from the tower and enclosed in a locked 6-foot tall fenced area measuring 8 feet by 15 feet.

Action Alternative

Under the Action Alternative, the instrumentation for measuring ET would be placed on the existing fire tower located at the fire station near the corner of First Street and Avenue C about 4000 feet south of the Barrens restoration area. A 60-foot extension to the fire tower would be necessary to house the instruments. At the existing fire tower site, useful data only would be collected when the wind is coming from the north. This may not provide sufficient data for future Barrens habitat management and land use decisions.

No-Action Alternative

In the No-Action Alternative, no structures would be erected to measure ET in the Barrens restoration area. Under the No-Action Alternative, AEDC would not be able to obtain accurate site-specific data on ET and hydrologic relationships for application in land management decisions that could affect Barrens and wetland habitats on the base and the sensitive species that use these habitats.

Environmental Consequences

There are no wetlands within the immediate proposed project area and no sensitive species would be negatively affected by the Proposed Action. Impacts from construction of the ET tower would be minimal, with approximately 25 square feet of surface area converted to concrete to support the tower and the guy wire anchors. Land enclosed within the fences (approximately 480 square feet) would be managed to preclude woody vegetation, which would be compatible with the Barrens restoration effort.

Access to the site would require crossing an intermittent stream. The road crossing has been rocked in the past to accommodate vehicle traffic involved in timber management activities. No impacts to the intermittent stream are anticipated because work would be conducted during the dry season.

There are no significant or potentially significant cultural resources in the area where the ET tower and guy wire anchors would be constructed. Therefore, no impacts to cultural resources are expected to result from implementation of the Proposed Action.

Restrictions

Construction activities for the Evapotranspiration Tower would be limited to the dry season to prevent impacts to the intermittent stream.

Conclusion

The attached EA was prepared pursuant to Air Force Instruction (AFI) 32-7061, 32 Code of Federal Regulations (CFR) 989, and U.S. Council on Environmental Quality (CEQ) regulations (Title 40, U.S. Code, Parts 1500-1508) for implementing the procedural requirements of the National Environmental Policy Act (NEPA). The Proposed Action, the Alternative Action, and the No Action Alternative were reviewed and found to have no significant impact on the human or natural environment.

A public notice for the intent to sign a FONSI was made on 27 July 2004. The draft FONSI and EA were made available to the public upon request.

FINDING OF NO SIGNIFICANT IMPACT

Based on the evaluation of the attached EA and information discussed above, a Finding of No Significant Impact to the environment is concluded for the Proposed Action, the Alternative Action, and the No Action Alternative and no Environmental Impact Statement (EIS) is required. The Proposed Action is selected as the preferred action for implementation.

31 Aug 04

Charles H. King
Chief, Environmental Management Division
Arnold AFB, TN

FINAL ENVIRONMENTAL ASSESSMENT

CONSTRUCTION OF EVAPOTRANSPIRATION TOWER, ARNOLD AIR FORCE BASE, TENNESSEE

Prepared for:
DEPARTMENT OF THE AIR FORCE
Arnold Air Force Base, Tennessee

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Contents

Figures

Tables

Appendices

Acronyms and Abbreviations

AEDC	Arnold Engineering Development Center
ARAP	Aquatic Resource Alteration Permit
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AICUZ	Air Installation Compatible Use Zone
BMP	Best Management Practice
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CWA	Clean Water Act
DoD	Department of Defense
EA	Environmental Assessment
EIAP	Environmental Impact Analysis Process
EO	Executive Order
ERP	Environmental Restoration Program
ESA	Endangered Species Act
ET	Evapotranspiration
FAA	Federal Aviation Administration
FONPA	Finding of No Practicable Alternative
FONSI	Finding of No Significant Impact
FY	Fiscal Year
HQ CEV	Headquarters Civil Engineering, Compliance
IEMP	Integrated Ecosystem Management Plan
MAJCOM	Major Command
NCO	non-commissioned officer
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NWP	Nationwide Permit

OSHA	Occupational Safety and Health Administration
PCBs	polychlorinated biphenyls
RCRA	Resource Conservation and Recovery Act
SAF	Secretary of the Air Force/Environmental Security
SARA	Superfund Amendments and Reauthorization Act
SHPO	State Historic Preservation Office
TDEC	Tennessee Department of Environmental Conservation
TSCA	Toxic Substance Control Act
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USACE	U.S. Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
UTSI	University of Tennessee Space Institute
VOQ	visiting officers quarters
WQA	Water Quality Act

1.0 Purpose and Need for Action

1.1 Arnold Engineering Development Center (AEDC) Background

AEDC is located on Arnold Air Force Base (AFB) in Coffee and Franklin Counties in Middle Tennessee. The center is approximately 70 miles southeast of Nashville, the state capitol. Positioned near the towns of Manchester, Tullahoma, and Winchester, AEDC is the largest employer in the two-county area (Figure 1-1).

Arnold AFB occupies 39,081 acres including the 3,632-acre Woods Reservoir, which contains approximately 26 billion gallons of water. Woods Reservoir provides cooling water for facilities in the industrial area. On Arnold AFB, there are 5,785 acres of cultivated pine forests and 23,492 acres of hardwood forests. Grasslands and early-successional habitats in utility rights-of-way occupy 1,479 acres on the installation and provide habitat for numerous rare species (Call, 2003).

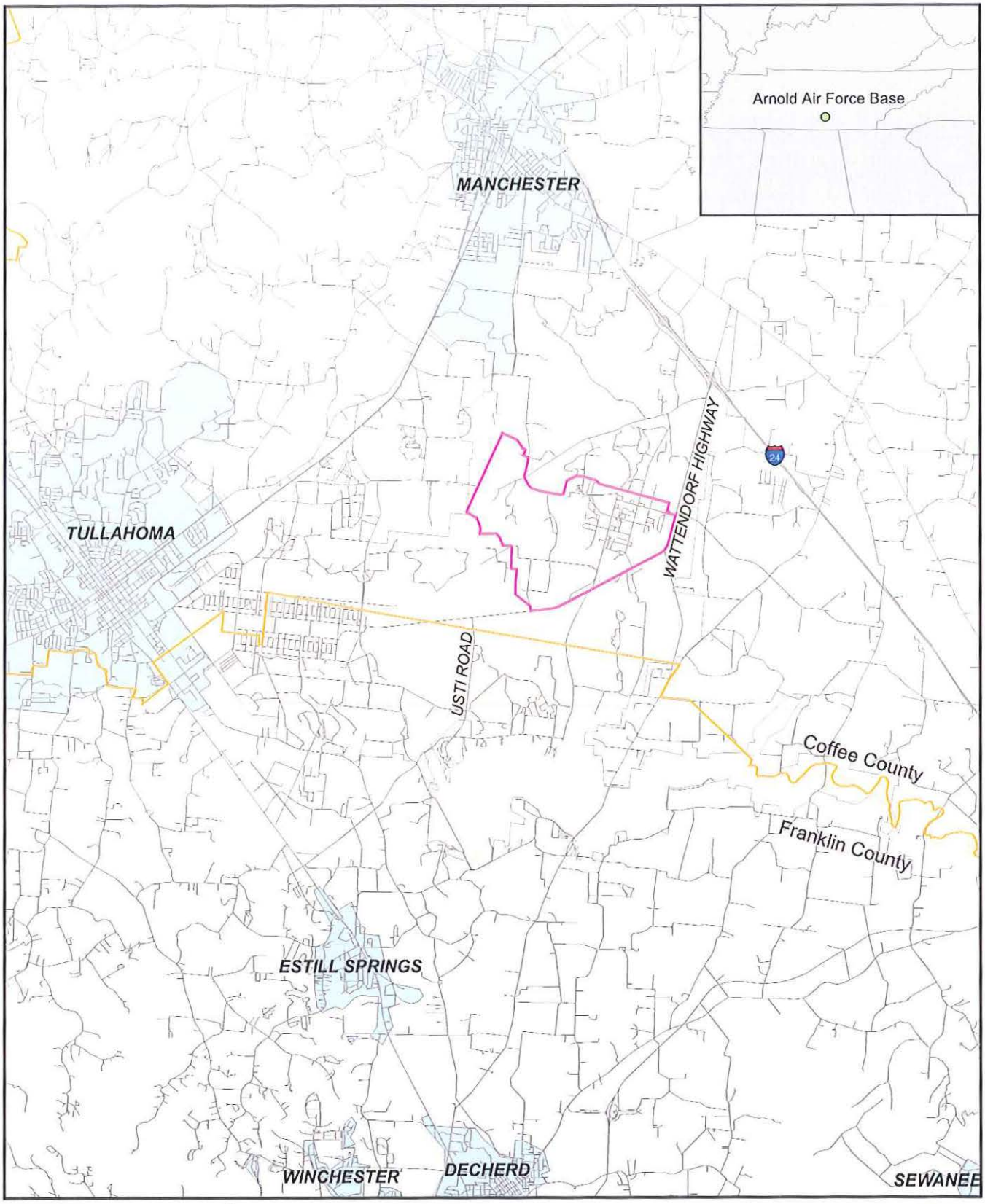
1.1.1 AEDC Operations

AEDC is the most advanced and largest complex of flight simulation test facilities in the world, with 53 aerodynamic and propulsion wind tunnels, rocket and turbine engine test cells, space environmental chambers, arc heaters, ballistic ranges, and other specialized units. Facilities can simulate flight conditions from sea level to altitudes of more than 100,000 feet, and from subsonic velocities to those well over Mach 20. Twenty-seven of the center's test units have capabilities unmatched in the world. AEDC has contributed to the development of nearly every top national aerospace program since the 1950s. Customers include the U.S. Air Force (AF), the Army and Navy, the National Aeronautics and Space Administration, the Federal Aviation Administration, private industry, allied foreign governments, and U.S. government and educational institutions.

AEDC is AF-owned and managed through a contractor work force. The AEDC commander is responsible for accomplishing the center's mission. The commander's staff of military personnel and civil service employees is responsible for the overall planning, direction, scheduling, assignment, and funding associated with mission requirements. Under staff supervision, the management, operation, and maintenance of test facilities, real property, and related equipment and utilities are accomplished by contract.

1.1.2 AEDC History

AEDC is named for the late Henry H. "Hap" Arnold. At the close of WW II, General Arnold, Commander of the Army Air Forces, asked Dr. Theodore von Karman, Chief Scientific Advisor to the AF and one of history's great aeronautical test scientists, to form a Scientific Advisory Group to chart a long-range research and development course for the future USAF. Dr. von Karman sent a task force from his newly formed group to



LEGEND

- Road Centerline
- County Boundaries
- AEDC Boundary
- Local Cities
- Arnold AFB Boundary

Figure 1-1

Arnold Air Force Base and General Vicinity

Construction of Evapotranspiration Tower
Final Environmental Assessment

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Germany to determine how the Germans had made such rapid progress in developing high-performance jet aircraft and rocket-powered missiles. One member of the task force, Dr. Frank Wattendorf, was responsible for surveying wind tunnels and ground test facilities. On his flight home, Dr. Wattendorf wrote a memo that proposed using captured German test facilities to establish a new engineering development center. The new center would consolidate the best civilian and military scientists as well as state-of-the-art test facilities to properly test and evaluate the weapon systems needed to guarantee the United States' superior airpower and thereby the national security. Dr. Wattendorf's "trans-Atlantic memo" became the blueprint for AEDC.

In 1949, Congress authorized $100 million for the construction of AEDC. A site was selected for the new center at the Army's old Camp Forrest near Tullahoma, and construction began in June 1950. The site was chosen because of the availability of land, water, and power, and to buffer surrounding communities from expected test hazards and noise. Water was needed to cool the rapidly flowing air and hot exhaust gases, and electricity was required to power the huge motordrive systems. The large land acquisition was necessary to accommodate growth for future test facilities and its remote location provided the security required by the size of the installation.

On June 25, 1951, one year after General Arnold's death, President Harry S Truman dedicated the AEDC and renamed it in honor of General Arnold. Anticipating the role this national facility would play in developing key weapon systems, President Truman said, "Never again will the United States ride the coattails of other countries in the progress and development of the aeronautical art. The genius that was General Arnold's is manifest in this installation which now bears his name."

1.1.3 AEDC Military Mission

The mission of AEDC is to support the development of aerospace systems by testing hardware in facilities that simulate flight conditions. The center also conducts a research and technology program to develop advanced test techniques and instrumentation and to support the design of new test facilities. The official mission at AEDC is:

> ***To provide our customers with the world's most effective and affordable aerospace ground test and evaluation, and simulation products and services. To ensure AEDC ground test facilities, technologies, and knowledge fully support today's and tomorrow's customers.***

Implicit within this mission is the need to anticipate and plan for growth of the test facilities at AEDC. Ecosystem management provides the framework for the careful assessment of environmental impacts, allowing for the planning and development of new facilities, while at the same time protecting the natural and cultural resources.

The implementation of ecosystem management at AEDC is also in direct support of the overall Department of Defense (DoD) mission. The DoD mission requires that natural resources be managed to provide for the environmental security necessary to support the military mission of national defense. By conserving biodiversity, ecosystem management contributes to national security by helping maintain the natural resources upon which this country's strength depends. Ecosystem management also helps

maintain natural landscapes for military training. Combat readiness is founded on the ability of the armed forces to sustain realistic military training now and into the future.

1.2 Proposed Action

The Proposed Action is for AEDC to construct and operate a 140-foot tall evapotranspiration (ET) tower in the Diameter-Limit-Cut Barrens restoration area north of the test area. The proposed tower would sit on a 16-square-foot steel-reinforced concrete pad within a 144-square-foot chain link enclosure topped with barbed wire and with a secure, locked gate. The foundation pad would be 4 feet thick. Guy wires would be spaced at 120-degree angular increments and attached to the tower at heights of 35, 70, 105, and 140 feet. The guy wires (total of 12) would be attached to three 12,000-pound capacity steel anchors set in reinforced concrete pads with minimum dimensions of 1.5-foot diameter and 4-foot depth. Each of the three anchors would be enclosed in a locked 6-foot tall chain link fence in an 8-foot by 15-foot rectangle. Construction would be scheduled for the spring and summer of 2004, and the tower would be operational in the summer of 2004. The United States Geological Survey (USGS) will provide support in data review and interpretation activities.

1.3 Need for Proposed Action

Numerous wetlands, including wetlands of potential regional significance based upon their ecological value and rarity, occur on Arnold AFB property. Management of these sensitive habitats requires a thorough understanding of the environmental factors that create suitable conditions for their formation. The quantity and the seasonal nature of water availability are critical factors affecting the development and the types of plants found within the wetland.. Consequently, it is important to understand the water balance of the habitat. "Water balance" refers to the relationship between the hydrologic inputs (rainfall, surface water flow, and groundwater flow) and losses (surface water flow, groundwater flow, and ET) of a system. ET is a measure of the amount of water returned to the atmosphere as water vapor through evaporation from land and water surfaces combined with the amount of water returned to the atmosphere as water vapor through transpiration, the uptake, metabolism, and respiration of vegetation.

For wetlands, the water balance must be positive (hydrologic inputs exceed hydrologic outputs) for a substantial portion of the year.

To enhance land management decisions as they pertain to wetlands, AEDC and the USGS Water Resource Division are collaborating on a 4-year project to support ecosystem management efforts by increasing knowledge of the relationships among vegetation, climate, and soils and their combined influence on water balance for the wetlands habitat near Sinking Pond. ET varies during the year and both evaporation and transpiration rates are higher during warmer weather. The project requires measurement of ET to prepare a water-budget model relating water inputs and outputs to wetland and stream function for the northern portion of Arnold AFB, where most of the wetland habitat on the Base occurs.

After discussions with several ET experts, notably the USGS National Research Program in Denver, Colorado, a system was selected to measure wind speed and direction (velocity) and the amount of moisture in the air (air-water concentration). These conditions will be measured simultaneously at small time intervals and high precision to evaluate water vapor fluctuations between the forest canopy and the atmosphere. This is the standard method used to develop national and global water budgets.

The 140-foot tower is required for the installation of instruments to measure ET from the open canopy, oak-dominated Barrens. The selected method requires measurements of very small shifts in air currents, temperature, atmospheric carbon dioxide (CO_2), and humidity to estimate net water and CO_2 changes between the land, the plant communities, and the atmosphere. To avoid distortion in air current measurements resulting from local turbulence, a precision anemometer must be positioned 1.5 times the average canopy height. An anemometer is a device that measures wind speed and direction. The average canopy height in the vicinity of the proposed location is approximately 90 feet, hence the need for a 140-foot tower.

Measuring ET from this habitat is desirable because of existing plans to restore Barrens habitats on Arnold AFB and the need to understand how restoration efforts are likely to alter the movement of water through the landscape. A previous USGS study on Arnold AFB found that annual precipitation had increased since approximately 1970, with resultant increased flooding duration in Sinking Pond National Natural Landmark (Wolfe et al., in press) This study also identified a spatial shift in regeneration patterns of wetland tree species, notably overcup oak (*Quercus lyrata*) and willow oak (*Quercus phellos*) in response to this climate change. The restoration of open canopy barrens areas in what has been densely forested drainage basins surrounding wetlands is expected to alter ET and the quantity of water delivered to wetlands. Understanding how vegetation structure affects ET, soil water recharge, and soil moisture balance would enable AEDC to estimate potential hydrologic changes in response to barrens restoration efforts and how the hydrologic functions of wetlands and streams might subsequently be affected. This knowledge would allow AEDC land managers to evaluate consequences in terms of threats or benefits to the regionally significant karst wetlands and associated rare ecological communities and protected species.

1.4 Objectives of Proposed Action

The objective of constructing an ET tower is to collect ET data that would enhance ecosystem management at AEDC. The data would be used to support barrens restoration activities on AEDC.

1.5 Related Environmental Documents

The following documents were used in the preparation of this EA:

- Integrated Ecosystem Management Plan (IEMP) for Arnold Integrated Ecosystem Management Plan for Arnold Air Force Base. The IEMP was prepared by G. Call, ATA, in 2003 for Environmental Management, Arnold Engineering and Development Center, Arnold Air Force Base, Tennessee.

- "Historic Building Survey and Evaluation, Arnold Air Force Base, Coffee and Franklin Counties, Tennessee," Draft Report, December 2001, submitted by TRC Garrow Associates, Inc., Atlanta, Georgia, and CH2M HILL, Atlanta, Georgia; M. Todd Cleveland, Architectural Historian and Author, Jeffrey L. Holland, Historian and Author.

1.6 Decision to Be Made

The decision to be made is whether to construct the ET tower at the proposed location, place an extension on the fire tower to accommodate the ET instruments or not to construct an ET tower (Figure 1-2).

1.7 Applicable Regulatory Permitting and Coordination

1.7.1 Environmental Policy

The National Environmental Policy Act (NEPA) of 1969 and Title 40 of the Code of Federal Regulations (CFR), Parts 1500-1508 (40 CFR 1500-1508), require federal agencies to consider the potential environmental consequences of proposed actions and alternatives. DoD Directive 6050.1 (32 CFR 214) provides DoD policies and procedures to supplement 40 CFR 1500-1508. The Air Force Environmental Impact Analysis Process (EIAP) is governed by 32 CFR Part 989. Air Force Instruction (AFI) 32-7061 describes specific tasks and procedures for complying with the NEPA through the EIAP, including responsibilities, compliance requirements, and document preparation and processing. Executive Order (EO) 11514, Protection and Enhancement of Environmental Quality (amended by EO 11991), provides policy directing the federal government to take leadership in protecting and enhancing the environment.

1.7.2 Biological Resources (Vegetation and Habitat, Wildlife, and Threatened and Endangered Species)

The Endangered Species Act of 1973 (16 U.S. Code [USC] 1531-1543), as amended (ESA), provides policy for federal agencies (with the assistance of the Secretaries of the Interior and Commerce) to ensure that their actions do not jeopardize the continued existence of any threatened or endangered species, or result in the destruction or adverse modification of critical habitat of such species.

The Fish and Wildlife Coordination Act, (16 USC 661, et seq.), as amended, provides policy for the Secretary of the Interior (through the U.S. Fish and Wildlife Service [USFWS]) and for the National Marine Fisheries Service (NMFS) (through the Secretary of Commerce) to assist and cooperate with federal, state, and public or private agencies and organizations in the conservation and rehabilitation of wildlife.

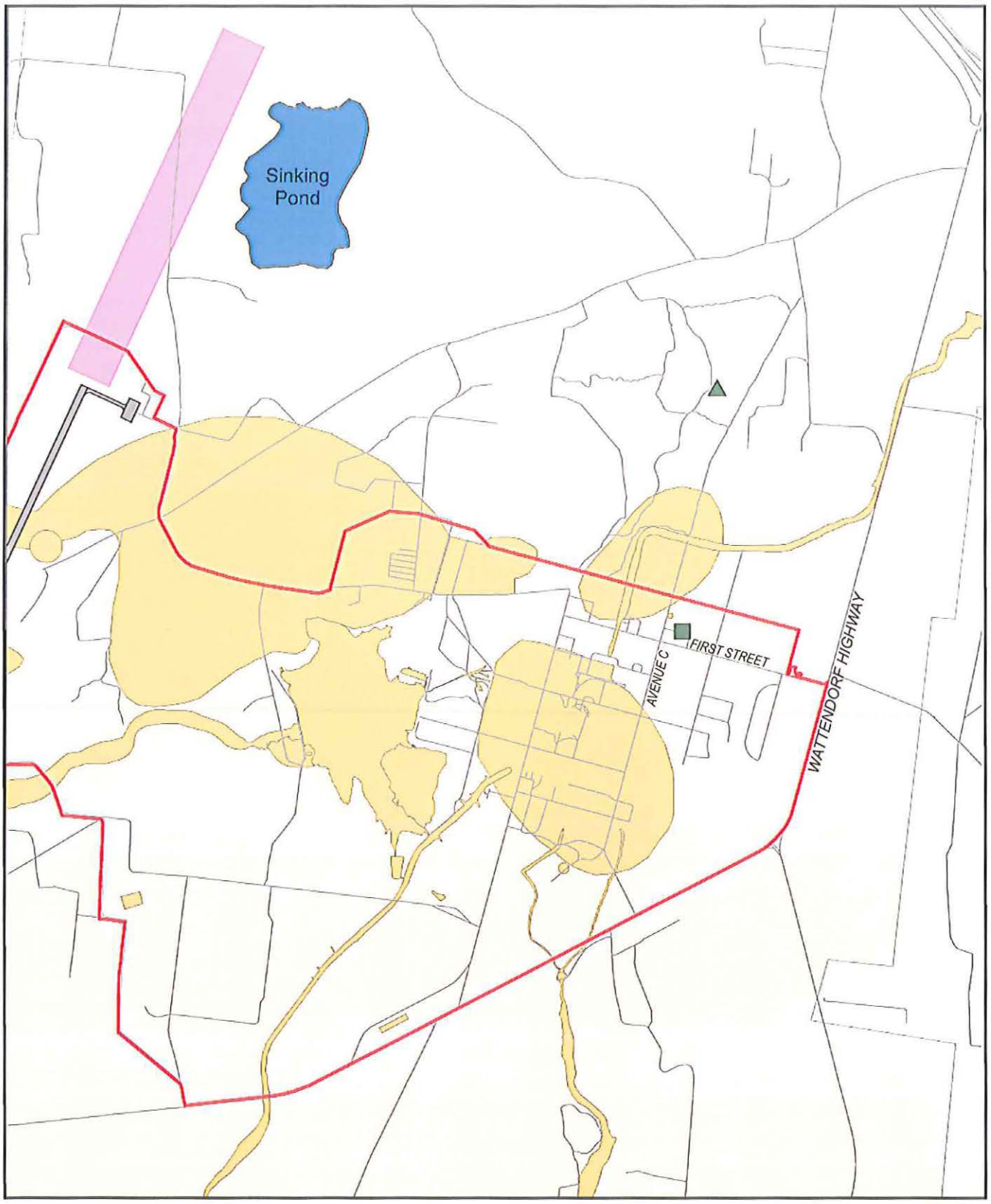

Figure 1-2
Location of Alternatives and Potential Impacts Excluded from Analysis
Construction of Evapotranspiration Tower
Final Environmental Assessment

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The Migratory Bird Treaty Act (16 USC 701, et seq.) provides for the protection of migratory birds. It forbids, among other things, the taking, importing, possessing, purchasing, or selling of migratory birds, with the exception of government-sanctioned hunting and capturing of birds. Although recent court rulings have resulted in the USFWS ceasing to issue permits to other federal agencies for incidental takings of migratory birds, the USFWS is developing an EO that will clarify the responsibilities of federal agencies with regard to the taking of migratory birds. The AF has issued interim guidance for complying with the Migratory Bird Treaty Act (memorandum dated 12 September 1997), effective until the EO is issued. The guidance requires the evaluation of non-lethal control measures, consultation with the USFWS regarding potential protected species issues, compliance with treaties, consultation with appropriate state agencies, proper oversight of contractors and volunteers, and compliance with NEPA.

1.7.3 Wetlands

The Clean Water Act (CWA) of 1977 and the Water Quality Act (WQA) of 1987 (33 USC 1251 et seq., as amended) provide policy for protecting wetlands and other waters of the United States. Section 404 of the CWA requires permits from the U.S. Army Corps of Engineers (USACE) to discharge dredged or fill material into such systems. EO 11990, Protection of Wetlands, requires federal agencies to minimize or avoid adverse impacts to wetlands and to preserve and enhance their beneficial values. AFI 32-7061 requires that EAs prepared for actions for which the AF has wetlands compliance responsibilities go through Headquarters Civil Engineering, Compliance to the Secretary of the Air Force/Environmental Security (HQ CEV to SAF/MIQ) for approval.

1.7.4 Land Use

EO 12372, Intergovernmental Review of Federal Programs, directs federal agencies to consult with and solicit concerns and comments from state and local governments that have jurisdiction over an area within which a federal action is proposed. The Farmland Protection Act of 1981 (7 USC 4201 et. seq., as amended) requires federal agencies to consult with the Natural Resources Conservation Service (NRCS) to ensure that preservation/conservation of important farmlands is considered in federal actions.

DoD 4165.57, Air Installation Compatible Use Zone (AICUZ), identifies policy on achieving compatible use of public and private lands in the vicinity of military airfields. DoD 4165.57 defines required restrictions on the uses and heights of natural and man-made objects in the vicinity of air installations to provide for flight safety and to assure that people and facilities are not concentrated in areas susceptible to aircraft accidents. It also defines desirable restrictions on land use to assure compatibility with the characteristics, including noise, of air installation operations and describes the procedures by which the AICUZ land uses may be defined. DoD 4165.57 provides policy on the extent of Government interest in real property within AICUZ that may be retained or acquired to protect the operational capability of active military airfields.

1.7.5 Hazardous Substances

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (as amended by the Superfund Amendments and Reauthorization

Act [SARA] of 1986, 42 U.S. Code 9601-9675, as amended) provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and cleanup of inactive hazardous substance disposal sites.

The Resource Conservation and Recovery Act (RCRA) of 1976 (42 U.S. Code 9601-9692, as amended) provides policy for proper disposal of solid waste and establishes standards and procedures for the handling, storage, treatment, and disposal of hazardous wastes.

The Toxic Substance Control Act (TSCA) provides policy for proper handling of polychlorinated biphenyls (PCBs), asbestos, radon, and lead-based paint. State and local regulations should be consulted when engaging in activities that involve these substances on civil works projects or properties.

1.7.6 Cultural Resources

The National Historic Preservation Act (NHPA) of 1966 (16 USC 470 et seq., as amended) provides policy for the protection of historic resources from federal actions. Protection of Historic Properties (36 CFR 800) Act provides specific procedures that federal agencies must implement, such as consulting with the State Historic Preservation Office (SHPO), to ensure compliance with the NHPA.

The Archeological Resources Protection Act of 1979 requires federal agencies to conduct archaeological investigations on lands under their jurisdiction to determine the nature and extent of the protected cultural resources present and to help manage extant resources in accordance with permit and enforcement provisions of the Act.

1.7.7 Water Resources

The CWA of 1977 and the WQA of 1987 provide federal policy on maintaining and restoring water quality to protect and enhance waters of the United States. Section 404 of the CWA requires permits from USACE to discharge dredged or fill material into waters of the United States.

EO 11988, Floodplain Management, provides federal policy for reducing flood damage risk, minimizing the impacts of floods potentially resulting from a federal action, and preserving the natural and beneficial values provided by floodplains/floodways. EO 11988 specifies that "Before taking an action, each agency shall determine whether the proposed action will occur in a floodplain–for major Federal actions significantly affecting the quality of the human environment, the evaluation required below will be included in any statement prepared under Section 102(2)(C) of the National Environmental Policy Act." Proposed actions covered under this order include "Federally undertaken, financed, or assisted construction and improvements." Floodplains are defined as "the lowland and relatively flat areas adjoining inland and coastal waters including floodprone areas of offshore islands, including at a minimum, that area subject to a 1 percent or greater chance of flooding in any given year."

AFI 32-7061, Environmental Impact Analysis Process, requires HQ CEV to SAF/MIQ approval of EAs prepared for actions for which the AF has floodplain compliance responsibilities. A Finding of No Practicable Alternative (FONPA) must be submitted to

HQ USAF/CEV when the alternative selected is located in wetlands or floodplains. The FONPA must discuss why no other practicable alternative exists to avoid impacts.

AFI 32-7064, Integrated Natural Resources Management, requires SAF/MIQ or other designated official to approve the FONPA before any action within a floodplain may proceed as specified in Secretary of the Air Force Order 790.1. In preparing the FONPA, the AF must consider the full range of practicable alternatives that meet justified program requirements, are within the legal authority of the AF, meet technology standards, are cost-effective, do not result in unreasonable adverse environmental impacts, and other pertinent factors. Only after the practicality of alternatives has been fully assessed should a statement regarding the FONPA be made in the associated Finding of No Significant Impact (FONSI) or Record of Decision (ROD). The Chairperson of the Major Command (MAJCOM) Environmental Protection Committee has the approval authority for FONSIs containing a FONPA for floodplains.

1.7.8 Air Quality

The Clean Air Act (CAA) (42 USC 7401 et seq., as amended) provides policy directing federal agencies to protect and enhance air quality. The CAA also requires agencies to verify that proposed actions conform to state implementation plans for attaining air quality goals.

1.7.9 Noise

The Noise Control Act of 1972 provides policy that directs federal agencies to limit noise emissions to within compliance levels.

1.7.10 Social Issues

EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations, provides policy directing federal agencies to evaluate the effects of proposed actions on minority communities and low income communities. Effects are to be evaluated to determine whether there are adverse impacts to human health, social conditions, environmental quality, and economic conditions.

EO 13045, Protection of Children from Environmental Health Risks and Safety Risks, provides policy directing federal agencies to identify and assess environmental health risks and safety risks that may disproportionately affect children.

1.8 Scope of the Environmental Assessment

This document was prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) of 1969, the Council on Environmental Quality (CEQ) regulations of 1978, and 32 CFR Part 989. To initiate the environmental analysis, the proponent (Arnold AFB) submitted an AF Form 813 – Request for Environmental Impact Analysis (Appendix A).

1.8.1 Issues Eliminated from Detailed Analysis

Since the ET tower would have a small footprint and be contained within one area of the Base, the Proposed Action would not have the potential for significant impacts to all resource areas on Arnold AFB. Consequently, the resource areas discussed below were eliminated from detailed analysis in this document.

1.8.1.1 Air Installation Compatible Use Zone

The project site (35.4018 N and -86.0363 W) is outside all designated AICUZs and not along flight paths for the airfield (Figure 1-2). The alternate location is within the AEDC industrial complex and not within a designated AICUZ. Construction and operation of an ET tower at the proposed location or the alternate location would not impact airfield operations and would not violate any AICUZ restrictions. Therefore, AICUZ was eliminated as an issue warranting further analysis.

1.8.1.2 Land Use

Construction of the ET tower at the proposed location would result in conversion of a limited portion of the Barrens restoration area into concrete support structures and fenced areas. However, a little more than 25 square feet of this area would be converted to impervious cover by constructing 4 concrete support pads: one for the tower (16 square feet) and one each for the 3 guy wire anchors (3 square feet each). The ET tower pad would be fenced, as would the anchor sites. Each anchor site would be contained within an 8-foot by 15-foot fenced area. The land within the anchor site fenced areas would remain in Barrens vegetation. However, maintenance would be required to control vegetative growth. Under the Alternative Action, only construction of the guy wire anchor sites would be required. Such a conversion would involve minimal impact, and land use was eliminated as an issue warranting further analysis.

1.8.1.3 Air Quality

Construction activities under the Proposed and Alternative Actions would generate engine emissions from construction equipment and could generate fugitive dust (particulate matter). However, ground disturbance would be limited to 25 square feet under the Proposed Action and less than 10 square feet under the Alternative Action. Engine emissions and fugitive dust that would result from this minor construction would be negligible. No change in air emissions from within the AEDC industrial complex is anticipated from operation of the ET tower. Therefore, air quality was eliminated as an issue warranting further analysis.

1.8.1.4 Geology

None of the activities considered in the Proposed Action or the Alternative Action would affect the underlying geology at Arnold AFB. Therefore, geology was eliminated as an issue warranting further analysis.

1.8.1.5 Geomorphology

Construction and the subsequent presence of new structures may contribute to the erosion potential of surrounding soils due to soil/ground disturbance. The site would have to be cleared to construct the tower pad, install the anchor points, assemble the

tower, and fence as necessary for security. Excess stormwater runoff resulting from the addition of impervious surfaces may also contribute to soil erosion. However, the total areas of permanent disturbance under the Proposed Action would be around 25 square feet and less than 10 square feet would be disturbed under the Alternative Action. Appropriate Best Management Practices (BMPs), including silt fencing and minimizing the area of disturbance, would be used to prevent or minimize erosion during construction. After construction, the disturbed areas would be covered with concrete and have no subsequent erosion potential. The procedure that would be used to dispose of excavated material is discussed in Section 2.1.

Because of the small magnitude and short duration of ground disturbance associated with the Proposed Action and the Alternative Action, geomorphology was eliminated as an issue warranting further analysis.

1.8.1.6 Water Quality

The addition of impermeable surfaces would result in an increase in stormwater runoff. Construction activities may result in increased sediment transport into waterways, with negative consequences for water quality. However, the amount of impervious surface that would be added is approximately 25 square feet under the Proposed Action and less than 10 square feet under the Alternative Action. Appropriate BMPs would be used to prevent or minimize the potential of sediment transport while ground disturbing activities occur. Because of the small magnitude and short duration of ground disturbance associated with the Proposed Action and the Alternative Action, water quality was eliminated as an issue warranting further analysis.

1.8.1.7 Noise

The Proposed Action would be located more than 1 mile from the airfield (Figure 1-2). The ET tower would not generate any noise during operation. Potential noise impacts would be related to the short-term use of construction equipment (anticipated use of one backhoe), and construction workers would be the only potential receptors at the proposed location. The alternate location is within the AEDC industrial complex toward the northeastern edge (Figure 1-2). Workers would be potential receptors, but the noise generated from operation of a single backhoe would be negligible against the background noise of the industrial complex. Construction activities would occur only during regular working hours, construction workers would use proper hearing protection, and the associated noise from construction equipment would be temporary (approximately 1 month during normal working hours of the day). Consequently, noise was eliminated as an issue warranting further analysis.

1.8.1.8 Safety and Occupational Health

Potential safety and occupational health impacts would be related to construction activities at the site of the Proposed Action or Alternative Action. However, construction workers would use hearing protection during work hours and would follow Occupational Safety and Health Administration (OSHA) standards and procedures. The contractor would be responsible for ensuring that all contractor employees (and subcontractors) comply with all applicable OSHA standards. Therefore, the safety and occupational health of construction workers or other persons in the area of the Proposed

Action or Alternative Action would not be impacted during construction activities. As a result, safety and occupational health was eliminated as an issue warranting further analysis.

1.8.1.9 Socioeconomic Factors

Socioeconomic factors are associated with the human environment, including demographics, community infrastructure and services, employment and wages, recreation, and environmental justice. Construction of the ET tower would have no significant effect on socioeconomic factors. There would be temporary employment from construction and associated use of construction materials, but these effects would be temporary and minor within the regional economy. No increase or loss in permanent staffing positions would result from installation of the ET tower nor would there be any gain or loss of permanent employment in the surrounding region. The tower would be on Arnold AFB and would not impact minority or low income population groups. The Proposed Action would be in compliance with EO 12898 and EO 13045.

There would be no change in demand for recreational facilities/opportunities and no change in recreational facilities/opportunities available to the staff of Arnold AFB or residents of the region. Construction of the tower would not cause people to move into or out of the area. With no change in population, the Proposed Action would not result in a change in demand for community infrastructure and services (fire, police, medical, housing, schools, etc.).

Therefore, socioeconomic factors were eliminated as an issue warranting further analysis.

1.8.1.10 Environmental Restoration Program (ERP) and Hazardous Materials

Arnold AFB has an active ERP designed to protect human health and the environment, and to restore areas for future use. Arnold AFB executes the ERP in consultation with the Tennessee Department of Environmental Conservation (TDEC) in accordance with CERCLA and RCRA. Twenty-six ERP sites have been identified on Arnold AFB and 11 of these have been closed after determinations of no further action required. The proposed site of the ET tower is not located near any active ERP sites (Figure 1-2). The alternate location would not result in activities that would impact any active ERP sites.

There would be no change in use/handling or storage of hazardous chemicals for any of the alternatives.

For the reasons described above, hazardous materials and the ERP were eliminated as an issue warranting further analysis.

1.8.2 Issues Studied in Detail

The resource areas below are discussed in detail in this document.

1.8.2.1 Non-Sensitive Biological Resources

Biological resources (plants and animals) and related habitats (foraging and nesting areas) may be directly affected by the Proposed Action during installation of the ET tower. The impacts analysis focuses on the potential for actions to directly and

physically affect plants and animals and the potential for actions to alter/affect the quality and utility of the habitats frequented by those species.

1.8.2.2 Sensitive Species

Construction activities (i.e. vehicular/construction equipment traffic) may occur near sensitive species and their habitat. The analysis focuses on the association between construction footprints and identified sensitive species within these areas, and the potential for adverse impacts to those species.

1.8.2.3 Sensitive Habitats

Habitat alteration is defined as the destruction or creation of a habitat that is essential for survival of one or more species. Sensitive habitats (e.g., wetlands and floodplains) may be disturbed or altered due to construction activities resulting from the Proposed Action and Alternative Action. Sensitive habitats located near the Proposed Action site and Alternative Action site are identified, and the required construction activities and impacts are analyzed. Potential impacts are identified if the construction footprints disturb identified sensitive habitats.

1.8.2.4 Cultural Resources

Cultural resources are defined as archaeological areas and historical architectural properties. Potential impacts are identified if construction footprints associated with the Proposed Action or Alternative Actions extend into the boundaries of identified cultural resource areas, resulting in the disturbance of such resources through construction activities such as earth removal.

1.9 Document Organization

This EA follows the organization established by the CEQ regulations (40 CFR, Parts 1/500-1508). This document consists of the following sections:

1.0 Purpose and Need for Action
2.0 Description of the Proposed Action and Alternatives
3.0 Affected Environment
4.0 Environmental Consequences
5.0 Plan, Permit, and Management Requirements
6.0 List of Preparers
7.0 List of Contacts and Correspondence
8.0 References
Appendices

2.0 Description of Proposed Action and Alternatives

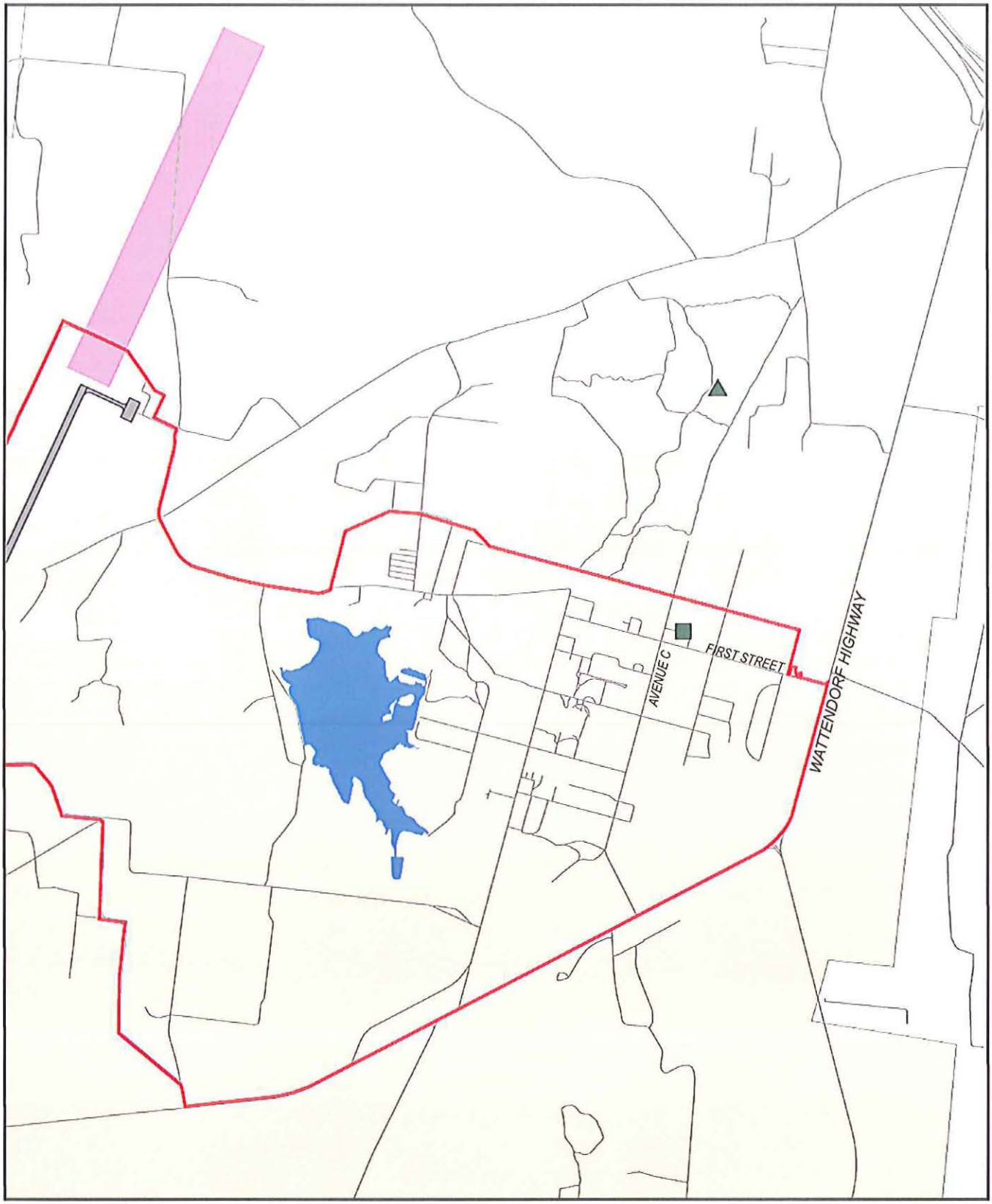
As required by federal regulation, this EA addresses the possible environmental impacts of the Proposed Action, an Alternative Action, and the No-Action Alternative. Section 2.5 provides a summary of the issues and potential impacts associated with the Proposed Action, Alternative Action, and No-Action Alternative.

2.1 Proposed Action (Preferred Alternative)

Under the Proposed Action, AEDC and the USGS would construct and operate a 140-foot tall ET tower approximately 4,000 feet north of the Base Fire Tower (Figure 2-1) in the Barrens restoration area (Figure 3-2). The fire tower is located near the corner of First Street and Avenue C. The proposed location is entirely within the Barrens restoration area and would provide data under all wind conditions.

The proposed tower would sit on a 4-foot by 4-foot (16-square-foot) steel-reinforced concrete pad within a chain link enclosure topped with barbed wire and a locked gate. The foundation pad would be 4 feet thick. Guy wires would be spaced at 120-degree angular increments and attached to the tower at heights of 35, 70, 105, and 140 feet. Guy wires would be attached to three 12,000-pound capacity steel anchors set in reinforced concrete pads with minimum dimensions of 1.5-foot diameter and 4-foot depth. Each of the three anchors would be located 90 feet from the tower and enclosed in a locked 6-foot tall fenced area measuring 8-feet by 15-feet. The pad and anchor pits would be excavated with a backhoe. Approximately 6 cubic yards of concrete would be required to fill the pits. The tower components, fencing materials, and supplies would be brought to the site on a flat bed truck. Ready mix concrete would be brought using one of two options: a concrete truck may be able to drive to the site to pour the concrete or concrete may be brought to the site in a tank pulled behind a backhoe or tractor. Assuming the tank can carry 1 cubic yard of concrete, then 6 trips would be necessary to bring the ready mix concrete to the site. Construction would be scheduled for the summer and early fall of 2004, and the tower would be operational in the fall of 2004.

The 140-foot tower is required for the installation of instruments to collect the information necessary to estimate the ET from the open canopy, oak-dominated Barrens by measuring minor changes in wind speed and direction and the amount of moisture in the air. These data are combined with information on temperature and atmospheric CO_2 to estimate the local relationship between water transport and CO_2 flux from the land and plant community to the atmosphere. To avoid distortion in air current measurements resulting from local turbulence, a precision anemometer must be positioned 1.5 times the average canopy height. The average canopy height in the around the proposed alternative is approximately 90 feet, hence the need for a 140-foot



0 1,500 3,000 Feet

N

LEGEND

- Alternate Location
- Proposed Location
- Road
- AEDC Boundary
- Reservoirs
- Airfield
- Air Accident Potential Zones
- Arnold AFB Boundary

Figure 2-1
Location of Proposed Action and Alternative Action
Construction of Evapotranspiration Tower
Final Environmental Assessment

File Path: Q:\CH2MHILL\Projects\TimberHarvest_EA\MXDs\Fig1-1_GeneralVicinity.mxd, Date: 03 23, 2004, User: RPATEL@AAFB\E032004022ATL

tower. Design specifications for the tower, support structures, and security are provided in Appendix B.

AEDC and the USGS Water Resource Division are collaborating on a 4-year project to support the Base's ecosystem management efforts by increasing knowledge of the relationships among vegetation, climate, and soils and their combined influence on water balance at the hillslope scale. The project requires quantification of ET demand from the land/vegetation system to calibrate spatially explicit water-budget models relating hydrologic inputs and outputs to wetland and stream function. This information would be used to understand the impact restoration efforts have on the movement of water through the landscape. The restoration of open canopy Barrens in areas that were previously densely forested drainage basins surrounding wetlands is expected to alter ET and the quantity of water sustaining the wetlands. Understanding how vegetation structure affects ET, soil water recharge, and soil moisture balance at the hillslope scale would enable AEDC to predict potential hydrologic changes in response to Barrens restoration efforts. These hydrologic changes would be useful in predicting local climate change, as well as wetland and stream responses to altered hydrologic conditions. This knowledge would allow AEDC land managers to evaluate consequences in terms of threats or benefits to the regionally significant karst wetlands and associated rare ecological communities and protected species.

Approximately 504 square feet of the site would be cleared for installation of the tower pad and the anchor sites. Cleared space would also be required to assemble the 140-foot tower. Cleared vegetation would be left onsite to provide small animal habitat. The area cleared for tower assembly would revert to natural vegetation. Construction of the ET tower infrastructure would entail limited earthwork to prepare the area for placement of the 16–square-foot reinforced concrete support platform, which would be 4 feet thick. Additionally, three 1.5-foot diameter holes 4 feet deep would be excavated to place the guy wire anchors. Approximately 6 cubic yards of soil would be removed to install the structures. This soil would be disposed of in an upland area and stabilized with vegetation to prevent erosion.

The excavation work would be done by backhoe, and materials would be hauled with a truck. Access to the proposed site would be along an existing forest road and would not require construction of any new roads.

2.2 Alternative Action: Install Instrumentation for Measuring ET on 60-Foot Extension to Fire Tower

Under the Alternative Action, the instrumentation for measuring ET would be placed on the existing fire tower located at the fire station near the corner of First Street and Avenue C (Figure 2-1). The fire tower is approximately 80 feet tall and does not extend above the tallest trees in the vicinity, which would make it impossible to obtain accurate ET measurements. Therefore, a 60-foot extension to the fire tower would be necessary to house the instruments. This extension would be of the same materials as the stand-alone tower and would be supported by guy wires at heights of 105 and 140 feet. Guy wires would be anchored as described for the Proposed Action.

Adapting the existing fire tower site for installation of the ET tower would limit the data collection capabilities, thus limiting the usefulness of the monitoring station. For example, with the fire tower extension, data could not be collected under all wind conditions. This would limit the use of data to those times when winds are from an approximately 40-degree arc generally to the north of the fire tower. This may not provide sufficient data for future barrens habitat management and land use decisions.

2.3 No-Action Alternative

In the No-Action Alternative, no structures would be erected to measure ET in the Barrens restoration area. Under the No-Action Alternative, AEDC would not be able to obtain accurate site-specific data on ET and hydrologic relationships for application in land management decisions that could affect Barrens and wetland habitats on the Base and the sensitive species that use these habitats.

2.4 Alternatives Considered but Not Carried Forward

AEDC considered alternatives to the eddy covariance method for measuring ET from the Barrens restoration area. However, other approaches for estimating ET were determined to be unsuitable for measuring ET from forested areas. For example, pan evaporation provides information on a portion of the evaporation rate or demand but it is not considered representative and does not account for transpiration. Methods to measure sap-flow in trees have been applied but address only woody plant transpiration and ignore interception, direct evaporation, and transpiration from herbaceous vegetation. Additionally, sap-flow methods sample only a portion of trees within a stand and the data would have to be extrapolated to the entire stand, which adds a degree of uncertainty to the results. Chamber and lysimeter methods are applicable to very small areas (typically less than 22 square feet) and are practical only with short herbaceous and shrub vegetation. As with sap-flow methods, chamber and lysimeter data would have to be extrapolated to the entire stand, with the associated increase in uncertainty. Models, such as Penman-Monteith, Priestly-Taylor, and Thornwaite, require that a crop coefficient be applied to the model. These models have not been calibrated for forest conditions and existing crop coefficients likely would not be relevant to the forest vegetation on Arnold AFB.

Because alternative methods to estimate ET were determined to be incapable of providing data of sufficient quality to enhance land management decisions on Arnold AFB, these methods were determined to be impracticable and are not carried forward for additional analysis.

2.5 Comparison of Alternatives

The Proposed Action, Alternative Action, and No-Action Alternative are compared in Table 2-1.

TABLE 2-1
Comparison of Impacts of Considered Alternatives
Construction of Evapotranspiration Tower EA

Resource Area	Proposed Action	Alternative Action	No-Action Alternative
Non-Sensitive Flora and Fauna	Insignificant impact from conversion of 25 square feet into support and anchor structures and 505 square feet within the fenced areas.	Insignificant impact from conversion of less than 10 square feet into anchor structures.	No impact.
Sensitive Species	Potential for long-term positive impact from improved management of these resources on Arnold AFB. Potential long-term positive impact from improved data collection to support land management decisions	Potential for long-term positive impact from improved management of these resources on Arnold AFB. Potential long-term negative impact from lack of sufficient data to support land management decisions.	No long-term positive impacts from improved management. Potential long-term negative impact from lack of accurate data to support land management decisions.
Sensitive Habitats	Potential for long-term positive impact from improved management of these resources on Arnold AFB. Potential long-term positive impact from improved data collection to support land management decisions	Potential for long-term positive impact from improved management of these resources on Arnold AFB. Potential long-term negative impact from lack of sufficient data to support land management decisions.	No long-term positive impacts from improved management. Potential long-term negative impact from lack of accurate data to support land management decisions.
Cultural Resources	No impact.	No impact.	No impact.

3.0 Affected Environment

3.1 Biological Resources

Biological resources include the native and introduced terrestrial plants and animals around Arnold AFB. The land areas at Arnold are home to unusually diverse biological resources including several sensitive species, habitats, and wetlands. Arnold AFB established a system of ecological associations based on floral, faunal, and geophysical characteristics. These ecological associations are described in the Arnold AFB IEMP (Call, 2003) and the *Environmental Baseline Study Resource Appendices* (U.S. Air Force, 1995).

3.1.1 Eastern Highland Rim Ecological Association

The eastern Highland Rim region is part of the Mississippian Plateau section of the Western Mesophytic Forest region, supporting a mixed oak-tulip-chestnut forest with accessory stands of beech and hemlock. Relic stands of mixed hardwood-white pine occur on some bluffs above streams. The Barrens is linked to the karst topography and was once an area of tall grass prairies.

3.1.1.1 Wildlife Species

Wildlife species at Arnold AFB are those common to the central southeastern United States. A literature review was conducted to identify representative common species of mammals, reptiles, amphibians, and birds (Table 3-1).

TABLE 3-1
Common Wildlife Species Occurring in Arnold AFB Vicinity
Construction of Evapotranspiration Tower EA

Common Name	Scientific Name
Bats	
Little brown bat	*Myotis lucifugus*
Northern myotis	*Myotis septentrionalis*
Red bat	*Lasiurus borealis*
Eastern pipistrelle	*Pipistrellus subflavus*
Big brown bat	*Eptesicus fuscus*
Rodents	
Eastern chipmunk	*Tamias striatus*
Groundhog	*Marmota monax*
Eastern gray squirrel	*Sciurus carolinensis*
Fox squirrel	*Sciurus niger*
American beaver	*Castor canadensis*
White-footed mouse	*Peromyscus leucopus*
Woodland vole	*Microtus pinetorum*
Raccoon	*Procyon lotor*
Virginia opossum	*Didelphis virginiana*
Smokey shrew	*Sorex fumeus*
Southeastern shrews	*Sorex longirostrus*

TABLE 3-1
Common Wildlife Species Occurring in Arnold AFB Vicinity
Construction of Evapotranspiration Tower EA

Common Name	Scientific Name
Least shrew	*Cryptotis parva*
Eastern mole	*Scalopus aquaticus*
Coyote	*Canis latrans*
Red fox	*Vulpes vulpes*
Gray fox	*Urocyon cinereoargenteus*
Long-tailed weasel	*Mustela frenata*
Striped skunk	*Mephitis mephitis*
Bobcat	*Lynx rufus*
White-tailed deer	*Odocoileus virginianus*
Eastern cottontail	*Silvilagus floridanus*
Amphibians	
Eastern newt	*Notophthalmus viridescens*
Spotted salamander	*Ambystoma maculatum*
Two-lined salamander	*Eurycea bislineata*
Bull frog	*Rana catesbeiana*
Green frog	*Rana clamitans*
Pickerel frog	*Rana palustris*
Southern leopard frog	*Rana sphenocephela*
Spring peeper	*Hyla crucifer*
Chorus frog	*Pseudacris triseriata*
American toad	*Bufo americanus*
Woodhouse's toad	*Bufo woodhousei).*
Reptile Species	
Common snapping turtle	*Chelydra serpentina*
Mud turtle	*Kinosternon subrubrum*
Musk Turtle	*Sternotherus odoratus*
Red-eared slider	*Trachemys scripta*
Eastern box turtle	*Terrapene carolina*
Eastern spiny softshell	*Apalone spinifera*
Eastern fence lizard	*Sceloporus undulatus*
six-lined racerunner	*Cnemidophorus sexlineatus*
Five-lined skink	*Eumeces fasciatus*
Broad-headed skink	*Eumeces laticeps*
Black racer	*Coluber constrictor*
Corn snake	*Elaphe guttata*
Black rat snake	*Elaphe obsoleta*
Common kingsnake	*Lampropeltis getulus*
Northern water snake	*Nerodia sipedon*
Rough green snake	*Opheodrys aestivus*
Common garter snake	*Thamnophis sirtalis*
Copperhead	*Agkistrodon contortix*

Mammal species from Lamb 2004a, Mullen et al. 1995; Bailey et al. 2000; J.W. Lamb personal communication, 2004.
Amphibian species from Mullen et al. 1995; J.W. Lamb personal communication, 2004.
Reptile species from Mullen et al. 1995; Bailey et al. 2000; J.W. Lamb personal communication, 2004.

A study was conducted in 2000 to document bird use of wetland flats and depressions (Roberts et al., 2001). This study identified 59 breeding season birds using wetland areas, including 34 neotropical migrant species. Forty-six bird species were identified using the wetland flats and depressions in winter. A list of the species identified during this study is provided in the report (Roberts et al., 2001). Eighty-six bird species have

been documented breeding at Arnold AFB (Lamb 1999, 2000, 2001, 2002, 2003a, 2004a). Including summer residents, migrants, and wintering species, a total of 226 species have been documented at Arnold AFB (J.W. Lamb, unpublished data).

In the 1950s, a comprehensive game management plan was initiated to increase wildlife populations so that reasonable harvests by the public would be possible. From 1954 to 1964, over 17,000 quail, 6,000 pheasant, 64 deer, and 21 turkeys were stocked. In 1974, the stocking of Canada goose began, with 53 geese stocked on the Retention Pond. An additional 50 geese were stocked in 1975. There are now abundant populations of deer, quail, geese, and turkeys on Arnold AFB. Since deer hunting was initiated in 1965, a total of 21,308 deer have been harvested to date (Call, 2003).

3.1.1.2 Plant Species

AEDC lies in the heart of the Barrens region of the eastern Highland Rim. "Barrens" most often refers to grasslands similar to the Midwestern tallgrass prairie but may also be used to describe openings with scattered trees that may resemble savanna or shrubland. Present vegetation on Arnold AFB is predominantly upland and swamp oak forest. Of the forested areas, 23,492 acres are in native hardwoods and 5,785 acres are in planted, non-native pines. Forested areas are most frequently characterized by closed canopies dominated by various oaks. Dry sites are dominated by post oak (*Q. stellata*), blackjack oak (*Q. marilandica*), scarlet oak (*Q. coccinea*), southern red oak (*Q. falcata*), and black oak (*Q. velutina*). Wet sites are dominated by white oak (*Q. alba*), willow oak (*Q. phellos*), water oak (*Q. nigra*), and overcup oak (*Q. lyrata*). Understories include a wide variety of species including dogwoods (*Cornus* spp.), maples (*Acer* spp.), sassafras (*Sassafras albidum*), sourwood (*Oxydendrum arboreum*), and blueberries (*Vaccinium* spp.).

Numerous wetlands occur across the Base, with prevailing vegetation ranging from grassland to closed-canopy forest. Several hundred acres of open, prairie-like barrens occur primarily near the airfield and along powerline and railroad rights-of-way. The flora of the region has long been noted for its unusual Coastal Plain disjuncts. Coastal Plain disjuncts are species that normally occur only in the Atlantic or Gulf coastal plains. These species are found nowhere else in Tennessee. To date, over 900 vascular plant species have been recorded on the Base (Call, 2003). The Nature Conservancy and the Tennessee Division of Natural Heritage classified and mapped the vegetation of Arnold AFB. The 33 plant associations delineated for Arnold AFB are listed in Appendix C. Seventeen of the 33 vegetation associations found on Arnold AFB are considered "imperiled" community types.

3.1.2 Sensitive Species

Sensitive species include those with federal endangered or threatened status, species proposed for listing as federal threatened or endangered, and state endangered, threatened, and species of special concern status (U.S. Air Force, 1995). An endangered species is one that is in danger of extinction throughout all or a significant portion of its range. A threatened species is any species that is likely to become endangered in the future throughout all or a significant portion of its range due to loss of habitat, anthropogenic effects, or other causes.

AF projects that may affect federally protected species and species proposed for federal listing are subject to the ESA. The ESA requires designation of critical habitat for federally listed species. However, no areas on Arnold AFB are designated as critical habitat under the ESA. The species present on Arnold AFB that are protected under the ESA are described below. A list of all sensitive species on Arnold AFB is provided in Appendix D.

3.1.2.1 *Myotis grisescens* (Gray Bat)

In size, the gray bat is the largest eastern representative of the genus *Myotis*. It occupies a limited geographic range in the limestone karst areas of the central and southeastern United States. The gray bat typically uses caves for both winter hibernation and summer roosting/maternity, although different caves are used for these two periods. Gray bats have narrow temperature requirements, which reduces the number of caves that are suitable for use. The species is particularly vulnerable, as 95 percent of the population hibernates in only 9 caves, with over half the population hibernating in a single cave (Rommé and Reaves, 1999). The gray bat is federally listed as endangered due to declining numbers and loss of habitat. Flooding of summer maternity caves and hibernacula as a result of reservoir construction has been a major contributor to decline of the species (Rommé and Reaves, 1999).

Informal Section 7 consultations between representatives from Arnold AFB and USFWS occurred in 1978, 1979, and 1996. As a result, a management action plan was developed to coordinate continued Base operations and protection of the gray bat colony at Woods Reservoir Dam and foraging habitat across the Base. The gray bat colony that resides on Arnold AFB at Woods Reservoir Dam is listed as a priority 2 maternity colony in the USFWS Gray Bat Recovery Plan (1982) and is one of a very few maternity colonies that have been identified as using manmade structures for a maternity roost (Lamb, 2003 b).

Gray bats forage primarily on aquatic insects along forested riparian corridors and use other forested corridors as travel routes. The canopy provides protective cover from potential predators (Rommé and Reaves, 1999;Lamb, 2003b). Mist net surveys at Arnold AFB have confirmed this life history characteristic, and gray bats have been captured while foraging along Elk River Bottoms, Bradley Creek, Brumalow Creek, and Rowland Creek. Gray bats also have been recorded with AnaBat II™ at Goose Pond, Sinking Pond, Tupelo Swamp, Westall Swamp, and near the Tennessee Valley Authority (TVA) substation.

Juvenile bats typically forage in wooded areas around the maternity cave (Rommé and Reaves, 1999;Lamb, 2003b). Therefore, protection of these areas also is important to recovery and maintenance of the species.

3.1.2.2 *Myotis sodalis* (Indiana Bat)

The Indiana bat is found in the eastern United States from eastern Oklahoma into Vermont and northwestern Florida. Indiana bats hibernate in caves and typically spend summers under the loose bark of trees in upland and bottomland forests and semi-wooded areas (Whitaker and Hamilton, 1998). Typically, Indiana bats make summer roost in hardwood trees with sloughing bark or cavities (Rommé and Reaves, 1999), but males have been documented roosting among the bark furrows of large pine trees on

Wright-Patterson Air Force Base (R.A. King, USFWS, personal communication, 2004). As with gray bats, Indiana bats may migrate several hundred miles between winter and summer habitat (Rommé and Reaves, 1999).

Indiana bats forage on insects in a variety of habitats. This species typically forages in and around the tree canopy of riparian, floodplain, and upland forests. They also may forage along fencerows, crops, clearings, and farm ponds (Rommé and Reaves, 1999).

AnaBat II™ surveys in 2003 identified the possible presence of Indiana bats along Bradley and Brumalow Creeks, but the species has never been captured in mist nets on the Base (Lamb, 2004b). There is some difficulty in positively identifying Indiana bats from calls recorded with an AnaBat II™ detector because of similarity and marginal overlap with other bat species. The USFWS does not currently accept AnaBat II™ identifications in the absence of confirmed captures (Robert Currie, USFWS, communication, 2004 to J.W. Lamb cited in Lamb, 2004b). Additional surveys would be required to confirm the presence of this species on the Base.

3.1.2.3 *Haliaeetus leucocephalus* (Bald Eagle)

The bald eagle is a federally threatened species. The bald eagle is found over most of North America, from Alaska and Canada to northern Mexico. There are an estimated 50,000 bald eagles in the United States, with 80 percent found in Alaska (Murphy et al., 1989).

The bald eagle is the only species of sea eagle that lives in North America. In the Southeast, bald eagles build their nests in early September. They usually build their nests in pine trees or bald cypress trees that are 1,000 feet or less from open water. In Everglades National Park, bald eagles nest in low mangrove trees or use nests that have fallen to the ground. But mostly, bald eagles build nests high in trees where they have a clear view of the water. These nests are large compared to the nests of other birds. The cone-shaped nests may be 6 feet across and from 6 to 8 feet from top to bottom. The nests are made of sticks and twigs from other trees. The nests may be lined with Spanish moss, corn husks, or grasses (Murphy et al., 1989).

Eagles may start laying eggs as early as late October. Most bald eagles in the Southeast lay eggs in the latter part of December. Bald eagles usually lay one or two eggs, sometimes three. The eggs take about 35 days to hatch. The newly hatched birds stay in the nest from 10 to 12 weeks. Bald eagle parents may care for their young for another 4 to 6 weeks after the eaglets learn to fly (Murphy et al., 1989).

Tennessee's bald eagle population is the highest in winter when birds migrate from the north. Most of the birds winter in western parts of the state, particularly at Reelfoot Lake and Dale Hollow Reservoir, but bald eagles may occur on almost any waterway in the state (TWRA, 2004).

Table 3-2 provides the numbers of mature and juvenile bald eagles observed at Woods Reservoir from 1988 through 2004. In most years a single pair of bald eagles winters on Woods Reservoir. Occasional sightings of transient eagles occur, but the species has not been documented nesting on Arnold AFB.

TABLE 3-2
Number of Wintering Bald Eagles at Woods Reservoir (1988-2004)
Construction of Evapotranspiration Tower EA

Year	Number of Adults	Number of Immature
1988	0	0
1989	2	0
1990	2	0
1991	2	0
1992	2	1
1993	2	0
1994	2	0
1995	1	0
1996	1	0
1997	2	0
1998	2	0
1999	1	0
2000	2	0
2001	2	0
2002	2	0
2003	2	0
2004	1	1
Total	28	2

Data from J.W. Lamb, unpublished data.

3.1.2.4 *Helianthus eggertii* (Eggert's Sunflower)

Eggert's sunflower is the only federally listed threatened plant species known from Arnold AFB. Management actions for the species are integrated with other aspects of the Arnold AFB ecosystem management program by employing a coarse filter-fine filter approach. The coarse filter approach is to restore and maintain vegetation structure and ecological processes in suitable habitats for Eggert's sunflower. Such process-oriented management supports mission flexibility by working at multiple spatial and temporal scales to conserve biological diversity associated with one of the Base's focal conservation targets–The Barrens mosaic (Fitch, 2003). Fine filter protective measures specific to Eggert's sunflower are also taken to ensure that localized destruction of the species or its habitat does not encroach on mission flexibility by violating provisions of the ESA. Management is coupled with monitoring to help track impacts to the plant. AEDC Conservation implements management and develops projects to further the recovery objectives outlined by the USFWS (Fitch, 2003).

All aspects of Eggert's sunflower management on Arnold AFB are planned in coordination with the Cookeville, TN office of the USFWS. The Service's recommendations are incorporated when developing new management strategies and projects or addressing unforeseen operational impacts (Fitch, 2003).

The document *AEDC Operational Information: Potential Impact to Helianthus eggertii* was developed and implemented through informal Section 7 consultation under the ESA. This document describes AEDC's operations, lists impacts to Eggert's sunflower that may occur from those operations, and outlines measures to reduce or avoid impacts when implementing Base operations. For each Base operation, the document gives the purpose of the operation, the method by which the operation is implemented, the potential impacts to the Eggert's sunflower resulting from each operation, and how to implement the operation to reduce/eliminate these impacts (Fitch, 2003).

It is understood that informal Section 7 consultation is to be reinitiated if (1) new information reveals impacts of the Proposed Action that may affect listed species or critical habitat in a manner not previously considered, (2) the Proposed Action is subsequently modified to include activities that were not considered during this informal consultation, or (3) new species are listed or critical habitat designated that might be affected by the Proposed Action (Call, 2003).

Prescribed burning, mechanical thinning, and invasive plant management are practices used to manage Eggert's sunflower on Arnold AFB. Eggert's sunflower habitat is maintained through Barrens restoration, forest management, and roads and ground operations, in addition to management of approximately 285 acres designed specifically for the species' conservation (Call, 2003). The management actions are driven by the recovery goals for the species, which are listed in the USFWS Recovery Plan for Eggert's sunflower (White and Ratzlaff, 2000). Through management, Arnold AFB seeks to minimize the threats to Eggert's sunflower, including vegetation succession, habitat destruction, and competition by invasive plants.

3.1.2.5 *Pleurobema gibberum* (Cumberland Pigtoe)

Cumberland pigtoe is a federally threatened aquatic invertebrate bivalve species. A member of the mollusk family, it was previously found to exist at Arnold AFB. However, a recent survey indicated that the species does not currently exist on-Base (Call, 2003). As such, it is not considered in this assessment.

3.1.3 Sensitive Habitats

Sensitive habitats are described as those supporting threatened or endangered plant and animal species, areas determined to be exemplary natural communities by federal or state agencies, or habitat areas exceptionally fragile and susceptible to damage.

3.1.3.1 Wetlands and Floodplains

Wetlands are inundated (water-covered) areas, or areas where water is present either at or near the surface of the soil for distinguishable periods of time throughout the year. Local hydrology and prolonged soil saturation largely affect soil formation and development, as well as the plant and animal community composition in wetland areas.

Wetland flats and depressions are the two primary wetland types on Arnold AFB. The USFWS completed a wetlands inventory and mapping project on Arnold AFB in 1998 and documented 1,894 acres of wetlands in 220 sites (Figure 3-1). Two hundred wetlands on Arnold AFB totaling about 1,775 acres are classified as either flats or depressions. At

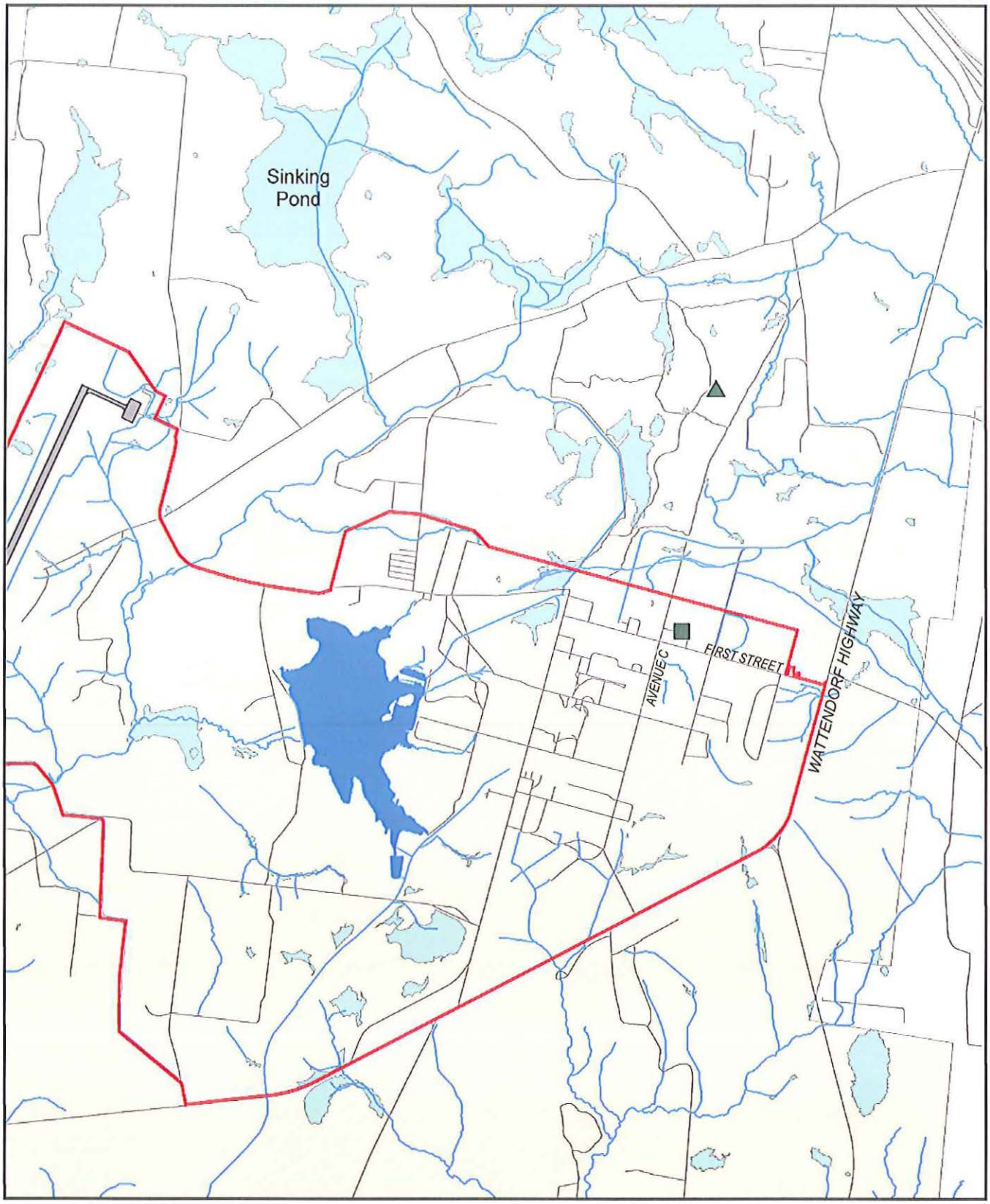


Figure 3-1
Streams and Wetlands on Arnold Air Force Base
Construction of Evapotranspiration Tower
Final Environmental Assessment

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present, an interagency effort is underway to develop models, on the basis of hydrology and geomorphology, for assessing function in wetland flats and depressions. This and other ongoing projects would increase the understanding of how varying land uses in and adjacent to wetlands influence wetland function.

Wetlands at AEDC result from three major geomorphic features: karst pans, compound sinks, and intermittent headwater streams (Call, 2003). Karst pans typically have depths less than 4.9 feet and level bottom topography. Compound sinks generally have depths greater than 8.2 feet and complex bottom topography dominated by internal drainage systems consisting of coalesced sinkholes and connecting channels.

Wetlands associated with headwater streams display a rapid surface water response to localized precipitation events. These areas remain wet for extended periods due to level topography and poorly drained soils. Hydrologic monitoring at AEDC has identified distinct water regimes associated with karst pans and compound sinks.

Two karst pans, Tupelo Swamp and Goose Pond, have water regimes characterized by narrow ranges of flooding depth, gradual seasonal rises and recessions, long hydroperiods, persistent soil saturation, and perched surface water systems. These similarities persist across significantly different hydrologic conditions. Most pans on the Base support wet forests of willow oak, sweet gum, black tupelo, or red maple, but several support unusual natural communities that often include rare or disjunct plants and animals (Call, 2003). Goose Pond, which is named as a National Natural Landmark, is remarkable for the diverse forest communities bordering it, and is also the site of a large number of rare plant species.

Three compound sinks, Sinking Pond, Westall Swamp, and Willow Oak Swamp, share the geomorphic characteristics of about 9.8 feet of internal relief and plainly visible sinkhole drains. Their water regimes are characterized by abrupt seasonal rises and recessions, typically 6.6 feet or more during periods as short as 1 to 3 days, and close interactions between surface water and groundwater. These interactions include water table control of sinkhole drainage and very flashy groundwater response under the influence of concentrated recharge through the sinkholes. The annual flooding behavior of compound sinks is more sensitive to rainfall during the fall and early winter than to total annual rainfall (Call, 2003). Sinking Pond, designated a National Natural Landmark by the U.S. National Park Service, is well known locally for its abrupt seasonal flooding and draining. One of the most pristine areas at AEDC, Sinking Pond, also is the site of one of the largest great blue heron rookeries in Tennessee.

According to the Ecosystems Management Plan, 10 plant association target communities are included in the wetland flats and depressions classification. The communities are listed in Appendix C.

Twenty-six target species are associated with wetland flats and depressions. The gopher frog (*Rana capito*) occurs in wetlands on Arnold AFB. However, the subspecific status of the gopher frog on Arnold AFB has not yet been determined. The Arnold AFB population of gopher frog is disjunct, separated from the next nearest population by several hundred miles and may represent a distinct, as yet undescribed, subspecies. The three subspecies of the gopher frog recognized in the scientific literature are considered

species of concern by the USFWS. Many of the rare plants associated with the wetland flats and depressions classification also are disjunct populations of species whose central ranges are limited to the Atlantic or Gulf Coastal Plains. Several of the disjunct species associated with wetland flats and depressions are documented in Tennessee only from Arnold AFB. A list of all the conservation target species associated with wetlands on Arnold AFB and the wetland types in which they are typically found is provided in Appendix D.

3.1.3.2 Barrens Mosaic

"Barrens" is a term that has been used in American scientific literature since the mid-1700s to describe generally grassy openings occurring in otherwise forested landscapes throughout the eastern and midwestern United States (Homoya, 1994; Juras, 1997). Barrens typically are characterized by the localized soil or bedrock features that preclude development of a forest cover, but many barrens are disturbance-maintained (Homoya, 1994). Some barrens types, such as shale barrens and dolomite barrens, provide habitat for a substantial number of endemic plant species (Allison and Stevens, 2001; Homoya, 1994).

Within Tennessee, "The Barrens" is a term applied to that part of the Highland Rim region where many grassy openings occurred in the historic hardwood forests (DeSelm, 1994). In the modern landscape, this region has been impacted by human settlement and only scattered remnants of the historic barrens remain (DeSelm, 1994). Even during presettlement times, The Barrens was not a contiguous landscape feature, but was a component of a landscape mosaic consisting of grasslands, shrub-dominated habitats, savannas, woodlands, and forests (Call, 2003). The composition and structure changes spatially and temporally. The Tennessee Barrens are not known for a large number of endemic plant species, but are important to regional biodiversity from the standpoint of plant metapopulation dynamics resulting from the spatial and temporal heterogeneity associated with their position in the landscape mosaic (Fitch, 2001).

The following is an excerpt from Strohmeier (2003) describing the Barrens mosaic:

> *The IEMP for AAFB identifies the "Barrens mosaic" as one of four focal conservation targets to be managed for the installation. This mosaic represents an ecosystem approach for conserving a variety of plants and animals that are unusual in the region, rare in the state, or globally rare. Maintaining this mosaic across the landscape is necessary for the continued existence of many of those species. Desirable structural characteristics (i.e., habitat types) for each phase of the Barrens mosaic are described below, with information partially taken from Leach and Ross (1995):*
>
> *Upland dry-mesic forest - describe the areas least influenced by fire and other disturbances. Upland dry-mesic forests are the result of over 50 years of fire prevention and suppression and may be the result of exclusion of large herbivores such as bison and elk once prevalent in Tennessee until the late 1700 and early 1800s (Belue, 1996). These forests represent one end of the mosaic. Upland dry-mesic forests provide over 60% cover (or shade) to the ground resulting in a lower diversity of understory plant species compared to woodlands and savannas. Relatively few graminoid (grass-like) and forb (wildflower) species exist in the understory. They are the most prevalent habitat type on AAFB and occupy the broad ridges and slopes on the base. Upland dry-mesic forests*

represent a significant opportunity for restoring woodland, shrub-grassland, and savanna phases of the Barrens mosaic.

Oak woodland - consists of a mixed-aged, oak-dominated overstory and midstory that provides 35%-60% cover to the ground and vegetation below. Beneath the overstory and midstory, graminoid and forb species comprise the dominant ground cover of at least 25% and 15% respectively. The resulting appearance is one of a lightly wooded forest with abundant grasses, sedges, and wildflowers dominating the vegetation observed on the ground. Oak woodlands are considered a transitional state between oak savannas or shrub-grasslands and forests with a fully developed overstory and midstory.

Oak savanna - consists of a mixed-aged, oak-dominated overstory and midstory that provides 10%-40% cover to the ground and vegetation below. Graminoids and forbs comprise the dominant ground cover of at least 35% and 25% respectively. Graminoids and forbs are more abundant due to increased light availability beneath the reduced overstory and midstory. The resulting appearance is one of a prairie-like (grassland) habitat that includes a minor component of oak-dominated tree cover. Oak savanna is a transitional state between grassland or shrub-grassland and oak woodland.

Shrub-grassland - resembles oak woodland or oak savanna sites but consists of little overstory and a more closed midstory relative to woodlands or savannas. Graminoids and forbs will again be the dominant vegetation observed on the ground. As such, these habitats may be viewed as open or grassland habitats with a considerable shrubby component comprised largely of oaks and Vaccinium (blueberry) species. Shrub-grassland can be considered as a transitional state between grassland or hardwood regeneration habitats and oak savanna, woodland, or forest depending upon the disturbance regime under which succession occurs.

Grassland - prairie-like openings (grasslands) are the feature on the landscape most associated with the Eastern Highland Rim barrens. Grassland is typically dominated by species found more commonly in the prairies of the Midwest or in open habitats of the Coastal Plain. Grassland appears as open expanses of graminoids, and forbs with occasional small trees or shrubs. The abundance of woody vegetation in grassland is often related to the length of time since the most recent disturbance event (e.g., fire, grazing, mowing). Frequent disturbance is necessary to maintain its characteristic, nearly treeless appearance.

Historically, much of the land within the boundary of Arnold AFB was part of the barrens mosaic and featured many openings in the oak-dominated forest. The woodland and savanna components include lightly forested, oak-dominated habitats with a grass and forb-dominated understory (savannas may be described as grasslands with a minor canopy cover; woodlands may be described as a low density forest with a well developed herbaceous understory). Fire exclusion since approximately the 1940s has led to replacement of many of the grassy openings by forested habitats with shrub-dominated understories through ecological succession. Aerial photography from the late 1930s indicates that a woodland/savanna mosaic was a dominant habitat in the premilitary landscape on Arnold AFB. Currently, Arnold AFB is engaged in a project to restore Barrens habitat on the Base (Figure 3-2).

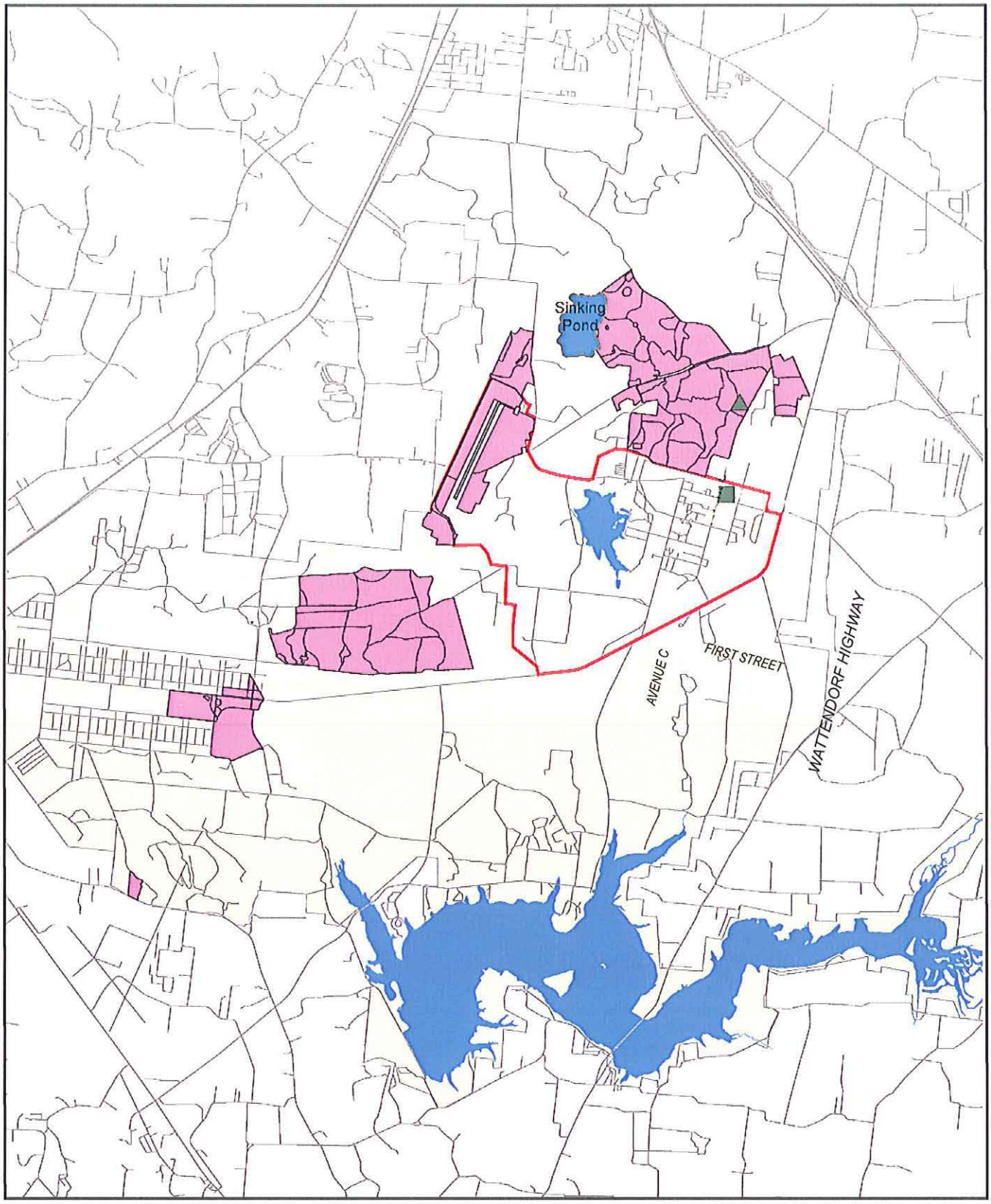

Figure 3-2
Barrens Restoration on Arnold Air Force Base
Construction of Evapotranspiration Tower
Final Environmental Assessment

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Grasslands are the habitat most commonly described in the scientific literature regarding The Barrens. Grasslands at Arnold AFB are dominated by species characteristic of tall grass prairies in the midwestern United States, and also include many wildflower and bird species associated with that region.

There are 18 target species and one species guild in the woodland/savanna/grassland classification. The species are divided into two groups: one associated with dry sites and the other with mesic sites (Appendix E). Some of the species may occur across the soil moisture gradient, but they are associated here with the habitat in which they are commonly found. Eggert's sunflower is the only federally listed (threatened) species associated with woodland/savanna/grassland. The guild identified for the classification is songbirds that utilize early successional habitats cited by Partners in Flight in the Interior Low Plateaus draft Bird Conservation Plan (Ford et al., 2000). Species of concern include:

- Henslow's Sparrow (*Ammodramus henslowii*)
- Bachman's Sparrow (*Aimophila aestivalis*)
- Grasshopper Sparrow (*Ammodramus savannarum*)
- Blue-Winged Warbler (*Vermivora pinus*)
- Prairie Warbler (*Dendroica discolor*)
- Northern Bobwhite (*Colinus virginianus*)
- White-Eyed Vireo (*Vireo griseus*)

3.1.3.3 Upland Dry-Mesic Forests Habitat

The most prevalent habitat type on Arnold AFB lands are the upland forests that occupy most of the broad ridges and slopes on the Base. Portions of this forest may present opportunities for restoring woodland or savanna communities, such as were present historically. However, the upland dry-mesic forests are also regionally important in their current condition, as large, contiguous forested tracts are uncommon in the southeastern portion of the Highland Rim physiographic province. The larger, mature forest tracts on Arnold AFB provide important breeding territory for interior forest songbirds and also help in many ways to maintain the function of nearby wetland habitats.

Five conservation target communities are included in the upland dry-mesic forests classification (Appendix C).

The upland dry mesic forests collectively have focal conservation targets on Arnold AFB. Five community types are included in the upland dry-mesic forest classification:

- *Quercus falcata - Quercus coccinea - Quercus (stellata, velutina)/Vaccinium pallidum* Forest (Southern red oak – scarlet oak – post (black) oak/lowbush blueberry Forest)
- *Quercus falcata - Quercus alba - (Quercus coccinea)/Oxydendrum arboreum/Vaccinium pallidum* Forest (Southern red oak – white (scarlet) oak/sourwood/lowbush blueberry Forest)
- *Quercus alba - Quercus (falcata, stellata)/Chasmanthium laxum* Forest (White oak – southern red (post) oak/slender woodoats Forest)

- *Juniperus virginiana var. virginiana - Quercus* spp. Forest (Eastern red cedar – oak Forest)
- *Juniperus virginiana var. virginiana/Rhus copallinum/Schizachyrium scoparium* Forest (Eastern red cedar/winged sumac/little Bluestem Forest)

The single conservation target species guild identified is interior forest songbirds that require large (i.e., >500 acres), contiguous forest tracts for establishing breeding territories and includes:

- Wood Thrush (*Hylocichla mustelina*)
- Scarlet Tanager (*Piranga olivacea*)
- Ovenbird (*Seiurus aurocapillus*)

The original forest vegetation on Arnold AFB consisted of an oak-hickory forest type on the better-drained soils and a mixed bottomland hardwood type on the poorly drained soils. High grade logging practices and burning for woodland pasture for over 100 years have developed an understocked forest which consists primarily of blackjack oak, post oak, and scarlet oak on the poorer upland soils. The better stands of southern red oak, white oak, water oak, and willow oak occur on the wetter sites.

Pine is not native to this part of Tennessee, but grows well on most sites in this area. Approximately 4,300 acres of pine were planted between 1950 and 1960. This was done as part of a sound attenuation program designed to establish a noise barrier between Arnold AFB and the surrounding communities. Old fields and other areas that required little or no site preparation were planted with loblolly, shortleaf, white, and Virginia pines. An additional 1,400 acres were planted between 1960 and 1972. These plantings converted poor quality management units of hardwood with low productivity into more productive loblolly pine. A pine reforestation program was initiated in 1983. The reforestation program re-establishes loblolly pine on pine sites where final harvests have been accomplished. During the early years of this reforestation effort, a few abandoned agricultural fields (less than 200 acres) were also converted to loblolly pine. Loblolly pine is used exclusively for the reforestation program because it has proven to grow better over a wide range of site classes.

Early in the ecosystem management process, the decision was made to continue to manage the pine forest as part of the overall ecosystem and to maintain the current pine-to-hardwood ratio. However, the recent infestations of southern pine beetle have required re-evaluation of the pine management strategies. In 2003, the decision was made to convert some of the pine acreage to open Barrens habitat (Call, 2003).

3.2 Cultural Resources

Section 106 of the NHPA requires that federal agencies analyze the impacts of federal activities on historic properties. Areas potentially impacted by mission activities are surveyed as part of the AF Cultural Resources Management Program.

Surveys conducted on Arnold AFB have identified 107 prehistoric and historic sites dating back to Early Archaic times (Hajic et al., 2002). These include 40 prehistoric sites,

55 historic sites, and 12 mixed prehistoric and historic sites. Of these 107 sites, 6 have been deemed eligible for listing on the NRHP and 40 are considered potentially eligible (R. Alvey, personal communication, 2004). The prehistoric sites include open habitations, isolated projectile points/knives, and a midden mound. The historic sites include the remains of houses, outbuildings, wells, cemeteries, and trash dumps (Call, 2003). Due to the sensitive nature of these sites, their exact locations are undisclosed.

A total of 340 buildings on Arnold AFB were surveyed by Geo-Marine Inc, and 104 of these structures are considered eligible for listing in the NRHP (Peyton, 2004a; 2004b; R. Alvey, personal communication, 2004). In accordance with NRHP eligibility criteria, most notably Criteria Consideration G, 31 facilities at Arnold AFB have exceptional significance and are therefore recommended as eligible for the NRHP under Criteria A and C. The facilities illustrate the Cold War heritage of the United States in the area of materiel development, and they illustrate key Cold War themes, especially in the area of science and technology. The facilities retain integrity and display distinguishing engineering, technological, and scientific characteristics (Peyton, 2004a; 2004b; TRC Garrow Associates et al., 2001).

Pre-dating Arnold AFB, Camp Peay occupied a 1,040-acre tract in the southwest portion of the present Base. It was established in 1926 as a Tennessee National Guard camp. Subsequently, Camp Forrest was founded in 1941, also predating Arnold AFB. Located mostly within present Base boundaries and encompassing 85,000 acres, it was one of the nation's largest training centers just before World War II. Approximately 22,000 prisoners of war were housed here, representing a number of nationalities, including resident aliens, Germans, and Italians (TRC Garrow Associates et al., 2001). After the war ended, Camp Forrest was declared a surplus property and the buildings and support systems were dismantled and sold (TRC Garrow Associates et al., 2001). There are four surviving structures associated with Camp Forrest: two small concrete utility buildings of unknown use, a former brick jail, and a cold storage building. These resources were recommended as ineligible for the NRHP due to loss of integrity and loss of context caused by the removal of Camp Forrest (TRC Garrow Associates et al., 2001).

4.0 Environmental Consequences

This section discusses the environmental consequences of the Proposed Action, the Alternative Action, and the No-Action Alternative with regard to the resource areas considered in detail.

4.1 Biological Resources

Biological resources (plants and animals) may be directly affected by the Proposed Action and Alternative Action due to construction and maintenance of the site to control vegetative growth inside the fenced areas. The data collected from the tower would be transmitted via telemetry and minimal visits to the site would be required. A potential long-term positive impact from improved data collection to support land management decisions would occur from implementing the proposed alternative. Impacts analysis focuses on the potential for actions to directly and physically affect sensitive biological organisms (threatened and endangered species) and the potential for actions to alter/affect the quality and utility of the sensitive habitats (e.g. wetlands and foraging areas) frequented by those species. Construction activities at the tower site include clearing the vegetation, digging holes for pouring the tower pad and the anchor points, assembling the tower, raising the tower, and fencing the pad and anchor points. There is an existing two-track road over which vehicles can transport materials and equipment to the site.

4.1.1 Impacts to Non-Sensitive Flora and Fauna

Impacts to common flora and fauna may result from direct physical contact during construction activities or from disturbance-related displacement of soil. Maintenance of anchor sites and tower pad fenced areas would have continual impacts on vegetation. Potential impacts for each of the project alternatives are described below.

4.1.1.1 Proposed Action

Construction of the Proposed Action would require ground preparations at four locations on the tower site: the tower foundation and three anchor sites. The tower foundation would require a concrete pad 4 feet by 4 feet that is fenced within a 12-foot by 12-foot enclosure. Each of the three anchor sites would require a fenced area 8 feet by 15 feet. In the fenced area, a 1.5-foot diameter hole 4 feet deep would be augered. The areas would require clearing and grading. During land clearing and grading, all plants would be removed from the area and it is anticipated that any animals present in the area would quickly leave, thus minimizing the possibility of injury or mortality. The concrete areas of the tower pad and anchor sites would be a permanent impact. However, the amount of vegetation that would be lost (25 square feet of impervious surface) would constitute a negligible impact on non-sensitive vegetation. The area is not a unique habitat. Vegetation cleared to allow work to proceed would be left onsite to provide habitat for small animals.

Most animals would be able to detect the construction activity and would leave the area prior to experiencing direct physical harm. Therefore, direct injury and mortality of animals are expected to be negligible.

Animals displaced from the construction area would relocate to other similar habitats nearby. Animals displaced from the adjacent habitats would be expected to return following the disturbance. Therefore, displacement of animals would be temporary.

The security fence would preclude larger animals from using the area within the fence. However, the size of the area that would be excluded (144 square feet for the tower pad, and 360 square feet total for the anchor points) is negligible compared to the extent of the surrounding habitat.

The physical presence of the ET tower and its supporting guy wires could present a hazard to birds and bird migration. Bird-tower collisions have been documented for years (Ornithological Council, 1999; Manville, 2000). In North America tower collisions are a relatively minor cause of mortality (4-5 million birds per year), ranking well below estimates for domestic cats (hundreds of millions per year), tall buildings (97 – 970 million birds per year), and pesticides (65 million birds per year) (Manville, 2000).

Incidents of substantial bird mortality from tower collision have occurred primarily at tall towers, those greater than 200 feet in height (Ornithological Council, 1999; Manville, 2000). Federal Aviation Administration (FAA) regulations require that structures that exceed 200 feet in height be lighted; the lights placed on towers appear to be an attractant for birds, particularly migrating birds (Ornithological Council, 1999; Manville, 2000). Under clear conditions migrating birds typically fly well above even the tallest towers. However, under low visibility conditions, such as low and dense cloud cover or heavy fog, migrating birds travel at low altitudes and may encounter towers. Under these conditions, lights appear to attract birds to the tower vicinity. During periods of poor visibility, birds are reported to continually circle the tower in flight and collide with the tower, its guy wires, or other birds, with the result being mortality (Ornithological Council, 1999; Manville, 2000).

The proposed tower is only 140 feet high and would not be lighted. Without lights, there would be no attractant to the tower area. Impacts are considered minor. Some incidental collisions could occur, but these would be expected to be small in number and not threaten local or migratory bird populations.

4.1.1.2 Alternative Action

The Alternative Action would have impacts to non-sensitive flora and fauna similar to those described for the Proposed Action. However, the Alternative Action would disturb less than 10 square feet of ground and would have correspondingly lower impacts. The location of the Alternative Action, within the AEDC industrial complex, further reduces the likelihood of impacts to non-sensitive flora and fauna. Only 360 square feet would be excluded from use by deer after erection of the security fences for the guy wire anchors. Given the small magnitude of disturbance and its location, impacts to non-sensitive flora and fauna would be expected to be negligible.

The potential for bird strikes would be somewhat higher for the Alternative Action than for the Proposed Action. The extension would not be lighted, but it would be close to a lighted area. The lights could attract resident or migratory birds and result in mortality events.

4.1.1.3 No-Action Alternative

Under the No-Action Alternative, no construction would occur and there would be no impacts to non-sensitive flora and fauna.

4.1.2 Impacts to Sensitive Species

Construction activities (i.e., vehicular/construction equipment traffic) may occur near gray bat and Eggert's sunflower habitat. Analysis focuses on the association between construction footprints and identified sensitive species within these areas and the potential for adverse impacts to those species.

4.1.2.1 Proposed Action

Inventories conducted by the Conservation staff at AEDC have not documented any occurrences of Eggert's sunflower at the site. The closest known large occurrence is approximately 4,200 feet west of the site of the Proposed Action, although 3 small occurrences have been recorded along roads nearer to the site (Figure 4-1). The gray bat is another sensitive species that could experience impacts from the Proposed Action. The bats primarily use aquatic habitat and adjacent riparian vegetation as forage sites to capture aquatic insects. Bats have been documented as foraging along streams such as Brumalow Creek and Bradley Creek (Lamb, 2004b). Sinking Pond has been identified as a potential foraging site. Conservation staff at AEDC collaborated on selection of the tower site to ensure that impacts to Eggert's sunflower and other sensitive species would be avoided or minimized. Additionally, construction activities would occur during daylight hours and the team would leave the area prior to sunset. As a result, impacts to bats would be avoided. Therefore, no direct impacts to sensitive species are expected to result from implementation of the Proposed Action.

The data collected from the ET tower would be used to enhance land management on AEDC. As this information is incorporated into the decision-making process, sensitive species that use Barrens and depressional wetland habitats on Arnold AFB are likely to benefit from improved management.

4.1.2.2 Alternative Action

No sensitive species are known to occur on the Alternative Action site (Figure 4-1). Therefore, no direct impacts to sensitive species are expected to result from implementation of the Alternative Action.

Because of wind condition constraints, data collected from the fire tower location would be less representative of all conditions in the restoration area and would therefore be less useful than data collected from the Proposed Action location. As a result, it is likely that long-term beneficial impacts resulting from improved management would be more

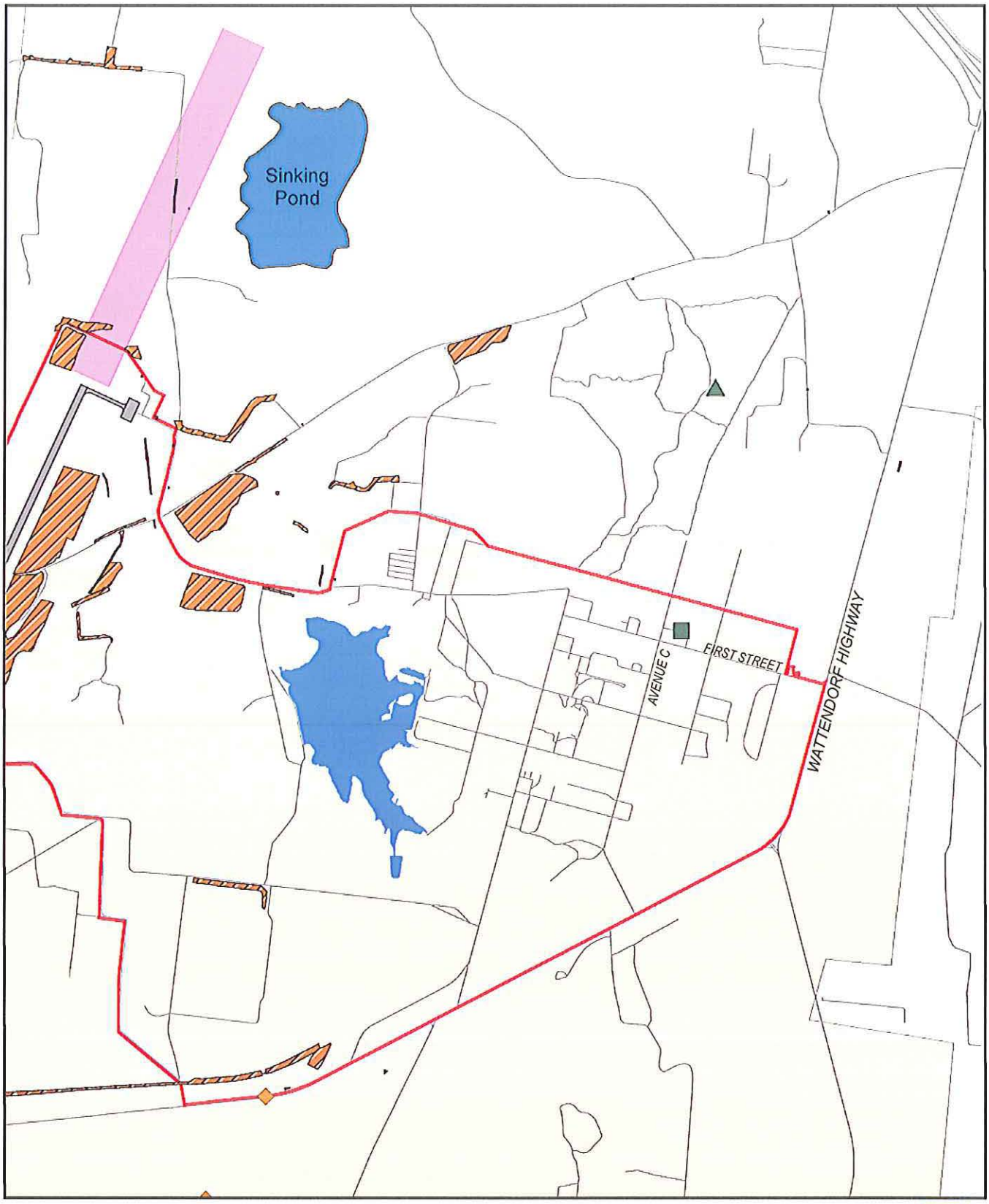

Figure 4-1
Sensitive Species Occurrences and Proposed Project Area
Construction of Evapotranspiration Tower
Final Environmental Assessment

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limited or that decisions made on less accurate and less representative data could have negative long-term impacts. Figure 4-2 is a wind rose showing data from Arnold AFB. Based upon data presented in the wind rose, it is apparent that the prevailing wind coming from the north occurs approximately 18.6 percent of the time.

4.1.2.3 No-Action Alternative

Under the No-Action Alternative, no construction would occur. Therefore, no impacts to sensitive species would result from implementation of this alternative.

Long-term beneficial impacts resulting from improved management would not occur, as no ET data would be collected. Lacking this information, land management decisions could be made that result in negative long-term impacts to sensitive species using Barrens and depressional wetland habitats.

4.1.3 Alteration of Sensitive Habitats

4.1.3.1 Proposed Action

There are no wetlands within the immediate proposed project area (Figure 4-3). However, access to the site would require crossing an intermittent stream. The location of the stream is indicated on Figure 4-3. Within the stream the forest road has been rocked in the past to accommodate vehicle traffic.

Construction and the associated equipment traffic would occur during the dry season (July – September) and the number of trips to the tower would be the minimum number required to complete construction. During the dry season, vehicle traffic across the rocked intermittent stream will not impact waters.

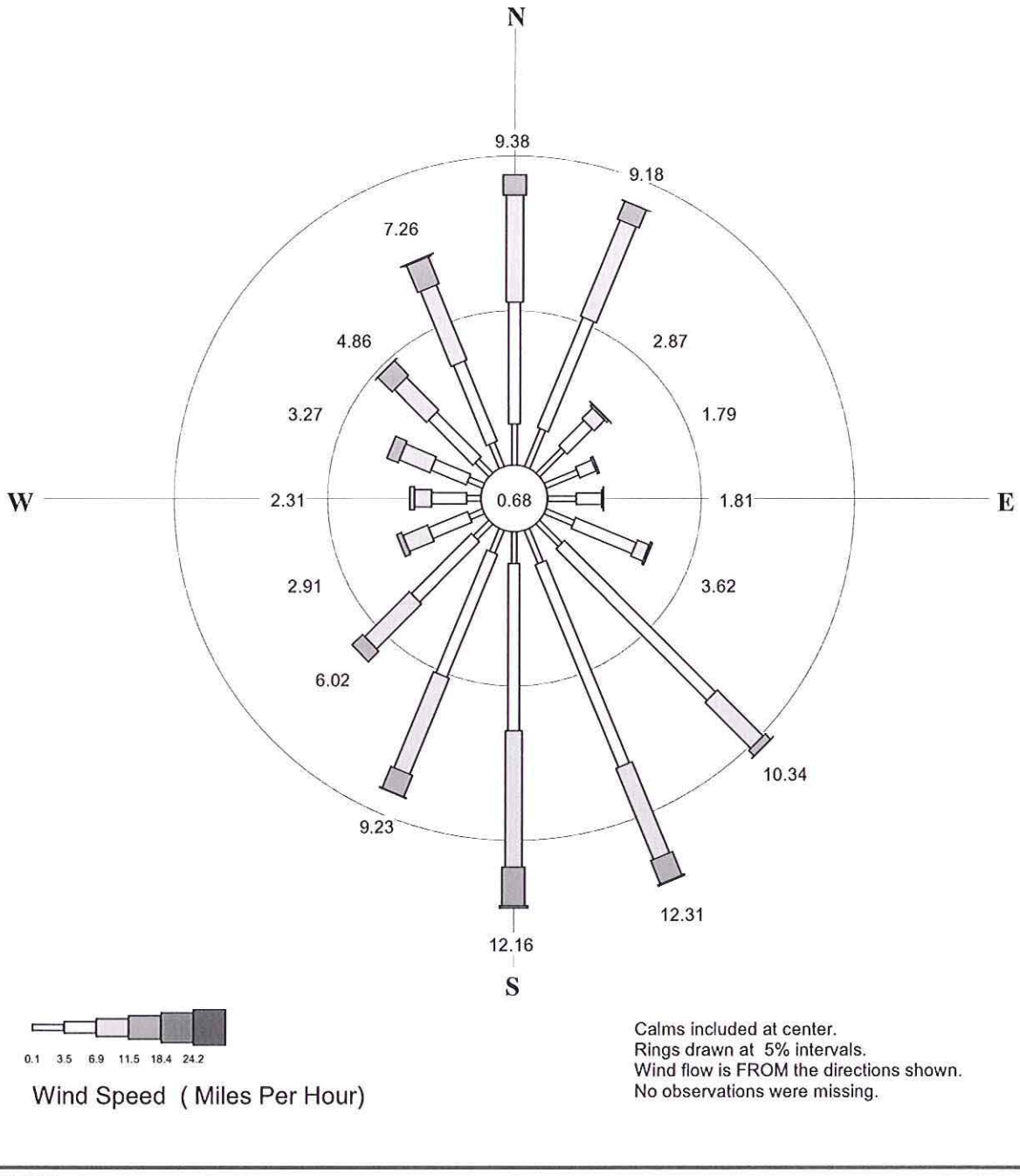
The proposed project area is within a Barrens restoration area (Figure 4-4). Impacts from construction of the ET tower would be minimal, with approximately 25 square feet of surface area converted to concrete to support the tower and the guy wire anchors. Additional land enclosed within fences (approximately 480 square feet) would be managed to preclude woody vegetation, which would be compatible with the Barrens restoration effort.

The data collected from the ET tower would be used to enhance land management on AEDC, particularly with regard to Barrens restoration and depressional wetlands. As this information is incorporated into the decision-making process, it is likely that Barrens and depressional wetland habitats on Arnold AFB would benefit from improved management.

4.1.3.2 Alternative Action

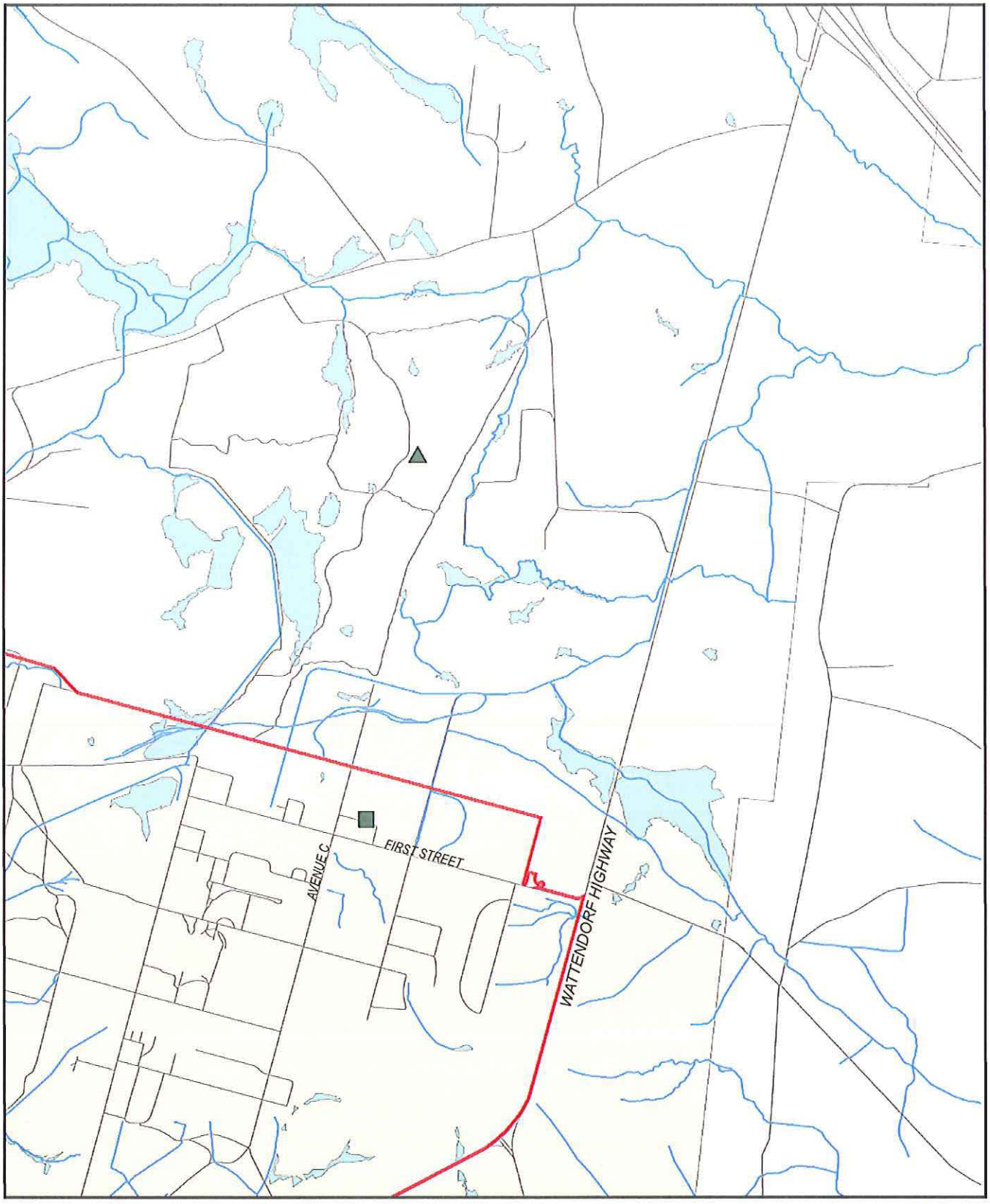
There are no sensitive habitats within the area where construction would occur around the fire tower (Figure 4-3). Therefore, no direct impacts to sensitive habitats would result from implementation of the Alternative Action.

Because of wind condition constraints, data collected from the fire tower location would be less representative of all conditions in the restoration area and would therefore be less useful than data collected from the Proposed Action location. As a result, it is likely that long-term beneficial impacts resulting from improved management would be more



Source: AEDC, 2004

Figure 4-2
AEDC Wind Rose
Construction of Evapotranspiration Tower
Final Environmental Assessment



0 1,500 3,000 Feet

N

LEGEND

- Alternate Location
- Proposed Location
- Road
- Streams
- AEDC Boundary
- Airfield
- Arnold AFB Boundary
- Wetlands

Figure 4-3
Streams and Wetlands in Project Vicinity
Construction of Evapotranspiration Tower
Final Environmental Assessment

File Path: Q:\CH2MHILL\Projects\TimberHarvest_EA\MXDs\Fig1-1_GeneralVicinity.mxd, Date: 03.23.2004, User: RPATEL@AAFB\E032004022ATL

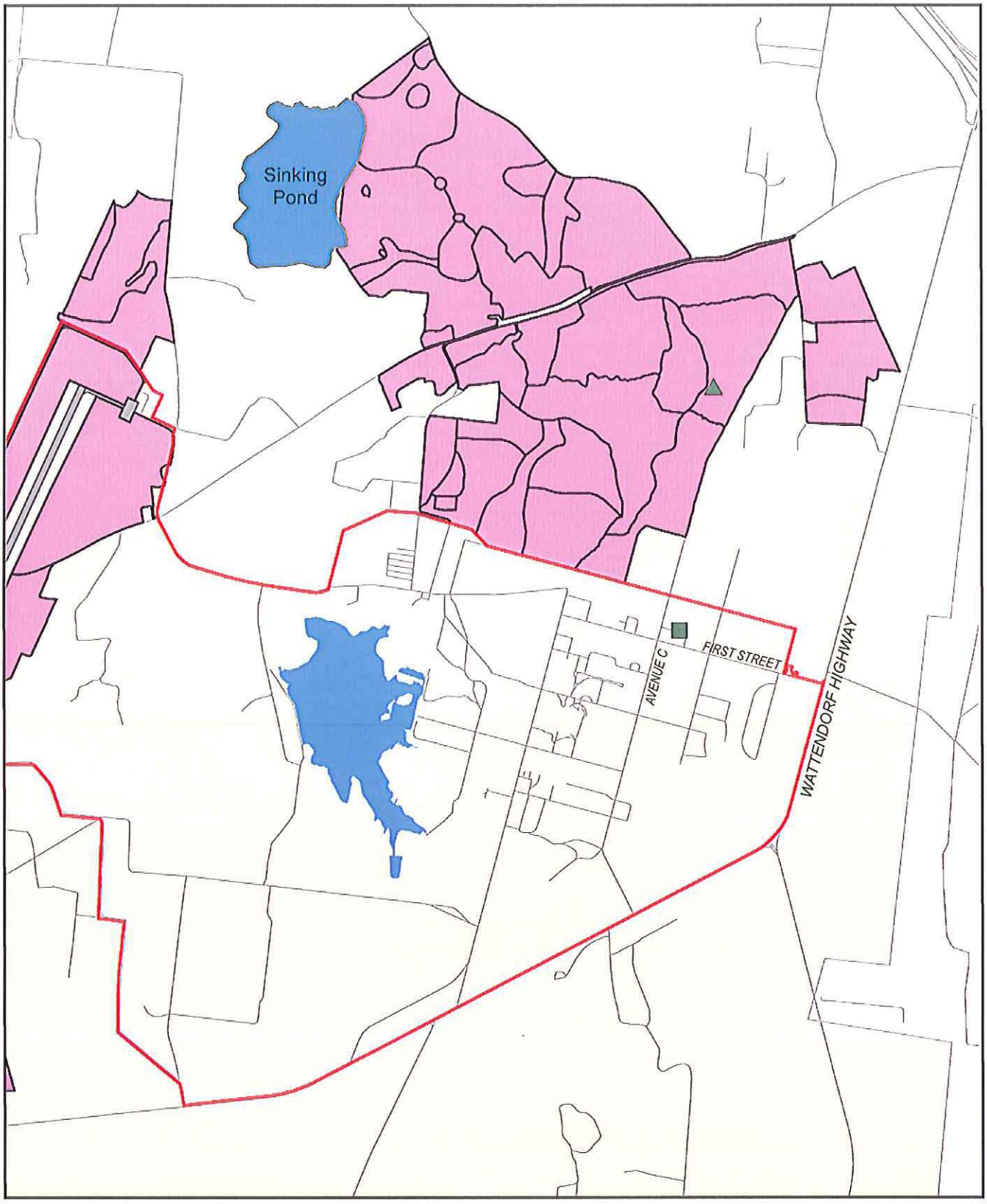


Figure 4-4
Barrens Restoration and Proposed Project Area
Construction of Evapotranspiration Tower
Final Environmental Assessment

File Path: Q:\CH2MHILL\Projects\TimberHarvest_EA\MXDs\Fig1-1_GeneralVicinity.mxd, Date: 03 23, 2004, User: RPATEL@AAFB\E032004022ATL

limited or that decisions made on less accurate and less representative data could have negative long-term impacts.

4.1.3.3 No-Action Alternative

No change in existing conditions would occur under the No-Action Alternative. Therefore, no impacts to wetlands would result from implementation of this alternative.

No additional data on hydrologic cycles and ET would be collected. Therefore, no benefits of improved habitat management would occur.

4.2 Cultural Resources

Potential impacts to cultural resources are identified if construction footprints associated with the Proposed Action or Alternative Actions extend into the boundaries of identified cultural resource areas, resulting in the disturbance of such resources through construction activities such as earth removal.

4.2.1.1 Proposed Action

The project area was previously screened for cultural resources. The Diameter-Limit-Cut management unit where the ET tower would be located was investigated for cultural resources concerns through consultation with the SHPO in 2003, and this effort was documented in Archeological Assessment Report No. 300 (R. Alvey, personal communication, 2004). Based on the results of the 2003 survey and SHPO consultation, there are no significant or potentially significant cultural resources in the area where the ET tower and guy wire anchors would be constructed.

Therefore, no impacts to cultural resources are expected to result from implementation of the Proposed Action.

4.2.1.2 Alternative Action

The Alternative Action would be located on the northern edge of the AEDC industrial complex, away from any potentially significant historic structures. No significant or potentially significant cultural resources would be impacted by implementation of the Alternative Action. Therefore, no impacts to cultural resources would result from implementation of the Alternative Action.

4.2.1.3 No-Action Alternative

Under the No-Action Alternative, no change in existing conditions would occur. Therefore, no impacts to cultural resources would result from implementation of the No-Action Alternative.

5.0 Applicable Regulatory Requirements, Permits, and Coordination

Possible permits that could be required to implement the project include a National Pollutant Discharge Elimination System (NPDES) Stormwater permit and a CWA Section 404 permit.

Neither the Proposed Action nor the Alternative Action would require a National Pollutant Discharge Elimination System (NPDES) Stormwater permit from TDEC. These permits are required for construction sites involving clearing, grading, or excavation that result in an area of disturbance of one or more acres, and activities that result in the disturbance of less than one acre if it is part of a larger common plan of development. The proposed construction would result in the excavation of 25 square feet at the site and is not part of a common plan of development. Clearing would take place over a slightly larger area to accommodate assembling the 140-foot high tower. If a path 10 feet wide were cleared, this would represent 1,400 square feet, which is substantially less than 1 acre (43,560 square feet).

The two tower locations discussed above are not located within waters of the United States. No improvements would be required to the forest road that provides access to the site of the Proposed Action or to the road to the fire tower. Therefore, to complete either the Proposed Action or the Alternative Action, a CWA Section 404 permit from USACE would not be required, nor would a water quality certification under CWA Section 401 or a Tennessee Aquatic Resources Alteration Permit from TDEC.

6.0 List of Preparers

6.1 CH2M HILL

Russell Short/Senior Project Manager/28 years of experience/Master of Arts

Rich Reaves/Environmental Scientist/9 years of experience/Ph.D.

Dawn Abercrombie/GIS Analyst/6 years of experience/Master of Science

Rakesh Patel/GIS Analyst/3 years of experience/Bachelor of Business Administration

David Dunagan/Technical Editor/26years of experience/Master of Arts

7.0 List of Contacts and Correspondence

Richard McWhite, Civ AEDC/SED

Rick Alvey, Aerospace Testing Alliance Natural Resources

Steve Farrington, Aerospace Testing Alliance Natural Resources

Kevin Fitch, Aerospace Testing Alliance Natural Resources

Mark Moran, Aerospace Testing Alliance Natural Resources

Ed Roworth, Aerospace Testing Alliance Natural Resources

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Appendix A

Air Force Form 813
Request for Environmental Impact Analysis

ok pc

REQUEST FOR ENVIRONMENTAL IMPACT ANALYSIS

Report Control Symbol
RCS: AAFB-04-006

INSTRUCTIONS: *Section I to be completed by Proponent; Sections II and III to be completed by Environmental Planning Function. Continue on separate sheets as necessary. Reference appropriate item number(s).*

SECTION I - PROPONENT INFORMATION

1. TO *(Environmental Planning Function)*	2. FROM *(Proponent organization and functional address symbol)*	2a. TELEPHONE NO.
Phillip Sherril	Mark Moran	4066

3. TITLE OF PROPOSED ACTION
Construction of Evapotranspiration Tower

4. PURPOSE AND NEED FOR ACTION *(Identify decision to be made and need date)*
Approval for proposed site location and construction of a 140-foot tower.

5. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES *(DOPAA) (Provide sufficient details for evaluation of the total action.)*
See attachment.

6. PROPONENT APPROVAL *(Name and Grade)*	6a. SIGNATURE	6b. DATE
Mark R. Moran	Mark R Moran	10 Nov 03

SECTION II - PRELIMINARY ENVIRONMENTAL SURVEY. *(Check appropriate box and describe potential environmental effects including cumulative effects.) (+ = positive effect; 0 = no effect; - = adverse effect; U = unknown effect)*

	+	0	-	U
7. AIR INSTALLATION COMPATIBLE USE ZONE/LAND USE *(Noise, accident potential, encroachment, etc.)*		X		
8. AIR QUALITY *(Emissions, attainment status, state implementation plan, etc.)*		X		
9. WATER RESOURCES *(Quality, quantity, source, etc.)*		X		
10. SAFETY AND OCCUPATIONAL HEALTH *(Asbestos/radiation/chemical exposure, explosives safety quantity-distance, bird/wildlife aircraft hazard, etc.)*		X		
11. HAZARDOUS MATERIALS/WASTE *(Use/storage/generation, solid waste, etc.)*		X		
12. BIOLOGICAL RESOURCES *(Wetlands/floodplains, threatened or endangered species, etc.)*			PS X	X
13. CULTURAL RESOURCES *(Native American burial sites, archaeological, historical, etc.)*		X		
14. GEOLOGY AND SOILS *(Topography, minerals, geothermal, Installation Restoration Program, seismicity, etc.)*		X		
15. SOCIOECONOMIC *(Employment/population projections, school and local fiscal impacts, etc.)*		X		
16. OTHER *(Potential impacts not addressed above.)*		X		

SECTION III - ENVIRONMENTAL ANALYSIS DETERMINATION

17.
- [ ] PROPOSED ACTION QUALIFIES FOR CATEGORICAL EXCLUSION (CATEX) # _____ ; OR
- [X] PROPOSED ACTION DOES NOT QUALIFY FOR A CATEX; FURTHER ENVIRONMENTAL ANALYSIS IS REQUIRED.

18. REMARKS
Further Environmental Analysis is required.

19. ENVIRONMENTAL PLANNING FUNCTION CERTIFICATION *(Name and Grade)*	19a. SIGNATURE	19b. DATE
Frank A. Duncan, GS-13 Deputy, Env. Mgt. Division		1 Dec 03

AF-813 Attachment

Purpose of and Need for Action:

Request for approval of site location and construction of 140-foot tower.

Description of Proposed Action and Alternatives:

Proposed Action: Construction of 140-foot tower for installation of instrumentation measuring evapotranspiration (ET) in the Diameter-Limit-Cut Barrens restoration area north of the Model Shop.

AEDC and USGS Water Resources Division are collaborating on a four-year project to support the base's ecosystem management efforts by increasing knowledge of the relationship among vegetation, climate, and soils and their combined influence on water balance at the hillslope scale. The project requires quantification of ET demand from the land/vegetation system in order to calibrate spatially explicit water-budget models relating hydrologic inputs and outputs to wetland and stream functions. The eddy covariance method uses comparison of wind velocity and air-water concentration, measured at small time steps and high precision to infer water-vapor flux between a surface and the atmosphere. It is the standard method in national and global water and carbon-flux networks. Additional equipment can be added to an eddy covariance ET system to calculate energy-balance estimates of ET that provide a check on the eddy covariance results. After discussing the available options with several specialists in measuring ET (notably Dave Stannard, 303-236-4983, of the USGS National Research Program in Denver), we selected eddy covariance with energy balance as the method for this project.

The 140-foot tower is required for the installation of instruments for measuring evapotranspiration from open canopy, oak-dominated Barrens using the eddy covariance method. The eddy covariance method tracks very small shifts in air current and combines that data with information on temperature, atmospheric CO_2, and humidity to estimate net water and CO_2 flux from the land/vegetation system to the atmosphere. In order to avoid distortions in the air-current measurements from local turbulence, the precision anemometer must be positioned well above the top of the vegetation. The standard rule of thumb is that the height of the instrumentation should be at least 1.5 times the canopy height. The approximate average height of the vegetation in the vicinity of the proposed tower site is approximately 90 feet, hence the need for a 140-foot tower. Tower specifications are provided below.

The proposed tower location (see attached map) was selected for the presence of an open canopy, oak-dominated Barrens restoration site with well-developed herbaceous ground cover. Measuring ET demand from this type of vegetation is desired because of existing plans for restoring Barrens habitats on AAFB and the need to understand how restoration efforts are likely to alter the movement of water through the landscape. A previous USGS study on AAFB determined that climate change, in the form of increased annual precipitation since approximately 1970, has increased flooding durations in Sinking Pond National Natural Landmark. The study also revealed that a spatial shift in regeneration

patterns of wetland tree species, notably overcup and willow oaks, has occurred in response to climate change. Restoration of densely forested drainage basins surrounding wetlands to open canopy Barrens vegetation also is predicted to increase the quantity of water delivered to wetlands, presumably by altering ET. Understanding how vegetation structure affects ET and, ultimately, recharge and soil moisture balance at the hillslope scale would enable AEDC to 1) predict potential hydrologic changes that might occur in response to proposed Barrens restoration activities and predicted regional climate change and 2) understand how hydrologic functions of wetlands and streams might in turn be affected. The ability to predict likely hydrologic changes in wetlands will position land managers at AEDC to judge the consequences in terms of threats or benefits to the base's regionally significant karst wetlands conservation target and associated rare ecological communities and listed species.

SPECIFICATIONS

TOWER

Material: Three main uprights of heavy-gage aluminum tubing (1 3/16-inch outside diameter, 1/8-inch wall thickness).
Cross section: Equilateral triangular cross section with straight 22-inch sides.
Bracing: Z-struts of continuous 3/8-inch solid aluminum welded to uprights; horizontal brace every 20 inches.
Section length: 10 feet.
Number of sections: 14
Height above ground: 140 feet
Connection: Tenon and socket, double pinned at right angles; Tenon sections 3 inches long with 1 1/4-inch outside diameter and 3/8-inch wall thickness.

FOUNDATION

Pad: 4-feet X 4-feet X 4-feet steel-reinforced concrete pad.
Anchors: Three 2-inch diameter X 48-inch long steel tubes with welded hinge plates of. ½-inch steel bar and 2-inch steel sleeves to receive bottom tower section.

GUY CABLES

Wire: 4,000-pound test stainless cable.
Arrangement: Three guy wires attached to tower at heights of 35, 70, 105, and 140 feet above base and run to anchors located 90 feet from center of tower, equally spaced at 120-degree angular increments.
Anchors: Three 12,000-pound capacity steel anchors set in reinforced concrete pads with minimum dimensions of 4-feet depth X 1.5-feet diameter.

SECURITY

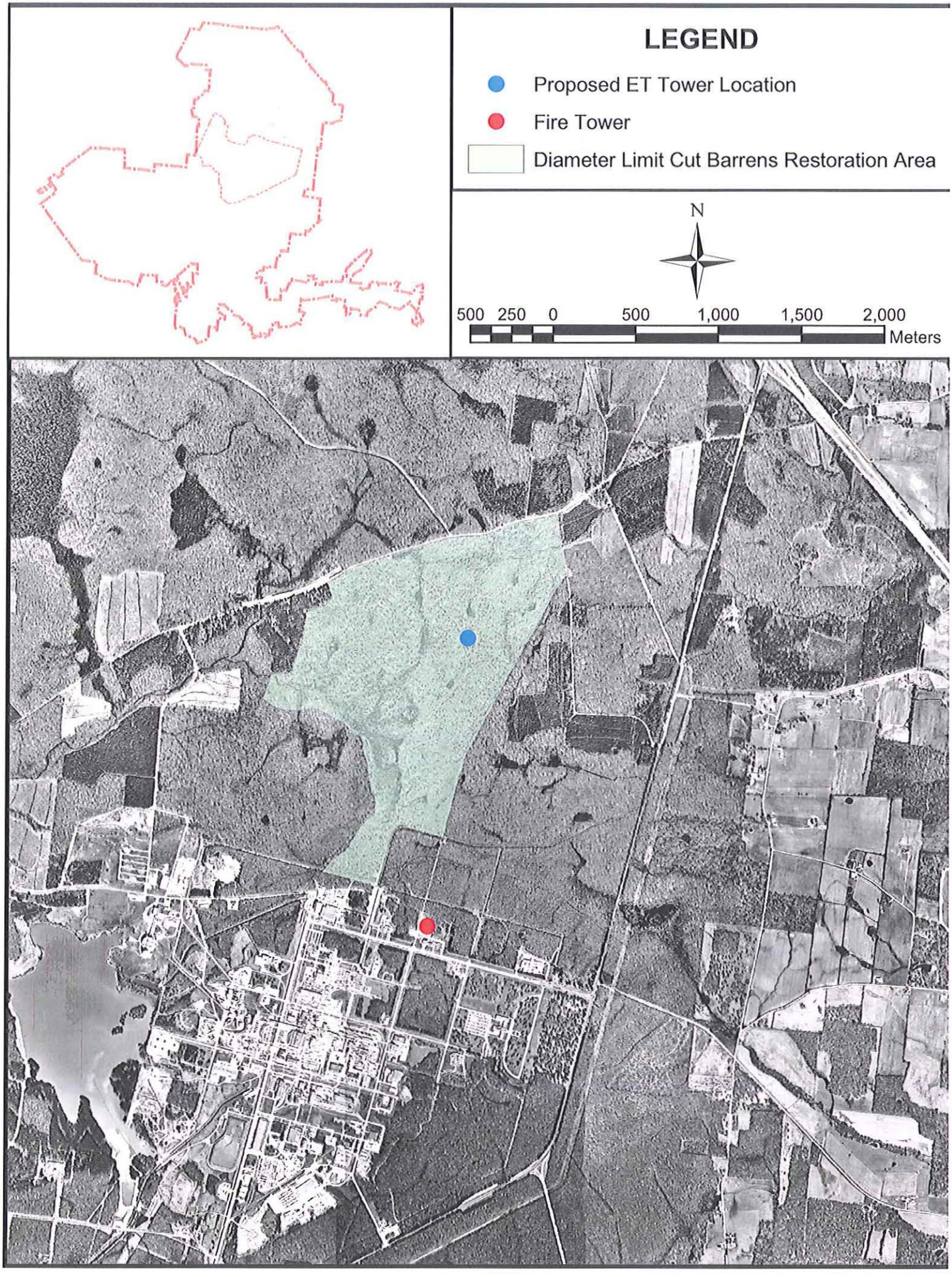
Tower: Locking anti-climb device.
Tower base: 6-feet tall X 12 feet X 12 feet chain-link fence topped with barbed wire and equipped with locked gate.
Guy anchors: 6-feet tall X 8 feet X 15 feet chain link fence with locked gate.

Alternative One: Install instrumentation for measuring ET on an existing fire tower behind AEDC Fire Hall and south of the Diameter-Limit-Cut Barrens Restoration Area.

The instrumentation for measuring ET would be installed on the existing fire tower that is located south of the Diameter-Limit-Cut Barrens Restoration Area (see attached map). While this alternative would eliminate the need for constructing a new, stand-alone structure on AAFB, the fire tower is unsuitable for the desired purpose. The fire tower is approximately 80-feet tall and does not exceed the height of the tallest trees in the vicinity. As stated above, the standard rule of thumb for measuring ET is that the height of the instrumentation should be at least 1.5 times the canopy height. In order for this alternative to be effective, an extension adding approximately 60 feet to the fire tower height would be necessary to satisfy the height requirement. Use of the fire tower would have the additional undesirable effect of limiting wind directions that would be useful for estimating ET demand from Barrens vegetation to approximately 40-degrees of the compass rose in a generally northerly direction from the tower.

Alternative Two: Estimation of ET using alternatives to the Eddy Covariance method.

Many common approaches for estimating ET are unsuitable for accurate measurement of ET from forests. **Pan evaporation** provides only evaporative demand under unrepresentative conditions and does not account for transpirational demand from vegetation. **Models**, such as Penman-Monteith, Priestly-Taylor, and Thornthwaite require specification of "crop coefficients" whose relevance to actual vegetation is generally unknown. **Sap-flow** methods treat woody-plant transpiration only, ignoring interception, direct evaporation, and herbaceous vegetation; extrapolation from sampled trees to forest stands is problematic. **Chamber** and **lysimeter** methods are applicable to very small areas (typically <2 m^2) and are only practical with short herbaceous or shrub vegetation


LEGEND
Proposed ET Tower Location
Fire Tower
Diameter Limit Cut Barrens Restoration Area
N
500 250 0 500 1,000 1,500 2,000
Meters

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
640 Grassmere Park, Suite 100
Nashville, TN 37211

Mr. Mark Moran
ACS Conservation
1100 Kindell Drive
Arnold Air Force Base, TN 37389-1800

August 1, 2003

Dear Mr. Moran,

Under MIPR 03780036, the U.S. Geological Survey is conducting a hydrologic investigation in support of AEDC's natural resources management and conservation program. The goal of the investigation is to increase understanding of the interactions between rainfall, soil moisture, recharge, runoff generation, and vegetation in The Barrens and improve prediction of the effects of different management and restoration strategies. A central component of the investigation, specified in Scope of Work E.3019, is instrumenting and servicing a station to monitor evapotranspiration (ET) at a site on Arnold Air Force Base.

After considering several alternatives with Geoff Call of the ACS Conservation staff, we identified a suitable site in the Barrens restoration area south and across the road from the Dixie greentree reservoir. The proposed site for the ET station is marked by a yellow star on the enclosed map. The site is an open-canopy oak savanna, which has been subjected to diameter-limited clearing for the purpose of restoring the historic vegetative structure of The Barrens. Canopy height was measured in the field and found to be 80-90 feet above land surface.

The instrumentation at the site will include an eddy-covariance ET station designed to measure evaporative flux through the correlation of humidity gradients with precisely measured wind velocity over very small time steps. One of the technical requirements for developing a meaningful correlation is that locally-induced perturbations of wind velocity, such as turbulence around treetops, be minimized. The rule of thumb for meeting this requirement is that the instruments should be sites at a height 1.5 times that of the canopy. The required height for the ET station at this site is thus about 140 feet above land surface.

I am writing to request (1) Air Force permission to construct a 140-foot tall tower in the Barrens restoration area and (2) logistical support in the form of a backhoe and operator to assist with the construction. Construction will be performed by a bonded, licensed contractor under USGS supervision. The tower will be set in a poured concrete pad with dimensions of 4 feet by 4 feet by 4 feet and anchored by steel guy cables set in three smaller pads. We will construct a security fence around the tower foundation and each of the guy anchors. The USGS will take responsibility for training, safety, and liability issues associated with the tower and the personnel who service it.

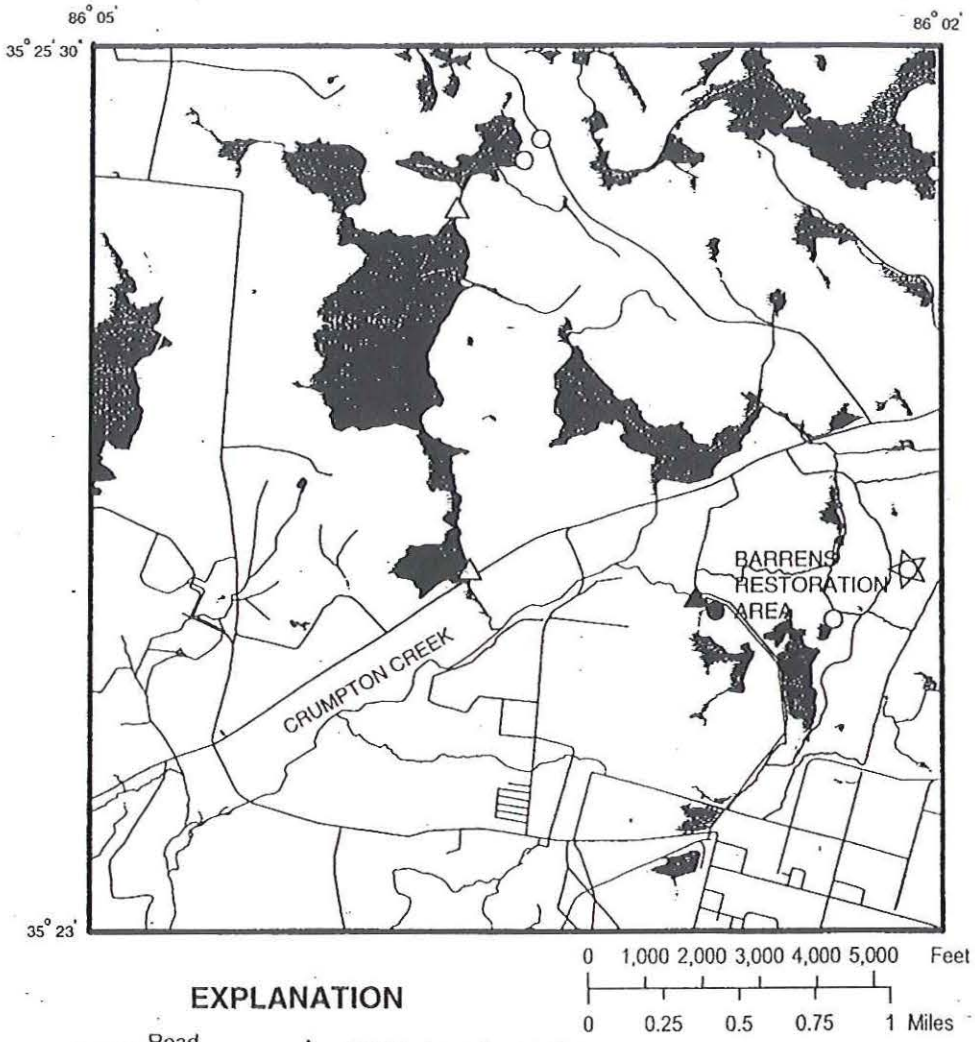
We anticipate construction in late August or early September 2003. If permission and technical support are granted, we will coordinate the actual construction dates with ACS Conservation staff. Please let me know if I can provide any additional information regarding either the scientific need for the tower or the technical requirements for its construction.

Yours Sincerely,

William J. Wolfe

William J. Wolfe, Ph.D.
Hydrologist

Enclosure


86° 05'
86° 02'
35° 25' 30"
35° 23'
CRUMPTON CREEK
BARRENS RESTORATION AREA
0 1,000 2,000 3,000 4,000 5,000 Feet
0 0.25 0.5 0.75 1 Miles
EXPLANATION
Road
Stream
Jurisdictional wetland
Evapotranspiration station
USGS streamflow station
USGS soil-moisture station
AEDC streamflow station
AEDC soil-moisture station

Appendix B

Design Specifications for Evapotranspiration Tower, Supports, and Security

Tower Specifications

Material: Three main uprights of heavy-gage aluminum tubing (1 3/16-inch outside diameter, 1/8-inch wall thickness.

Cross Section: Equilateral triangular cross section with straight 22-inch sides.

Bracing: Z-struts of continuous 3/8-inch solid aluminum welded to uprights; horizontal brace every 20 vertical inches.

Section Length: 10 feet.

Number of Sections: 14.

Height above Ground: 140 feet.

Connection: Tenon and socket, double pinned at right angles; Tenon sections 3 inches long with 1 1/4-inch outside diameter and 3/8-inch wall thickness.

Foundation Specifications

Pad: 4-feet X 4-feet X 4-feet steel reinforced concrete pad.

Anchors: Three 2-inch diameter X 48-inch long steel tubes with welded hinge plates of 1/2-inch steel bar and 2-inch steel sleeves to receive bottom tower section.

Guy Cable Specifications

Wire: 4,000-pound test stainless steel cable.

Arrangement: Three guy wires attached to tower at heights of 35, 70, 105, and 140 feet above base and run to anchors 90 feet from the center of the tower, equally spaced at 120-degree angular increments.

Anchors: Three 12,000-pound capacity steel anchors set in reinforced concrete pads with minimum dimensions of 4 feet depth and 1.5 feet diameter.

Security Specifications

Tower: Locking anti-climb device.

Tower Base: Chain link fence (6 feet tall X 12 feet X 12 feet) topped with barbed wire and equipped with a locked gate.

Guy Anchors: Chain link fence (6 feet tall X 8 feet X 15 feet) with locked gate.

Appendix C

Plant Associations Occurring on Arnold Air Force Base

FOREST

Planted/Cultivated

Pinus taeda Planted Forest

Natural

Upland Forest

Quercus falcata - Quercus coccinea - Quercus (stellata, velutina) / Vaccinium pallidum Forest

Quercus falcata - Quercus alba - (Quercus coccinea) / Oxydendrum arboreum / Vaccinium pallidum Forest

Quercus alba - Quercus (falcata, stellata) / Chasmanthium laxum Forest

Juniperus virginiana var. virginiana - Quercus spp. Forest

Juniperus virginiana var. virginiana / Rhus copallinum / Schizachyrium scoparium Forest

Wetland Forest

Quercus lyrata / Betula nigra / Pleopeltis polypodioides Forest

Quercus phellos - Quercus alba / Vaccinium fuscatum - (Viburnum nudum) / Carex (barrattii, intumescens) Forest

Liquidambar styraciflua Forest

Quercus phellos - Quercus nigra - (Nyssa biflora) Forest

Nyssa aquatica / Cephalanthus occidentalis Forest

Floodplain - Floodplain Terrace / Bottomland Forest

Quercus alba - Carya (alba, ovata) - Liriodendron tulipifera -(Quercus phellos) / Cornus florida Forest

Quercus nigra - Quercus (alba, phellos) Forest

Liquidambar styraciflua - Quercus michauxii - Carya laciniosa / Fagus grandifolia -(Aesculus flava) Forest

Quercus velutina - Carya (alba, glabra) / Vaccinium arboreum Forest

Platanus occidentalis - (Liquidambar styraciflua, Acer rubrum) / (Carpinus caroliniana) / Onoclea sensibilis Forest

Salix nigra - Acer (rubrum, saccharinum) / Alnus serrulata - Cephalanthus occidentalis Forest

WOODLAND

Quercus (falcata, stellata) / Quercus marilandica / Gaylussacia (baccata, dumosa) Woodland

Quercus stellata - (Quercus coccinea) / Quercus marilandica / Vaccinium pallidum - (Vaccinium stamineum) Woodland

SHRUBLAND

Upland shrubland

Rubus (argutus, trivialis) - Smilax (glauca, rotundifolia) Shrubland

Wetland shrubland

Cephalanthus occidentalis - Hibiscus moscheutos ssp. moscheutos Shrubland

HERBACEOUS VEGETATION

Upland Grassland

Andropogon gerardii - (Andropogon glomeratus, Panicum virgatum, Sorghastrum nutans) Herbaceous Vegetation

Andropogon gerardii - Schizachyrium scoparium - (Calamagrostis coarctata, Panicum virgatum) Herbaceous Vegetation

Schizachyrium scoparium - Andropogon (gyrans, ternarius, virginicus) Herbaceous Vegetation

Schizachyrium scoparium - Calamagrostis coarctata Herbaceous Vegetation

Andropogon virginicus var. virginicus Herbaceous Vegetation

Wetland Grassland

Juncus effusus Herbaceous Vegetation

Eleocharis microcarpa - Juncus repens - Rhynchospora corniculata - (Mecardonia acuminata - Proserpinaca spp) Herbaceous Vegetation

Panicum hemitomon - Dulichium arundinaceum Herbaceous Vegetation

Saccharum baldwinii - Calamagrostis coarctata - Panicum rigidulum - Rhynchospora capitellata Herbaceous Vegetation

Scirpus cyperinus - Panicum rigidulum var. elongatum - Rhynchospora corniculata Herbaceous Vegetation

Typha latifolia Herbaceous Vegetation

Wetland Perennial Forb

Pontederia cordata - Sagittaria graminea - Sagittaria latifolia Herbaceous Vegetation

Source: Call, 2003

Appendix D

Sensitive Species Known to Occur on Arnold Air Force Base

Plants		Designated Status		Rank	
Scientific Name	Common Name	Federal	Tennessee	Global	Tennessee
Agalinis pseudophylla	Shinner's false-foxglove	C2*	E	G2?Q	S1
Asclepias hirtella	Prairie milkweed		S	G5	S1
Carex barrattii	Barrat's sedge		E	G4	S1
Carex buxbaumii	Brown bog sedge		S	G5	S1
Clethra alnifolia	Coastal sweet pepper-bush		E	G5	S1
Cypripedium acaule	Pink lady's-slipper		E*	G5	S4
Cypripedium kentuckiense	Kentucky lady's-slipper	C2*	E	G3	S1
Dicanthelium aciculare	Needleleaf witchgrass		E	G4G5	S1
Dicanthelium ensifolium	Small-leaved panic grass		S	G?	S1S2
Dicanthelium leucothrix	Roughish witchgrass		S	G4?Q	S1
Drosera brevifolia	Dwarf sundew		T	G5	S2
Echinacea pallida	Pale-purple coneflower		T	G4G5	S1
Eleocharis intermedia	Matted spike-rush		S	G5	S1
Eupatorium leucolepis	White-bract thoroughwort		E	G5	S1
Festuca paradoxa	Cluster fescue		S	G5	S1
Gaylussacia dumosa	Dwarf huckleberry		T	G5	S2S3
Gentiana puberulenta	Prairie gentian		E	G4G5	S1
Gymnopogon brevifolius	Broad-leaved beardgrass		S	G5	S1
Helianthemum propinquum	Low frostweed		S	G4	S1
Helianthus eggertii	Eggert's sunflower	T	T	G2G3	S2
Hypericum adpressum	Creeping St. John's-wort	C2*	T	G2G3	S1
Iris prismatica	Slender blue flag		T	G4G5	S2
Isoetes melanopoda	Blackfoot quillwort		E	G5	S1
Juglans cinerea	White walnut, butternut		T	G3G4	S2S3
Lachnanthes caroliniana	Carolina redroot		E	G4	S1
Lechea pulchella	Legget's pinweed		E	G5	S1
Lespedeza angustifolia	Narrowleaf bushclover		T	G5	S2
Lilium michiganense	Michigan lily		T	G5	S2
Liparis loeselii	Fen orchis		E	G5	S1
Listera australis	Southern twayblade		E	G4	S1S2
Lobelia canbyi	Canby's lobelia		T	G4	S2S3
Ludwigia sphaerocarpa	Globe fruited false loosestrife		T	G5	S1
Lycopodiella alopecuroides	Foxtail clubmoss		T	G5	S1
Marshallia trinervia	Broad-leaved Barbara's		T	G3	S2
Muhlenbergia glabrifloris	buttons		S	G4?	S1
Muhlenbergia torreyana	Hair grass		E	G3	S1
Myriophyllum pinnatum	Torrey's dropseed		T	G5	S1
Panicum acuminatum var. densiflorum	Cutleaf water-milfoil Eaton's witchgrass		E	G4G5	S1
Panicum hemitomon			S	G5?	S1S2
Platanthera integra	Maidencane		E	G5?	S1
Pogonia ophiglossoides	Yellow fringeless orchid		T	G5	S2
Polygala mariana	Rose pogonia		S	G5	S1
Polygala nuttallii	Maryland milkwort		E	G5	S1
Prenanthes aspera	Nuttall's milkwort		PE	G4?	S1
Prunus pumila	Harsh rattlesnake-root		T	G5	S1
Ranunculus flabellaris	Sand cherry		T	G5	S2
Rhyncospora perplexa	Yellow water crowfoot		T	G5	S2
Sagittaria graminea	Obscure beak-rush Grass-leaved arrow head		T	G5	S1

C2 indicates a species formerly classified as a federal candidate species.
T = Threatened, E = Endangered, S = Special Concern
Rank is an indication of global and state rarity ranging from 1 (most rare) to 5 (most common)
? = inexact numeric rank
Q = taxonomic status is questionable, numeric rank may change with taxonomy
T =taxonomic subdivision (trinomial)

Animals		Designated Status		Rank	
Scientific Name	Common Name	Federal	Tennessee	Global	Tennessee
Accipiter striatus	Sharp-shinned Hawk		D	G5	S2
Aimophila aestivalis	Bachman's Sparrow	C2	E	G3	S2
Ambystoma talpoideum	Mole Salamander		D	G5	S4
Ammodramus henslowii	Henslow's Sparrow	C2		G4	SPB
Ammodramus savannarum	Grasshopper Sparrow		D	G5	S4
Circus cyaneus	Northern Harrier		D	G5T?	S1N
Haliaeetus leucocephalus	Bald Eagle	T	T	G4	S1
Hemidactylium scutatum	Four-toed salamander		D	G5	S3
Hemitremia flammea	Flame Chub		D	G4	S4
Hyla gratiosa	Barking Tree Frog		D	G5	S3
Myotis grisescens	Gray Bat	E	E	G2G3	S2
Napaeozapus insignis	Woodland Jumping Mouse		D	G5	S4
Ophisaurus attenuatus	Eastern Slender Glass Lizard		D	G5T5	S3
Pituophis melanoleucus melanoleucus	Northern Pine Snake	C2	T	G5T4	S3
Pleurobema gibberum	Cumberland Pigtoe	E	E	G1	S1
Rana capito	Gopher Frog	C1NL		G4T3	S1
Sorex cinereus	Masked Shrew		D	G5	S4
Sorex fumeus	Smoky Shrew		D	G5	S4
Sorex longirostris	Southeastern Shrew		D	G5	S4
Zapus hudsonius	Meadow Jumping Mouse		D	G5	S4

C2 and C1NL indicate species formerly classified as a federal candidate species.
T = Threatened, E = Endangered, D =Deemed in Need of Management
Rank is an indication of global and state rarity ranging from 1 (most rare) to 5 (most common)

Source: Call, 2003

Appendix E

Conservation Target Species Occurring in Wetlands on Arnold Air Force Base

Conservation Target Species Occurring in Wetland Flats

Carex barrattii (Barrat's sedge)
Iris prismatica (Slender blue flag)
Listera australis (Southern twayblade)
Lycopodiella alopecuroides (Foxtail clubmoss)
Muhlenbergia torreyana (Torrey's dropseed)
Platanthera flava var. flava (Southern rein-orchid)
Trillium pusillum var. pusillum (Least trillium)
Vaccinium macrocarpon (Cranberry)
Zigadenus leimanthoides (Death camas)

Conservation Target Species Occurring in Wetland Depressions

Ambystoma talpoideum (Mole salamander)
Hemidactylium scutatum (Four-toed salamander)
Rana capito (Gopher frog)
Clethra alnifolia (Coastal sweet pepperbush)
Hypericum adpressum (Creeping St. John's-wort)
Lachnanthes caroliniana (Carolina redroot)
Ludwigia sphaerocarpa (Globe-fruited false loosestrife)
Panicum aciculare (Needleleaf witchgrass)
P. acuminatum var. densiflorum (Eaton's witchgrass)
P. acuminatum var. leucothrix (Roughish witchgrass)
P. ensifolium (Small-leaved panicgrass)
P. hemitomon (Maidencane)
Rhynchospora perplexa (Obscure beakrush)
Sagittaria graminea (Grass-leaved arrowhead)
Vaccinium elliottii (Mayberry)
Woodwardia virginica (Virginia chainfern)
Xyris fimbriata (Fringed yellow-eyed-grass)
X. iridifolia (Wide-leaved yellow-eyed-grass)

Source: Call, 2003