DEVELOPMENT OF A GIS-BASED PROCEDURE TO IDENTIFY WETLAND MITIGATION OPPORTUNITIES IN MILL CREEK, YELLOW CREEK, AND MEANDER CREEK WATERSHEDS

by

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Submitted in Partial Fulfillment of the Requirements

for the Degree of

Master of Science in Engineering

in the

Civil and Environmental Engineering

Program

YOUNGSTOWN STATE UNIVERSITY

OCTOBER 2002

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ABSTRACT

A user-friendly, turnkey method was developed using GIS (geographic information system)-based screening and ranking procedures to aid in the identification of sites with high potential for wetland mitigation in the Mill Creek, Yellow Creek, and Meander Creek watersheds. The procedures use well established, publicly available data sets, including soil type, land cover, waterways, and topography overlaid in digital format so that the watershed study area can be analyzed spatially. A GIS database for wetlands and related factors in the Mill Creek, Yellow Creek, and Meander Creek watersheds was created. Application of the ranking screening technique yielded several large "Target Areas" in the Mill Creek and Meander Creek watersheds with high potential for wetland mitigation. It is recommended that the AWARE (Alliance for Watershed Action and Riparian Easements) Wetland Mitigation Committee use the ranking procedure developed in this study to identify and evaluate numerous sites within the three watersheds worthy of further investigation for potential wetland mitigation. This information can serve as a starting point for approaching landowners to discuss the acquisition of land parcels for wetland mitigation. The screening and ranking procedures may contribute to the development of an effective Wetland Mitigation Plan as established under the objectives of the AWARE Watershed Action Plan.

ACKNOWLEDGMENTS

I would like to give my sincere appreciation and gratitude to my advisor, Dr. Scott C. Martin, for his help and guidance throughout my academic career.

To the Youngstown State University Center for Urban Studies, especially Mr. John Bralich, for his numerous efforts and for teaching me the art and power of using GIS map overlays.

To the Mahoning County Soil and Water Conservation District for providing funding for this project.

And to my Family, for their support in allowing me to complete this project properly.

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CHAPTER ONE

INTRODUCTION

1.1 Background Information and Problems Associated with Mill Creek, Yellow Creek, and Meander Creek Watersheds

Mill Creek, Yellow Creek, and Meander Creek are tributaries of the Mahoning River near the City of Youngstown in northeastern Ohio. Meander Creek and Yellow Creek serve as drinking water sources for a combined population of over 300,000 residents of Mahoning and southern Trumbull Counties. (Martin, 2001) Mill Creek is the focal point of Mill Creek Metroparks, one of the nation's largest urban parks and the most popular recreational area in Mahoning County. (Martin, 2001) The three watersheds cover nearly 60% of Mahoning County, and extend into adjacent Columbiana and Trumbull Counties. The population within Mahoning County continues to shift from the City of Youngstown to the southern and western suburbs and rural areas. The resulting impacts from the rapid residential and commercial development within these watersheds have contributed to water quality problems within each watershed.

Three man-made lakes (Newport, Cohasset, and Glacier) along Mill Creek in Mill Creek Park are highly eutrophic as a result of high nutrient loading from both point and nonpoint sources in the watershed. (Martin, 2001) In Meander Creek Reservoir, the area's primary source of drinking water, severe taste and odor problems have occurred due to the growth of algae blooms believed to be the result of an increase in nutrient loading from nonpoint sources (e.g., residential development). Heavy sediment loading from farms and construction sites has caused the deposition of over 400,000 cubic yards of sediment in Lake Newport. (Martin, 2001) Reservoirs along Yellow Creek have also experienced high productivity due to nonpoint source nutrient loading. In addition, heavy runoff from a number of shopping plazas has caused increased streambank erosion and deposition of trash in flood plain areas. Mill Creek Metroparks administrators have observed the severe stress on wildlife populations resulting from the loss of habitat as a consequence of the new development. One such observation is a deer population nearly six times the estimated sustainable limit despite continuing efforts to control the population.

Another trend associated with development, which contributes to water quality impairment, is the destruction of riparian areas and wetlands in the watersheds. A local watershed group, AWARE (Alliance for Watershed Action and Riparian Easements), has focused much of their attention on the protection of riparian areas in the Mill Creek and Yellow Creek watersheds. Despite this effort, the loss of riparian areas and wetlands continues with development. Environmental consciousness of these types of losses prompted the federal government to adopt a "no net loss" policy for wetlands. Generally, developers must replace lost wetlands with constructed (man-made) wetlands, a process called mitigation. (Martin, 2001) When developers disturb these areas in Ohio, a Clean Water Act (CWA) Section 404 permit is required from the U.S. Army Corps of Engineers (USACE) that specifies how the lost function and values of the affected areas will be replaced. While preference is given to mitigation on-site or within the same watershed, there has been little previous adherence to this standard within the local watersheds.

AWARE established general objectives to address these problems mentioned above in their Watershed Action Plan. Under the objectives of the Action Plan, a Wetland Mitigation Plan is being developed for all three watersheds. Establishing the

Wetland Mitigation Plan requires an investigation of the existing and possible future wetland resources in all three watersheds. The goals of this project were to:

1) Develop a geographic information system (GIS) database for wetlands and related factors in the Mill Creek, Yellow Creek, and Meander Creek watersheds;
2) Develop a convenient GIS-based procedure to identify and rank suitable locations for wetland mitigation; and
3) Apply the procedure to identify and rank several prospective mitigation sites in the three watersheds and evaluate its performance.

Youngstown State University (YSU) received input from the AWARE Wetland Mitigation Committee on this project. Funding was provided by a grant from the Ohio Department of Natural Resources (ODNR) through the Mahoning Soil and Water Conservation District (MSWCD).

CHAPTER TWO

LITERATURE REVIEW

2.1 Characteristics of Wetlands

2.1.1 Types of Wetlands

Jurisdictional wetlands are defined as those areas that are inundated by surface or ground water for a frequency and duration sufficient to normally support vegetation adapted to hydric soils or reducing soil conditions. (Environmental Laboratory, 1987) Jurisdictional wetlands are defined by field procedures using the *U.S. Army Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987) and subject to USACE oversight. A general or potential jurisdictional wetland is defined as an area having one or more of the three indicators (vegetation, soil type, hydrology) of jurisdictional wetlands. (Lyon, 2001) General wetlands are distinct from jurisdictional wetlands because they can be inventoried using a variety of techniques in addition to field visits. This distinction allows for assessment and inventory of wetlands over large areas using aerials photographs, GIS, satellite remote sensing data, and field evaluation. (Lyon, 2001) A general wetland may or may not be a jurisdictional wetland, but a general wetland has value based on its potential to be enhanced, restored, or protected from future development.

A number of common terms have been used over the years to describe different types of wetlands. (Mitsch and Gosselink, 1986) Mitsch and Gosselink described these popular wetland terms as follows:

- Swamp – Wetland dominated by trees or shrubs (reed and grass-dominated wetlands are also called swamps).

- Marsh – A frequently or continually inundated wetland characterized by emergent herbaceous vegetation adapted to saturated soil conditions.
- Wet Meadow – Grassland with waterlogged soil near the surface but without standing water for most of the year.
- Slough – A swamp or shallow lake system in the northern and Midwestern United States.

2.1.2 Functions and Values of Wetlands

Wetlands are among the most biologically productive natural ecosystems in the world. (Dennsion, 1997) Wetlands provide a number of beneficial functions including:

- Water supply and quality maintenance
- Conveyance and storage of floodwaters
- Prevention of erosion
- Sediment control
- Wildlife habitat formation
- Recreation

Wetlands recharge underground aquifers, serve as a source of surface water supply, and improve water quality by intercepting surface water runoff and removing or retaining nutrients, processing organic wastes, filtering out pollutants, and reducing sediment before it reaches open waters. Trees and other wetland vegetation control erosion by trapping soil washed from nearby uplands. Wetlands often function like natural tubs or sponges, storing floodwater and surface water in natural depressions before slowly releasing it. This function reduces the likelihood of flood damage to crops near agricultural areas and helps control increases in rate and volume of runoff in urban areas. Wetland biomass serves as an excellent habitat for fish and wildlife, which enhances fishing, hunting, and wildlife recreation. Because wetlands are so productive, and because they greatly influence the flow and quality of water, they are of great public value. (Dennison, 1997)

Wetland values, which arise from the functional ecological processes described above, can be conveniently considered at three hierarchal levels – population, ecosystem, and global. (Mitsch and Gosselink, 1986) The populations that depend on wetland habitats for survival are easiest to identify. Although wetlands are most noted for waterfowl populations, other species such as fur-bearing animals and a host of freshwater fish are supported by wetlands. At the ecosystem level, wetlands have value to the public for flood mitigation, storm abatement, aquifer recharge, water quality improvement, and aesthetic qualities. Global wetland values are exhibited on a much broader scale than within the ecosystem itself. For example, wetlands help to maintain water and air quality by affecting the global cycles of nitrogen, sulfur, methane, and carbon dioxide. (Mitsch and Gosselink, 1986)

A number of efforts have been made to quantify the "free services" provided by wetlands. (Mitsch and Gosselink, 1986) Because of concerns with the inadequacy of all-inclusive methods to evaluate wetland functions and values, the Section 404 permit review process is done on a case-by-case basis. (Dennison, 1997) In order to assess wetland value, there are several generic considerations that should be addressed. (Mitsch and Gosselink, 1986):

1) Wetlands are multiple-value systems; they may be valuable for different reasons and necessitate comparison by weighing different commodities.

2) The most valuable products of wetlands are public amenities that have no commercial value for the private wetland owner, which often raises a conflict of private versus public interests.

3) As wetland area decreases, its marginal value increases, following conventional economic theory. This concept is further complicated because different natural processes operate on different scales. Thus, wetland value is related to its *interspersion* in the landscape with other ecosystems and not necessarily on size alone.

4) Commercial values are finite, whereas wetlands provide values in perpetuity. But once a wetland is drained and developed, it is usually lost forever because of resulting changes to the hydrologic regime in the area.

2.1.3 National Wetlands Inventory Classifications

The U.S. Department of the Interior's Fish and Wildlife Service has classified five major categories of wetlands; Estuarine, Marine, Palustrine, Lacustrine, and Riverine. (Cowardin *et al.*, 1979) The Office of Biological Services utilized this classification in preparation of the National Wetlands Inventory (NWI). Within the three watersheds of this study, only Palustrine, Lacustrine, and Riverine wetlands are present. These systems are described below as they pertain to the affected watersheds: (Cowardin *et al.*, 1979)

<u>Palustrine</u> – All nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens. The Palustrine System is bounded by upland or by any of the other systems and was developed to group vegetated wetlands traditionally referred to as marsh, swamp, bog, fen, and prairie. It also includes the small, shallow, permanent or intermittent bodies of water called ponds. Palustrine wetlands may be

situated shoreward of lakes and river channels, on river floodplains, in isolated catchments, or on slopes.

Lacustrine – Wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30% coverage; and (3) total area exceeding 8 ha (20 acres). The Lacustrine System is bounded by upland or by wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens and by the contour approximating the normal spillway or pool elevation for systems formed by damming a river channel. Lacustrine wetlands include permanently flooded lakes and reservoirs.

Riverine – Wetlands and deepwater habitats contained in a channel except when the wetland is dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. The Riverine System is bounded on the landward side by upland, by the channel bank (including natural and man-made levees), or by wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. The Riverine System terminates downstream where the channel enters a lake, and upstream where the channel leaves a lake. Water is usually, but not always, flowing in the system.

2.2 Wetland Mitigation

2.2.1 Wetland Mitigation Compliance

Wetland mitigation is the key component to the federal government's "no net loss" policy. Wetland mitigation has been defined as wetland restoration, creation, enhancement, and in exceptional circumstances, preservation undertaken expressly for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial. (USACE, 1995) Mitigation, although not specifically mentioned in Section 404 of the CWA (provision governing wetland dredge and fill permits), is a requirement found in other federal laws, most notably the National Environmental Policy Act (NEPA) and the Fish and Wildlife Coordination Act. (Dennison, 1997)

In the United States, wetland mitigation efforts are usually implemented within two general contexts:

1) as a component of regulatory programs, wetlands are restored or created as compensatory mitigation for unavoidable adverse impacts of development projects on wetlands and;

2) wetlands restoration or creation efforts are conducted for resource management or stewardship objectives. (USACE, 1992)

Pursuant to Section 404(b)(1) of the CWA, the Environmental Protection Agency (EPA) has issued Guidelines that the USACE uses to evaluate the environmental impacts of proposed activities on wetlands when reviewing applications for dredge and fill activities, the fundamental component of the federal wetland permit process. (Dennison, 1997) Wetland mitigation compliance is often a complex and difficult process requiring developers to readjust lot lines, redirect stormwater or other runoff, or completely relocate a project in order to protect important wetland values. To avoid having to perform activities such as these, organizations can be authorized to conduct projects associated with wetland mitigation. (USACE, 1992)

2.2.2 Wetland Mitigation Options

A 1990 Memorandum of Agreement (MOA) between the EPA and the Department of the Army formalized a three-step sequencing requirement for determining appropriate mitigation of impacts: avoidance, minimization, and compensatory mitigation. (Dennison, 1997) The MOA interprets Section 404(b)(1) Guidelines to mean that the analysis of mitigation alternatives should first focus on the "avoidance of impacts" "to the maximum extent practical." (Dennison, 1997) This step is synonymous with the "practical alternatives" analysis of Section 404(b)(1) Guidelines. When impacts cannot be avoided, the 1990 MOA requires minimization of unavoidable impacts using "appropriate and practical" steps to minimize potential adverse impacts to the aquatic ecosystem through project modifications and permit conditions. (Dennison, 1997) Compensatory mitigation, the final and least preferred step, is required as compensation for unavoidable adverse environmental impacts. The MOA describes compensatory actions as "restoration of existing degraded wetlands or creation of man-made wetlands" only after exhausting avoidance and minimization measures. (Dennison, 1997)

2.2.3 Wetland Mitigation Banking

The concept of mitigation banking, although practiced for more than 20 years, is still relatively new, and was developed in response to the "no net loss" policy. (Brumbaugh, 1995) In an effort to find innovative solutions to problems associated with standard on-site mitigation compensation, wetland mitigation banking was introduced in August 1993, as an important component of the Clinton Administration's Wetland Plan. (Brumbaugh, 1995)

Among the Plan's initiatives was strong support for incentives to state and local government to engage in watershed planning, with the intent of reducing the conflict between wetlands protection and development when decisions are made on a permit-by-permit basis. To encourage greater use of comprehensive planning and to identify wetland protection and restoration needs, concerns, and opportunities, support was given to mitigation banking. (Brumbaugh, 1995) In practice to date, there has been considerable variation in implementation because almost all banks established have been *ad hoc* arrangements between regulators and development entities. However, banks generally share the following characteristics:

- They are typically large blocks of wetlands or a suite of wetland sites with estimated tangible and intangible values termed "credits." These credits represent an increase in the function or value of the wetlands in the bank.
- As anticipated developments (e.g., industrial development, highways, etc.) take place, developers use the bank for its compensatory mitigation for unavoidable wetland loss, termed "debits," if regulatory agencies permit those losses.
- A bank usually compensates for multiple wetland losses. (Brumbaugh, 1995)

2.3 Source Data used to Create the Watershed GIS Databases

The fundamental layers of source data used to create the watershed GIS were obtained from the Ohio Department of Natural Resources (ODNR) and the United States Geological Survey (USGS). From ODNR, 1994 Land Cover, 1971 Soil Maps, and the 1987 Ohio Wetlands Inventory (OWI) were used. From the USGS, the Hypsography (10-foot contours) was obtained from the most recent (prior to 1995) 7.5-minute quadrangle in digital line graph (DLG) format at a scale of 1:24,000. The development of the OWI is explained in greater detail in the following section. Brief abstracts of Land Cover, Soil Maps, and Hypsography are provided below. (ODNR, 2000)

1994 Land Cover – This coverage was created by ODNR for the National Aeronautics and Space Administration's Land Cover and Land Use Change Program, as part of the U.S. Global Change Research Program. The coverage was extracted from the 1994 statewide land cover inventory of Ohio produced by Bruce R. Motsch and Gary M. Schaal of ODNR. The land cover inventory for the State of Ohio was produced by digital image processing utilizing a multi-spectral scanner that collects electromagnetic radiation reflected from the earth's surface in the visible, near infrared and mid-infrared wavelength bands; this is called Landsat Thematic Mapper Data. The resolution of the Thematic Mapper data is a 30-meter by 30-meter cell. The Thematic Mapper data were processed using ERDAS image processing software. The data were originally created in raster format and georeferenced to Universal Transverse Mercator (UTM) zone 17 coordinates NAD27. The data were classified into the general land cover categories as shown in Table 2.1. (ODNR, 2000)

1971 Soil Maps – This coverage was created as part of an Ohio Capability Analysis Program (OCAP) Land Capability Project in cooperation with the Eastgate Regional Council of Governments and the Mahoning County Planning Commission. Soil mapping units are best used in environmental analyses, erosion analyses, land use planning, etc., since the coverage is only an approximation of the soil survey. A soil mapping unit designates a specific type of soil which has unique characteristics including texture, slope, and erosion class. These soils were digitized from the soil survey sheets. These sheets were taped together to form an area covering each of the USGS 7.5 minute quadrangle maps in the county. The areas for each quadrangle were then digitized using run-length encoding technique sampling along horizontal lines, which represented the midline of cells with a height of 250 feet. The measurement increment along these lines was 10 feet. The quadrangle files were then merged into a county file, and subsequently converted to Arc/INFO format.

Table 2.1 1994 Land Cover Classification Scheme

Code	Description
URBAN	Open impervious surfaces: roads, buildings, parking lots and similar hard surface areas which are not obstructed from aerial view by tree cover
AGRICULTURE/OPEN URBAN AREAS	Cropland and pasture; parks, golf courses, lawns and similar grassy areas not obstructed from view by tree cover
SHRUB/SCRUB	Young, sparse, woody vegetation; typically areas of scattered young tree saplings
WOODED	Deciduous and coniferous
OPEN WATER	
NON FORESTED WETLANDS	Includes wetlands identified from 1994 Thematic Mapper data as well as from the Ohio Wetlands Inventory
BARREN	Strip mines, quarries, sand and gravel pits, beaches; Many of the URBAN features identified in this inventory are constructed from materials obtained from the BARREN features. Because of this, there will on occasion be URBAN areas identified as BARREN as well as BARREN areas identified as URBAN

Source: (ODNR, 2000) http://www.dnr.state.oh.us/gims/report.asp

USGS Hypsography – Digital line graph (DLG) data were derived from USGS topographic maps published as 7.5-minute quadrangles at 1:24,000 or 1:25,000 scale. In addition to the hypsography, the DLG data contain transportation, hydrography, township and municipal boundaries. All DLG data distributed by the USGS are DLG - Level 3 (DLG-3), which means the data contain a full range of attribute codes, have full topological structuring, and have passed certain quality-control checks. (USGS, 1990)

2.3.1 Development of Ohio's GIS-Based Wetlands Inventory

Originally, more than five million of Ohio's 26.4 million acres were classified as having hydric soils or hydric inclusions. Today, only 20 percent of the original area with conditions indicative of wetlands remains unaltered. (Yi *et al.*, 1994) Growing public awareness of the values of wetlands along with the pressures to convert wetlands necessitate that resource managers have access to information such as the location, size, distribution, and abundance of wetland resources as well as categorization of adjacent land uses. (Yi *et al.*, 1994) The inability to maintain updated wetland maps, and incomplete coverage in Ohio, are the most critical shortcomings of the NWI. Thus, creation of a digital GIS database of Ohio' wetland resources allows for periodic and efficient monitoring. This database was intended for use among different organizations and agencies for a variety of applications including aiding decision makers in identifying the best locations for constructing or reclaiming wetlands. (Yi *et al.*, 1994)

The wetland inventory maps show eight different land-cover classes including various wetland types (e.g. open water, shallow marsh and wet meadow, shrub-scrub, farmed wetland), background vegetation types, and bare soil. The authors describe the OWI wetland classification schemes shown in Table 2.2 as follows (Yi *et al.*, 1994):

> The open-water zone is defined as the area of water without vegetation or without emergent plants extending above the water surface. The shallow-marsh zone is an area of emergent vegetation that normally maintains surface water for an extended period in spring and early summer, but is frequently dry in later summer and fall. Wetland meadows are lands characterized by nearly continuous moist-soil conditions and are usually dominated by sedges rather than grasses.

Wetlands were classified as 'farmed' when there was evidence of attempts at crop production within the wetlands.

Table 2.2 Comparison of wetland classification schemes used in the OWI & NWI

Ohio Wetland Inventory (OWI)	US Fish and Wildlife Service (NWI)
Open water	Palustrine or Lacustrine, littoral; aquatic bed; submergent, floating, and float-leaved
Shallow marsh	Palustrine; emergent; emergent/wet meadow
Scrub/shrub wetland	Palustrine; forested scrub/shrub
Wet meadow	Palustrine; emergent; broad-and-narrow-leaved persistent
Woods on hydric soil	Palustrine; forested needle-leaved evergreen and deciduous; and broad-leaved evergreen
Farmed wetland	Not present

Although great potential for application exists, the limitations of the OWI should be clearly understood to avoid improper usage. The original TM imagery was acquired and processed at a cell resolution of 30 by 30 meters and OCAP soil and land use data were resampled from a coarse 80 by 80 meter pixel size to the finer 30 by 30 meter size. (Yi *et al.*, 1994) The authors advise that "a 0.09 ha (0.2 ac) cell may provide reasonably accurate estimates of wetland acreage at a regional or even a local scale; however, this resolution, in combination with unnoticed registration, omission, and classification errors limit the applicability of this data set in land use regulation where precise jurisdictional wetland delineation is required." (Yi *et al.*, 1994) While these limitations do restrict direct use of the OWI for some regulatory activities, its benefits can be utilized as a reference in land use policy implementation and planning wetland management. (Yi *et al.*, 1994)

2.4 Modeling Wetland Mitigation Potential at a Watershed Level

2.4.1 Overview of the Role of GIS in Watershed Planning

Watershed assessment and protection efforts have generally been driven by mitigation requirements of regulatory agencies, leading to a "reactive" approach in which only wetlands and waters that show signs of water quality degradation are examined. The existing situation within Mill Creek, Yellow Creek, and Meander Creek watersheds necessitates a "proactive" approach in an attempt to mitigate and control damage resulting from rapid development. Understanding the linkages and interrelationships between land use activities and watershed resources are critical to the local policy decision-makers and landowners as well. (Schloss and Mitchell, 1996) Selecting sites for a successful long-term Wetland Mitigation Plan requires consideration of existing soil moisture conditions, topography and surrounding land use. (Rusell *et al.*, 1997; O'Neill, 1997) Watershed level planning also provides a logical start to a wetland mitigation identification strategy that maximizes the benefits of wetland functions in agriculturally dominated watersheds where chronic water quality degradation has occurred as a result of nonpoint source runoff. (White *et al.*, 1999)

The advent of Geographic Information Systems has provided a powerful inventory, analysis and educational tool for the investigation of mitigation opportunities within each watershed. (Schloss and Mitchell, 1996) Schloss and Mitchell (1996) explored the use of GIS overlays to model nonregulatory approaches to watershed protection such as land acquisition and/or conservation easements and discovered that overlay mapping was a cost-effective aid in decision-making.

2.4.2 Successful Integration of GIS Databases into Watershed Planning

The distributed nature of wetlands is well suited for the use of a spatial GIS to identify, catalogue and rank wetland mitigation opportunities. (Lyon, 2001) Several successful attempts to integrate a GIS database into watershed planning have been documented. In 1993, the Southwest Florida Water Management District published one such successful attempt, entitled "Development of a Water Supply Protection Model in GIS" in the *Water Resources Bulletin*. (Griner, 1993) The District covers approximately 10,000 square miles in part of 16 counties in west central Florida with the underlying Floridan aquifer serving as the primary potable water source from the Tampa-St. Petersburg area northward, as shown in Figure 2.1 below.

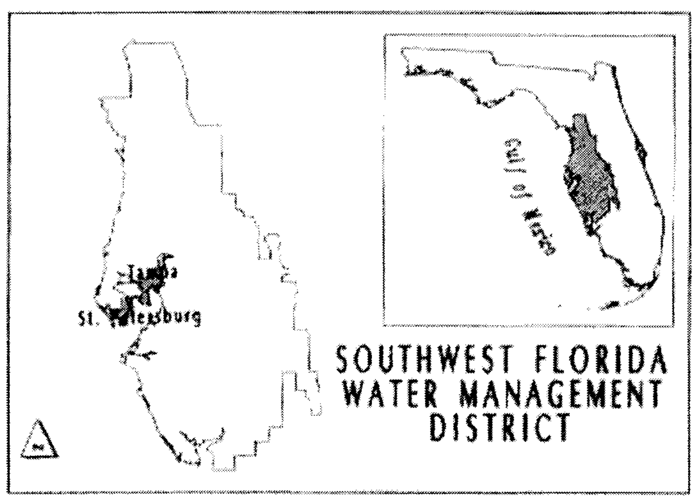


Figure 2.1 Location of the Southwest Florida Water Management District

One of the Districts many responsibilities is the acquisition of lands for the purpose of water management, water supply, and the conservation and protection of water resources. (Griner, 1993) In order to better identify lands suitable for purchase, the District developed a site identification model utilizing a GIS overlay setup for the objective mentioned above. The District concluded that implementation of the site identification model had several advantages. The GIS provided a means of integrating map layers from various sources and data from different databases into a single overlay with the ability to emphasize select items for consideration. (Griner, 1993) Lastly, the model continues to be refined as better quality and/or more current data layers become available. (Griner, 1993)

Another successful integration study was undertaken as a cooperative demonstration project between the Ohio EPA and the Ohio State University. The project, entitled *Modeling Wetland Restoration Potential at the Watershed Scale*, identified existing wetlands within the 815 square mile Cuyahoga River Watershed in northeastern Ohio and integrated a GIS-based model to select and prioritize proposed restoration locations that maximize nonpoint source pollution control and protect aquatic habitat. (White, *et al.*, 1999) The authors utilized a linear summation of weighted criteria to prioritize sites deemed most suitable for restoration. The relative importance or weight given to each criterion was determined through *paired comparisons*, which involved direct questioning of technical experts such as landscape geographers, wetland scientists, and engineers in order to gain insight into the tradeoffs between criteria sets. (White *et al.*, 1999) The weighted criteria used essentially gave the greatest priority to flat locations with large contributing runoff areas and low drainage potential. The weighted criteria was applied electronically to 100 square meter (0.0247 acre) grids throughout the entire watershed and scaled to a 100-point wetland restoration suitability index. (White *et al.*, 1999)

The model was found to be an effective guide to field verification of proposed restoration sites as well as a useful tool to focus wetland mitigation efforts in the

Cuyahoga River Watershed. (White *et al.*, 1999)

2.5 Integration of Multi-Criteria Evaluation with GIS

2.5.1 Introduction to Multi-Criteria Evaluation

Geographic information systems provide the decision-maker with a powerful set of tools for the manipulation and analysis of spatial information. (Carver, 1991) Multi-criteria evaluation (MCE) techniques began to emerge during the early 1970s from the regional economic planning and decision-making research fields. (Voogd, 1983) MCE techniques are used as part of evaluation models that analyze the complex trade-offs between choice alternatives with multiple criteria and conflicting objectives. (Voogd, 1983) The typical starting point of any MCE analysis is the construction of an evaluation matrix with elements that reflect the characteristics of the given set of choice alternatives on the basis of a specific set of criteria. MCE analysis techniques often require some form of standardization including weighted summation of criterion scores so that meaningful comparisons can be made on the basis of criteria measured on different scales. (Carver, 1991) Weights or criterion priorities allow the decision-maker to specify the perceived value of individual factors relative to others included in the evaluation. (Carver, 1991) Carver recommends using a combined GIS-MCE approach for site suitability selection that is divided into two stages, survey and preliminary site identification. In the survey stage, a GIS overlay can be used as a wide-area screening technique to identify all potentially feasible sites that meet specified criteria. During the preliminary site identification, MCE techniques are used to rank the best compromise solutions in terms of the predefined evaluation matrix.

2.5.2 Site-Search Procedures using GIS Map Overlays

The integration of analytical techniques designed to assess multi-criteria concerns in a GIS can provide a valuable tool to evaluate the suitability of sites falling within feasible areas identified in a standard GIS overlay procedure. This procedure is most often performed using digital map overlays to identify areas with overlapping siting criteria. However, such overlay procedures do little more than identify areas simultaneously satisfying all the specified criteria. (Carver, 1991) To address multiple and conflicting criteria and objectives, MCE techniques are used in support of complex siting decisions. Carver has summarized several advantages of using a combined GIS-MCE approach to site selection as follows:

1) GIS is an ideal means of performing deterministic analyses on all types of geographical data.
2) GIS provides a suitable framework for the application of spatial analysis methods, such as MCE techniques, which do not have their own data management facilities.
3) MCE procedures provide the GIS with the means of performing complex trade-offs on multiple and often conflicting objectives while taking multiple criteria and the expert knowledge of the decision-maker into account.
4) GIS and MCE based systems have the potential to provide a more rational, objective and non-biased approach to making decisions on siting.

CHAPTER THREE

PROCEDURES

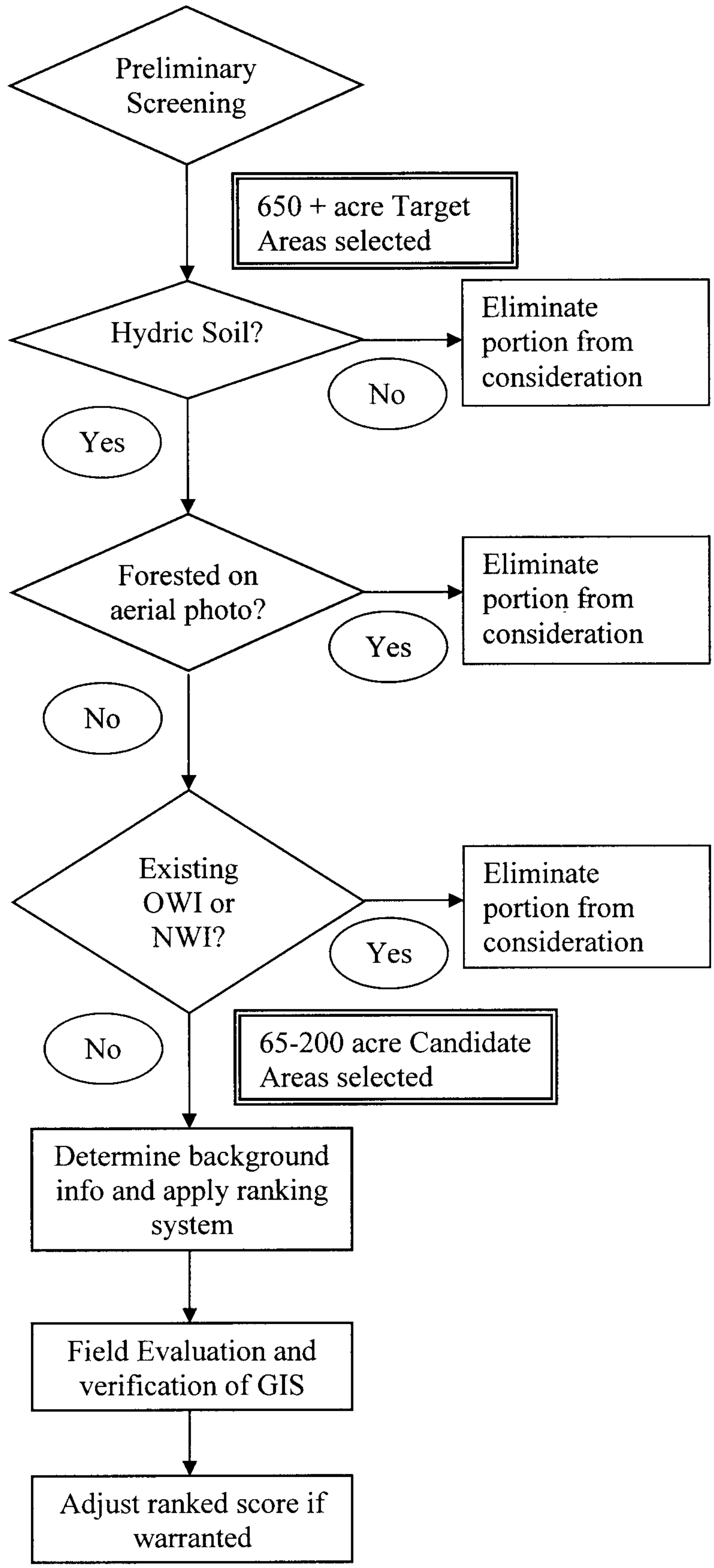
3.1 General Description

The procedure used to identify wetland mitigation opportunities within the Mill Creek, Yellow Creek, and Meander Creek watershed Study Area was developed using the GIS capabilities at the Center for Urban Studies on the campus of Youngstown State University, and verified through field observations. ArcView geographic information systems (Version 3.2) and Arc/INFO (Version 8.1) were used to model the factors needed to identify mitigation potential.

The fundamental procedure is depicted by the algorithm in Figure 3.1. The procedure was developed to facilitate quickly searching large tracts of land for potential mitigation opportunities utilizing a GIS to identify areas containing all three wetland indicators. These areas were called "Target Areas" in this study. These Target Areas were again screened eliminating forested, NWI, and OWI wetland areas from consideration. This secondary screening substantially reduced the size of the area of interest. The remaining areas were called Candidate Areas in this study. Site descriptions and background information were also catalogued for each Candidate Area.

A weighted ranking scheme was developed to answer the question – How well can the Candidate Area under review support the development of a wetland? This question is answered by evaluating the following three factors:

1) Hydrology
2) Soils
3) Environment capable of supporting hydrophytic vegetation.



Individual candidate parcels may still have small areas that are non-hydric and/or forested.

A "Yes" could indicate a jurisdictional wetland yet to be delineated or a farm that is a prior converted wetland.

Figure 3.1 GIS Overlay Methodology Flow Chart

The accuracy of the GIS was tested through field observations and digital images of target areas were catalogued in the GIS database. An adjustment to the ranked score was then applied if warranted by field observations. Finally, the weighted scores were tabulated so that comparisons and conclusions could be made.

The GIS was created by overlaying several layers of publicly available digital data to identify target areas worthy of further examination as a potential wetland mitigation opportunity. Target areas generated by this procedure were first examined for a single sub-basin, Lake Walaka, within the Mill Creek watershed. Upon field evaluation of the model's validity, adjustments were made to the GIS overlay model so that the GIS results matched field observations. The new model was then applied as a whole to the entire Study Area and several (five) Target mitigation areas were identified. Five large tracts within these target areas were selected as Candidate Areas for trial application of the ranking procedure. Site descriptions and background information were gathered from the GIS and the ranking system was applied to the Candidate Areas to quantify the potential for wetland mitigation. The ranked scores were then verified by field inspection and adjustments were made accordingly. The results of the GIS overlay model will serve as a critical component of the Wetland Mitigation Plan to be developed by the Alliance for Watershed Action and Riparian Easements (AWARE).

3.2 GIS Overlay Methodology

To effectively and conveniently evaluate target areas within a watershed for potential wetland mitigation, accurate and publicly available data sets must be used. This type of data was found readily available for use in ArcView GIS format from ODNR and the USGS via online Internet downloads. US Fish and Wildlife Service NWI coverages were used in the form of 7.5-minute quadrangle sheets as digitized layers for the Study Area are not yet complete. Mahoning County Enterprise GIS files were obtained on compact disks and imported into the GIS overlay. In order to search all three watersheds, data were required for Mahoning, Trumbull, and Columbiana counties of northeastern Ohio. Table 3.1 lists the counties included in each watershed.

Table 3.1 Counties Included in Each Watershed

Meander Creek	Mahoning Trumbull
Mill Creek	Mahoning Columbiana
Yellow Creek	Mahoning Columbiana

Table 3.2 shows a breakdown of the source data used as input in the GIS overlay.

Table 3.2 Source of GIS Data

Data Set	Data Source	Most Recent Year Available
Roads Hypsography (10-ft contour intervals) Township Boundary Municipal Boundary Hydrology	USGS	Taken from most recent 7.5-minute quadrangle sheet prior to 1995
Watershed Boundary	ODNR	1980
Land Cover		1994
Soil Type (OCAP Codes)[1]		1971
Underground Abandoned Mines		1995
Ohio Wetlands Inventory (OWI)		1987
National Wetland Inventory (NWI)[2]	US Fish and Wildlife Service	April 1977
Aerial Photograph Coverage Cadastral Layer (Parcel Tax Maps) Hypsography (2-ft contour intervals)	Mahoning County Enterprise GIS Files	April 1998

[1] Detailed soil types are not available for Columbiana County. To obtain this data, several pages of the Columbiana County Soil Survey had to be scanned and geo-referenced to the Digital Line Graph (DLG) Road layer for Columbiana County using Arc/INFO. The image was then digitized using the tracing feature of Arc/INFO into several coverages so that it could be transformed into polygons with the CLEAN and BUILD functions of Arc/INFO. Data attributes were entered for each polygon so that it could be imported and clipped into each watershed boundary in ArcView GIS.

[2] Actual "hard copies" in 7.5-minute quadrangle sheets of the NWI were used separate from the digital GIS overlay to locate existing wetlands within Candidate Areas. These identified NWI wetlands were subsequently digitized and added to the GIS overlay.

Data downloaded from ODNR were in State Plane Ohio North projection, NAD (North American Datum) 1983, and the units were feet. USGS data were in decimal degrees, and thus, were projected using the *Projector!* Extension in ArcView GIS to match ODNR data. Overlay aerial photos taken in April of 1998, hypsography at 2-ft contour intervals (Mahoning County only), and the cadastral (property boundary) layer were received from the Mahoning County Enterprise GIS and used for the initial Lake Walaka sub-watershed level examination as well as subsequent watershed investigations.

Once the data were acquired, they were manipulated in the GIS software by Center for Urban Studies technicians to produce continuous coverages for all three watersheds. The Meander Creek, Mill Creek and Yellow Creek watersheds were selected from ODNR watershed boundaries and saved as separate shapefiles (*.shp filename extension). Since part of the Meander Creek watershed is in Trumbull County and part of the Mill Creek and Yellow Creek watersheds are in Columbiana County, the coverages were merged together to form one shapefile for the entire watershed. The remaining ODNR and USGS data layers were clipped to fit inside watershed boundaries and written to shapefiles separately for each watershed.

The Lake Walaka watershed boundary was digitized from Figure 3.2. ODNR and USGS data were clipped to fit inside the Lake Walaka boundary. Land Cover, OWI, Hypsography (10-foot contours), and Soil Type are the fundamental components of the GIS overlay layers used to screen for potential wetland mitigation sites. In the initial Lake Walaka investigation, an additional layer of Land Use (1985) was used but was deemed unnecessary for the three subsequent mitigation searches.

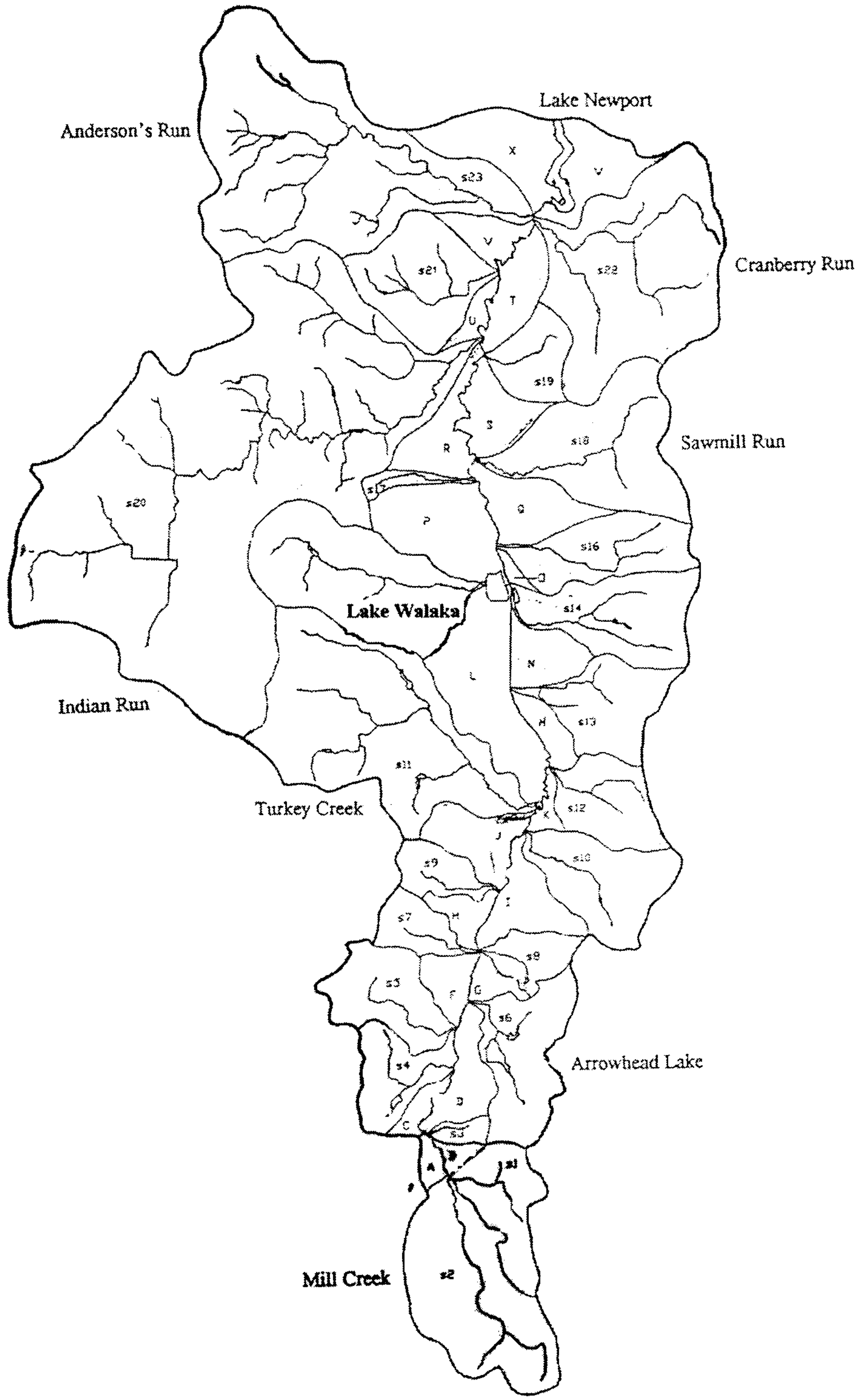


Figure 3.2 Tributary Sub-basins and Direct Runoff Areas in Mill Creek Watershed
SOURCE: (MRB-HER, 1994)

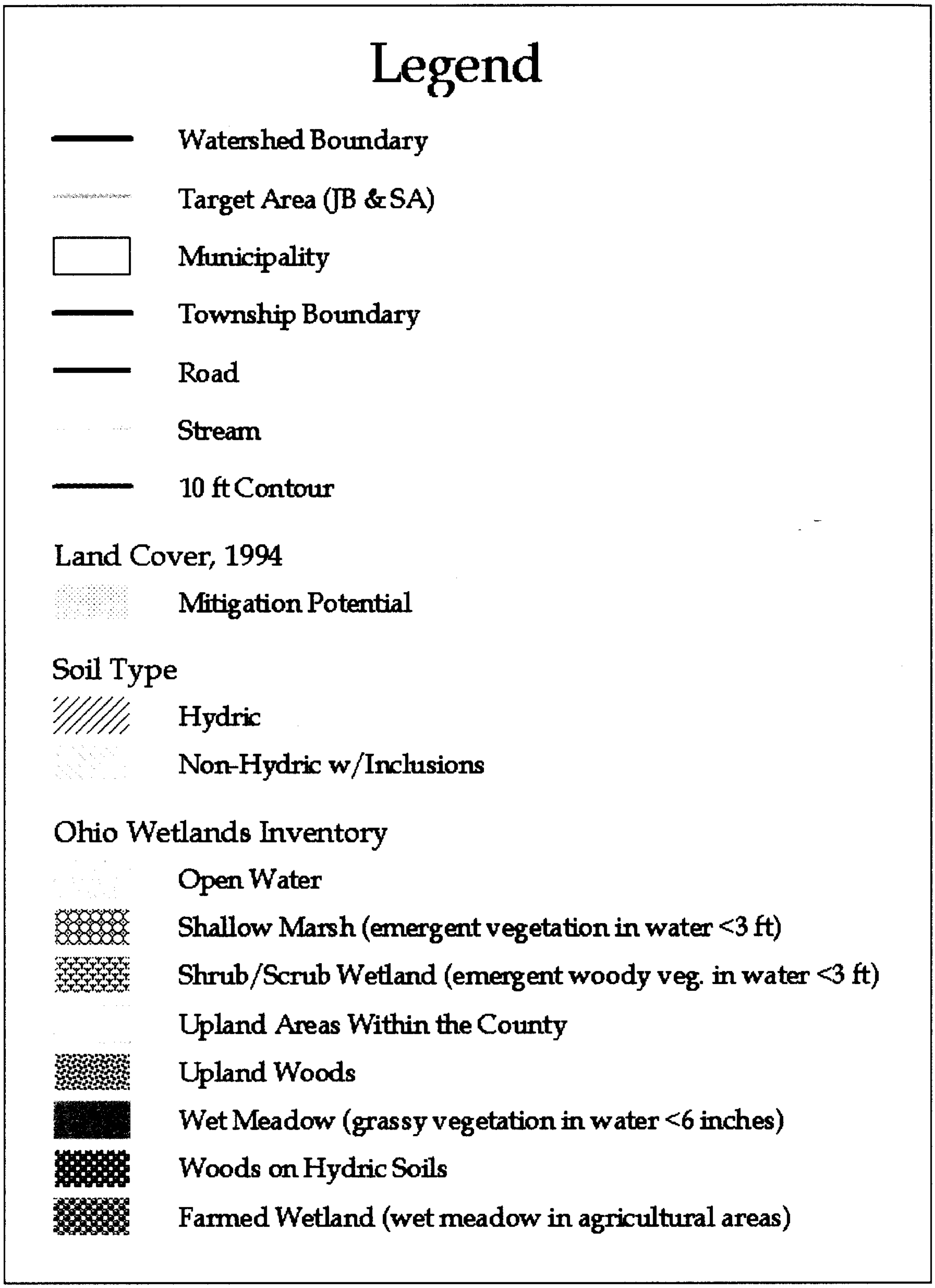


Figure 3.3 General Map Legend Used for GIS Analysis of Each Watershed

The other data sets mentioned previously were added to reference geographic location, to obtain site descriptions and background information, and to aid in producing maps. Soil type and Land Cover data were manipulated as binary constraints similar to the watershed level site-suitability GIS model used to assess potential wetland restoration potential in the Cuyahoga River watershed. (White *et al.*, 1999) Binary constraint data are either displayed or made transparent in the GIS spatial overlay using the *Legend Editor* in ArcView. Soil types that were not classified by OCAP as either hydric or non-hydric with hydric inclusions were considered unsuitable for the development of a wetland and were "hidden" in the layer. Urban, wooded, and open water Land Cover designations as well as underground mines were also "hidden" in similar fashion from the overlay map. (White *et al.*, 1999) Those areas still considered conducive to the development of a wetland as well as the OWI wetlands were assigned a specific color combination and pattern in the GIS overlay as illustrated in Figure 3.3, the general map legend for each watershed.

These colors and patterns were chosen as the most effective scheme to identify locations where Land Cover conducive to mitigation and hydric (and non-hydric with hydric inclusions) soils overlap in the GIS overlay. Large areas greater than 650 acres in size with predominantly overlapping conditions conducive to mitigation were located in areas of generally flat topography as evidenced by the Hypsography layer. Five of these large areas were delineated as the watershed Target Areas. This completed the Preliminary Screening step of the methodology shown in Figure 3.1. Within these Target Areas, five smaller areas between 65 and 200 acres were selected for further examination by reducing segments of the Target Areas to those sections that had predominantly hydric soils (or non-hydric with hydric inclusions) and minimal forest cover as shown by the aerial photographs.

Areas with existing OWI or NWI wetlands were also neglected according to the methodology. The reduced Target Areas were then considered Candidate Areas. Candidate Areas may contain portions of jurisdictional wetlands not yet delineated or may possibly be a farm that is a prior converted wetland. The data contained in the complete set GIS layers were utilized in gathering site descriptions and background information as well as in the application of the ranking system.

Brief summaries of the ArcView GIS functions and coverage layers used to evaluate Candidate Areas in terms of the site description/background information and the criterion parameters of the ranking system are provided in Tables 3.3 and 3.4, respectively. Field verification and a photographic log of observations were digitally catalogued and used to determine concurrence with the information produced by the GIS overlay methodology. Conditions that differed from the GIS overlay could be accounted for by adjusting the ranked score accordingly. For example, a development that has occurred since the April 1998 aerial photographs may change the mitigation buffer score.

Table 3.3 Evaluation Matrix for Site Description and Background Information

Parameter	**ArcView GIS Function & Layers Used**
Candidate Area ID	Identifier Tool, Mahoning County Cadastral Layer
Parcel ID	Identifier Tool, Mahoning County Cadastral Layer
Coordinates	ArcView View Frame, Candidate Area ID Layer
Watershed/Sub-watershed	Identifier Tool, Mahoning County Hydrology Layer
Size	Calculate Acreage Function, Candidate ID Layer
NWI wetlands on-site*	Digitized Hard Copy of NWI Quad
OWI wetlands on-site	ArcView View Frame, OWI Layer

*NWI wetlands were determined through "hard copy" maps. A digital layer for the Candidate Areas was created and imported into the GIS overlay.

Table 3.4 Evaluation Matrix for Ranking Scheme Criterion Parameters*

Parameter	ArcView GIS Function & Layers Used
Major Source of Hydrology	ArcView GIS/USGS Hydrology Coverage
Soil Types Present in Candidate Area	ArcView GIS "Calculate Acreage"/ODNR Detailed Soils Coverage
Proximity to delineated OWI wetlands or streams	ArcView GIS/ODNR Ohio Wetlands Inventory Coverage
Average Slope	ArcView GIS Spatial Analyst/USGS/Mahoning County Enterprise GIS Hypsography Coverages
Mitigation Buffer from Disturbed Areas	ArcView GIS "Measuring Tool"/All layers combined

*Ranked criterion scores can be adjusted if field observations warrant.

3.3 Development of Mitigation Ranking Scheme

The mitigation ranking scheme is comprised of a general inventory and a ranked assessment. The general inventory consists of a site description and background information, and provides relevant information about individual parcels within the Candidate Area. The ranked assessment was developed to evaluate the ability of the environment under review to support the development of a wetland by quantifying three factors related to the success of a mitigated wetland:

1) Adequate hydrology (55% weighting)
2) Hydric soils (35% weighting)
3) Environment capable of supporting hydrophytic vegetation (10% weighting)

The general inventory portion of the ranking scheme shown in Table 3.5 on the following page was designed to be completely answered using the data contained in the GIS.

The ranking scheme consists of a weighted scoring system that utilizes a linear weighted summation of several criteria to assess the three wetland factors. The ranking system is shown in Table 3.6.

Table 3.5 General Inventory of Candidate Area

Candidate Area Site Description & Background Information

1. Candidate Area ID ____________________

2. Parcel ID ____

3. Coordinates or Location Description

   ____

   Watershed ____________________ Sub-watershed ______________

4. Size ______________

5. Are NWI wetlands on-site? Yes No

   NWI 7.5-minute quadrangle(s): __________________________

   If yes, Type of Wetland

   ________ Open Water (OW)
   ________ Scrub/Shrub (SS)
   ________ Forested (FO)
   ________ Isolated (EM)

   List all NWI designation(s)
   (i.e. PSS6 - Palustrine, Scrub/shrub, Deciduous)

   ____

   ____

   ____

6. Have OWI wetlands been delineated on-site? Yes No

Table 3.6 Wetland Mitigation Ranking Scheme

Candidate Area Ranking Scheme

How well can the environment under review support the development of a wetland?

1) Hydrology	55%
2) Soils	35%
3) Environment capable of supporting hydrophytic vegetation	10%

W	R			W x R	Questions Addressed
35%	**Major Source of Hydrology**				1
	10	Perennial			
	7	Intermittent			
	4	Ephemeral (storm event)			
	1	Groundwater discharge			
25%	**Soil Types Present in Candidate Area**				2
	________	% Hydric	× 10 =		
	________	% Hydric inclusions	× 6 =		
	________	% Non-hydric	× 1 =	________	
			Total:		
20%	**Proximity to Delineated OWI Wetlands or Streams**				1,2,3
	10	Contiguous		(% allocation)	5%, 10%, 5%
	5	< 1 mile			
	1	> 1 mile			
15%	**Average Slope**				1
	10	0 - 0.5%			
	7	0.5 - 1%			
	2	> 1%			
5%	**Mitigation Buffer from Disturbed Areas**				3
	10	> 30 m			
	8	21 - 30 m			
	6	11 - 20 m			
	2	< 10 m			

Field Evaluation:

Concurs with GIS evaluation? Yes No*

* List conditions favorably for mitigation

____

____

*List conditions unfavorably for mitigation

____

____

Final Score = Σ W x R =** ____________

**Includes adjustments warranted by field observations

The ranking scheme includes five criteria related to the three factors that support the development of a wetland. Weighting percentages are assigned to each criterion as indicated in the W column. For each of these criteria, the potential conditions are listed in the R column and given a score between 0 and 10. The W percentage breakdown and R weighted values were determined by persons with expertise in wetland mitigation. The ranking scheme works as a checklist to describe and rate the characteristics within the area that would tend to support a potential wetland. The scoring for a parcel is calculated using the equation, $S = \Sigma W \times R$, where S is the parcel's ranked score.

Aerial photographs and digital photograph databases stored in the GIS can be used as an aid in completing the ranking scheme checklists. The scores of Candidate Areas can be adjusted according to actual field observations. Ultimately, a ranked list of wetland mitigation opportunities with the three watersheds could be formed. This would serve as a convenient decision-making tool for developing a wetland management strategy in the Yellow Creek, Mill Creek, and Meander Creek watersheds.

It is important to note that the Candidate Areas examined in this study and listed as results in Chapter 4 are by no means a complete list of opportunities in the three watersheds. They were chosen to illustrate the spectrum of possible ranked outcomes for Candidate Areas between 65 and 200 acres. Varying the Candidate Area size requirement would likely have produced different results. However, the same methodology would still be applicable, since the weighted ranking scheme can be applied to any area considered for the development of a potential wetland.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Description of Study Area

A method was developed for evaluating wetland mitigation opportunities in the Mill Creek, Meander Creek, and Yellow Creek watersheds. The approach was designed for use in the framework of a Wetland Mitigation Plan. The Study Area characteristics are described in Table 4.1.

Table 4.1 Physical Characteristics of the Study Area

Size (acres), (mi^2)	130,237	203.495
OCAP Soil Coverage	**(acres)**	**(percent)**
Hydric	24,276	19
Non-Hydric	85,721	66
Hydric Inclusions	16,063	12
Open Water	3,891	3
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open		
Urban	41,976	32
Barren	15	0.5
Non-Forested Wetland	3,052	2.3
Open Water	2,946	2.2
Shrub/Scrub	1,417	1
Urban	8,985	7
Wooded	71,843	55

Table 4.2 provides a summary of soil conditions and land cover in the individual watersheds of the Study Area.

Table 4.2 Physical Characteristics of Meander Creek, Mill Creek, and Yellow Creek Watersheds[1]

Mill Creek Watershed	**(acres)**	**(mile^2)**
Size	50,179	78.405
OCAP Soil Coverage	**(acres)**	**(percent)**
Hydric	9,941	20
Non-Hydric	33,639	67.5
Hydric Inclusions	6,182	12
Open Water	392	0.5
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open Urban	15,248	30
Barren	2	0.5
Non-Forested Wetland	784	1.5
Open Water	337	1
Shrub/Scrub	406	1
Urban	4,810	9
Wooded	28,590	57
Meander Creek Watershed	**(acres)**	**(mile^2)**
Size	54,826	85.665
OCAP Soil Coverage	**(acres)**	**(percent)**
Hydric	11,213	20
Non-Hydric	32,685	59
Hydric Inclusions	8,848	16
Open Water	2,151	8
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open Urban	18,700	34
Barren	8	1
Non-Forested Wetland	1,955	4
Open Water	1,397	2.5
Shrub/Scrub	778	1.4
Urban	2,470	4.5
Wooded	29,515	52.6
Yellow Creek Watershed	**(acres)**	**(mile^2)**
Size	25,231	39.423
OCAP Soil Coverage	**(acres)**	**(percent)**
Hydric	3,121	12
Non-Hydric	19,396	77
Hydric Inclusions	1,032	4
Open Water	1,354	7
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open Urban	8,027	31
Barren	6	0.5
Non-Forested Wetland	312	1.2
Open Water	1,210	4.7
Shrub/Scrub	232	1
Urban	1,705	7
Wooded	13,736	54.6

[1] The difference between Land Cover, 1994 Open Water and OCAP Soils Coverage Open Water Acreage is due to a difference inherent in the interpretation of Open Water within the datasets.

4.2 Description of Target Areas

The preliminary screening process identified large (> 650 acres) undeveloped and/or agricultural tracts within the study area where the three factors conducive to wetland mitigation exist coincidently. These areas were named "Target Areas". Screening the three watersheds as a whole yielded a total of five Target Areas as described in Table 4.3. Of these five areas, three were in the Mill Creek watershed with the remainder in the Meander Creek watershed.

Table 4.3 Physical Characteristics of Target Areas

Meander, Target Area 1		
Acres	8889	
Soils	**(acres)**	**(percent)**
Hydric	4009	45
Non-Hydric	4310	48
Hydric Inclusions	533	6
Open Water	37	1
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open Urban	4195	47
Barren	1	0.01
Non-Forested Wetland	330	4
Open Water	4	0.04
Shrub/Scrub	110	1
Urban	312	4
Wooded	3937	44
Boundaries		
North	Watershed Boundary	
South	Jackson/Ellsworth Twp. Boundary	
East	S. Lipkey Rd.	
West	Watershed Boundary	
Hydrology	Morrison Run, N. Jackson Ditch	
Township(s)	Jackson	
Meander, Target Area 2		
Acres	4165	
Soils	**(acres)**	**(percent)**
Hydric	1774	42
Non-Hydric	928	22
Hydric Inclusions	1396	34
Open Water	67	2
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open Urban	2234	54
Barren	1	0.02
Non-Forested Wetland	32	0.77

Table 4.3 Physical Characteristics of Target Areas (continued)

Open Water	2	0.05
Shrub/Scrub	96	2
Urban	13	0.31
Wooded	1778	43
Boundaries		
North	Watershed Boundary	
South	U.S. 224	
East	Huxley Rd.	
West	Watershed Boundary	
Hydrology	West Branch Meander Creek	
Township(s)	Ellsworth	
<u>Mill Creek, Target Area 1</u>		
Acres	670	
Soils	**(acres)**	**(percent)**
Hydric	397	59
Non-Hydric	262	39
Hydric Inclusions	10	1
Open Water	1	1
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open Urban	522	78
Non-Forested Wetland	2	1
Shrub/Scrub	10	1
Urban	8	1
Wooded	128	19
Boundaries		
North	Dublin Rd.	
South	Watershed Boundary	
East	OH 46	
West	Covington Cove	
Hydrology	Indian Run	
Township(s)	Canfield, Green	
<u>Mill Creek, Target Area 2</u>		
Acres	1171	
Soils	**(acres)**	**(percent)**
Hydric	404	34
Non-Hydric	698	60
Hydric Inclusions	67	5
Open Water	2	1
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open Urban	747	64
Non-Forested Wetland	8	1
Shrub/Scrub	18	2
Urban	8	1
Wooded	390	32
Boundaries		
North	W. Calla Rd.	
South	Watershed Boundary	
East	OH 11	

Table 4.3 Physical Characteristics of Target Areas (continued)

West	Watershed Boundary	
Hydrology	Turkey Creek	
Township(s)	Beaver	
Mill Creek, Target Area 3		
Acres	2113	
Soils	**(acres)**	**(percent)**
Hydric	1435	68
Non-Hydric	610	29
Hydric Inclusions	16	1
Open Water	52	2
Land Cover, 1994	**(acres)**	**(percent)**
Agricultural/Open Urban	685	32
Non-Forested Wetland	133	6
Open Water	150	7
Shrub/Scrub	26	1
Urban	53	3
Wooded	1066	51
Boundaries	Forms buffer of approximately 1000-3000 feet on either side of Mill Creek, from OH 11 to Columbiana Canfield Rd.	
Hydrology	Mill Creek	
Township(s)	Boardman, Beaver	

The distribution of the Target Areas within the study area is shown in Figure 4.1. This figure also shows the GIS overlay system used in the selection of Target Areas. Four of the five Target Areas are situated in the upland areas along the western edge of their respective watershed. Closer views of the Target Areas in the Meander Creek and Mill Creek watersheds are shown in Figures 4.2 and 4.3, respectively. Yellow Creek did not produce a target area of significant size due to its hilly topography. A closer view of Yellow Creek is provided in Figure 4.4.

The Target Areas are described as follows:

- Meander Creek 1: Encompassing the northwestern quarter of the watershed, the area is relatively flat and nearly half of the land is forested, containing a few OWI wooded wetlands. (See Figure 4.5)
- Meander Creek 2: Encompassing the southwestern quarter of the watershed, this area to is also relatively flat and has predominantly hydric soils. (See Figure 4.6)
- Mill Creek 1: The smallest of the Target Areas has predominantly agricultural land cover, and lies in the upland region in the southwestern portion of the watershed. (See Figure 4.7)
- Mill Creek 2: The next smallest Target Area has predominantly agricultural land cover, and also lies in the upland region in the southwestern section of the watershed. (See Figure 4.8)
- Mill Creek 3: This Target Area lies along Mill Creek from Interstate 76 (Ohio Turnpike) south to Columbiana. It contains a fish farm created from existing OWI wetlands. (See Figure 4.9)

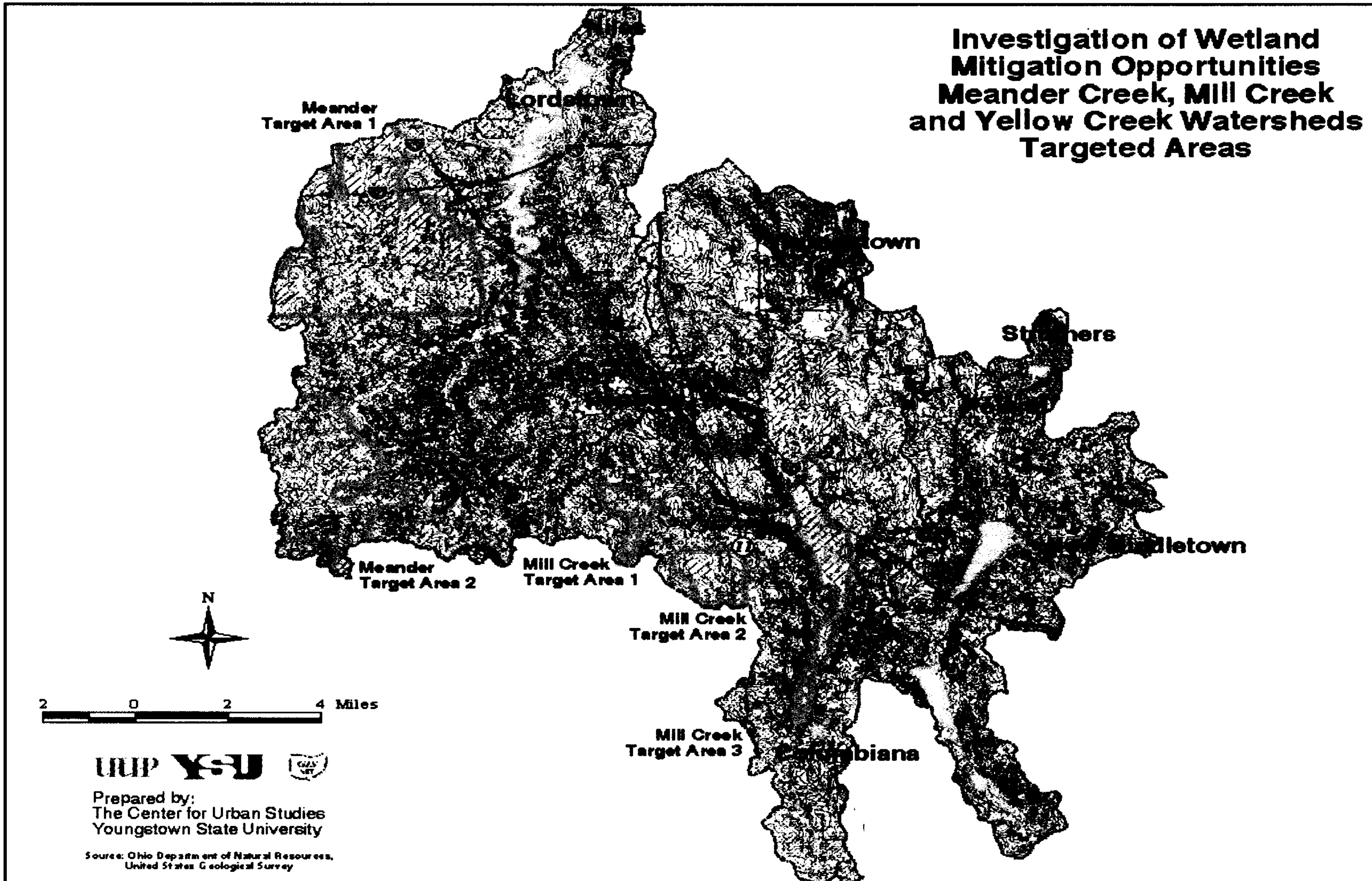


Figure 4.1 Map of Target Areas Identified within the Study Area

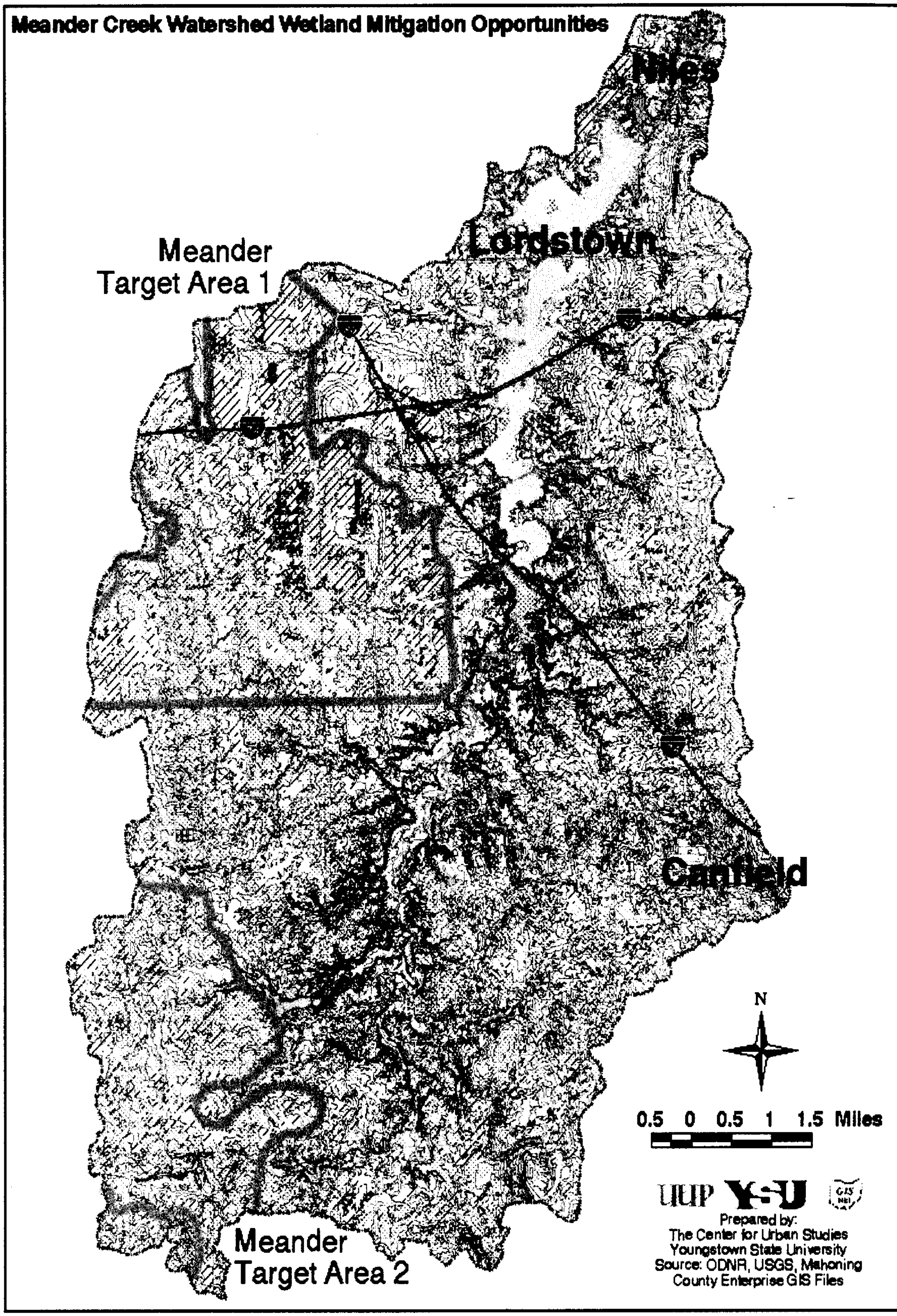


Figure 4.2 Map of Target Areas in Meander Creek Watershed

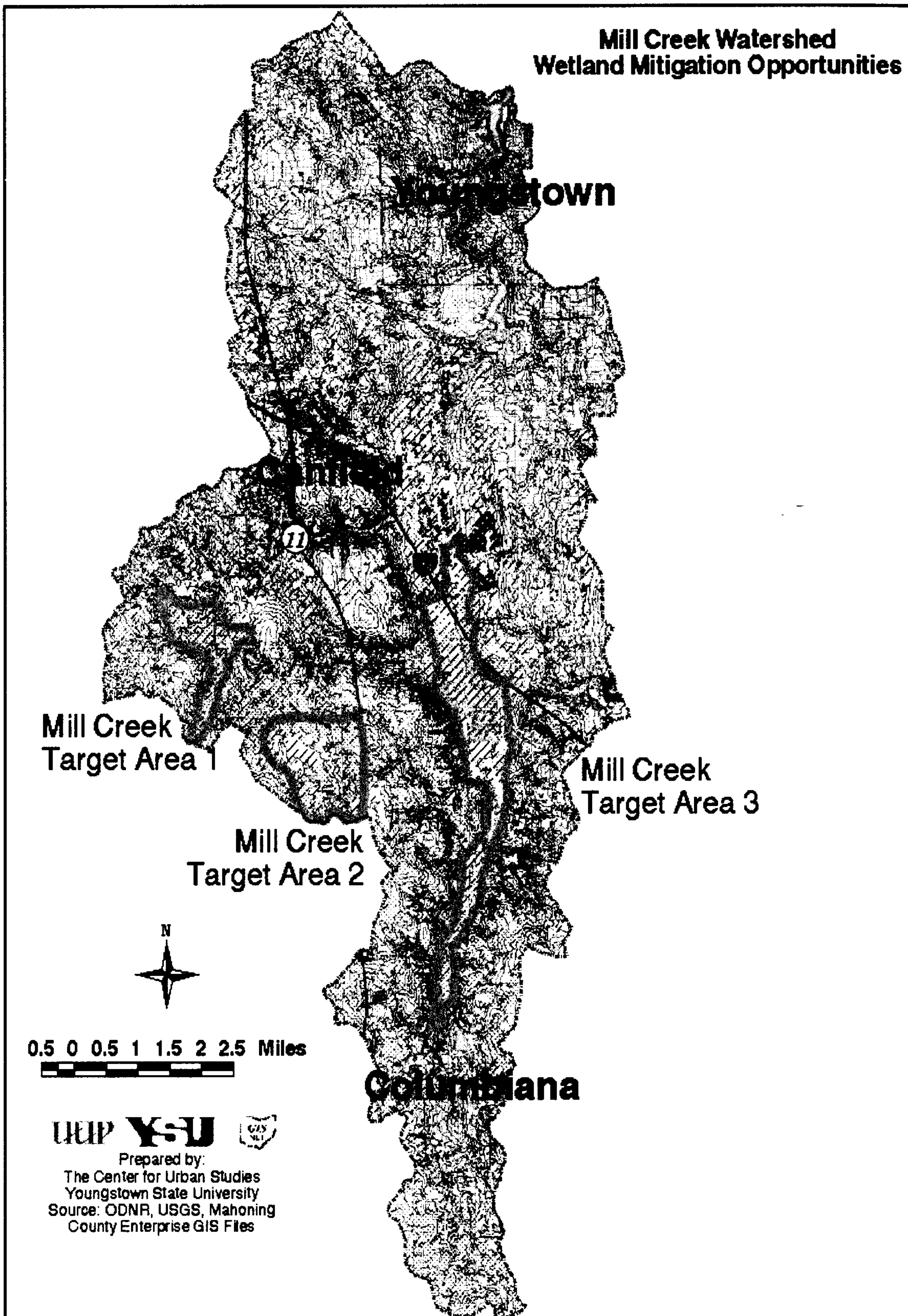


Figure 4.3 Map of Target Areas in Mill Creek Watershed

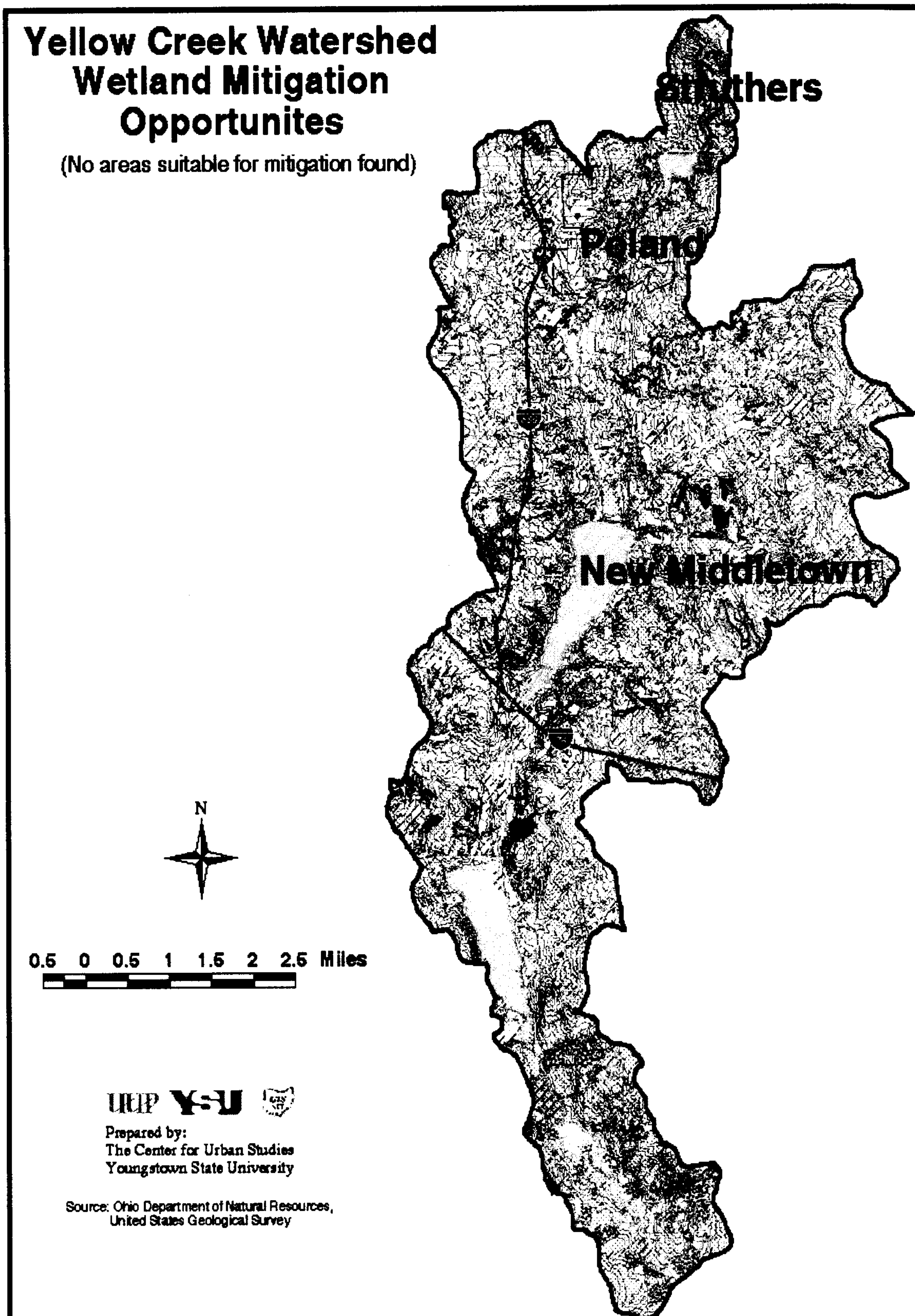


Figure 4.4 Map of Target Areas in Yellow Creek Watershed

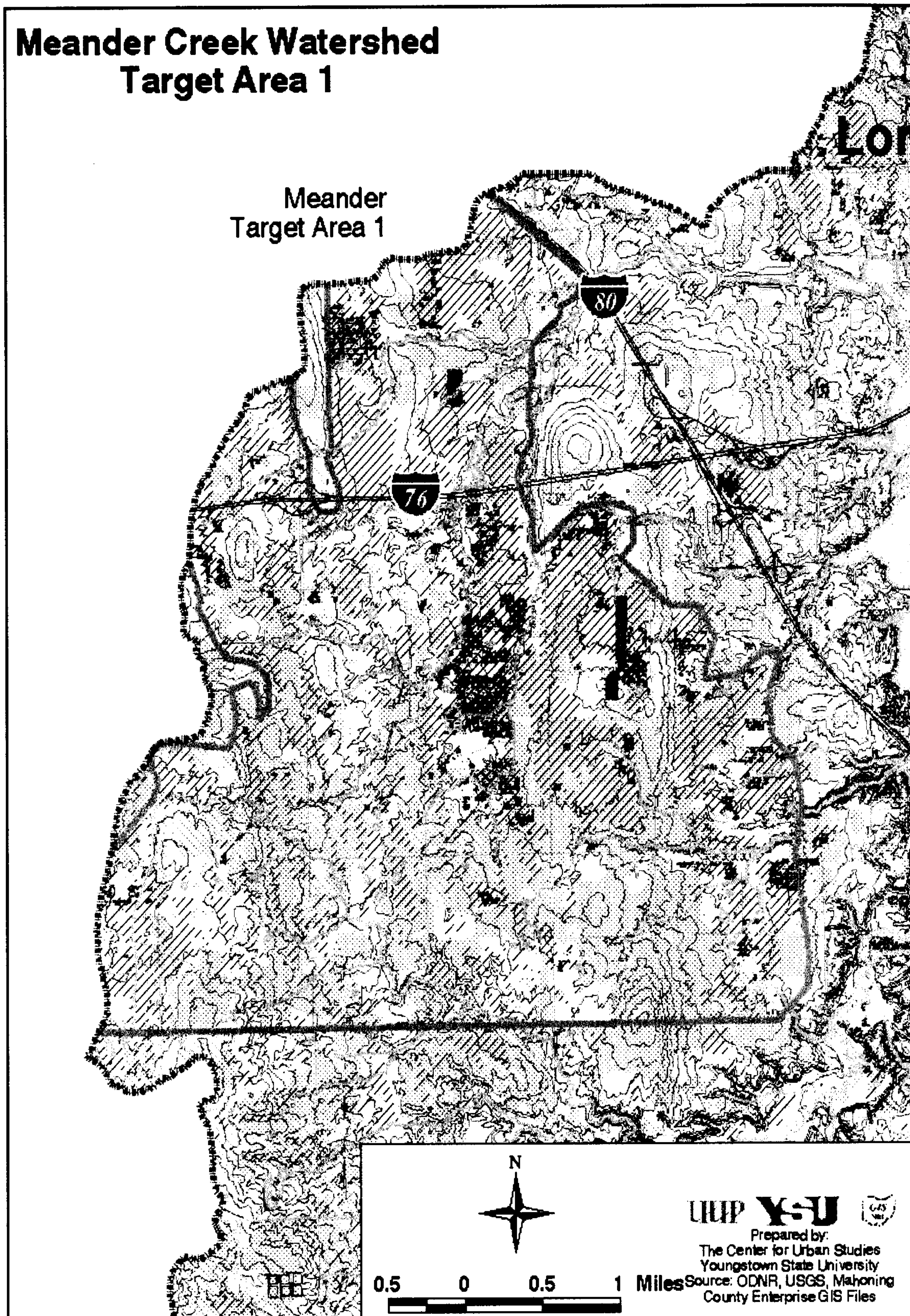


Figure 4.5 Map of Meander Creek Target Area 1

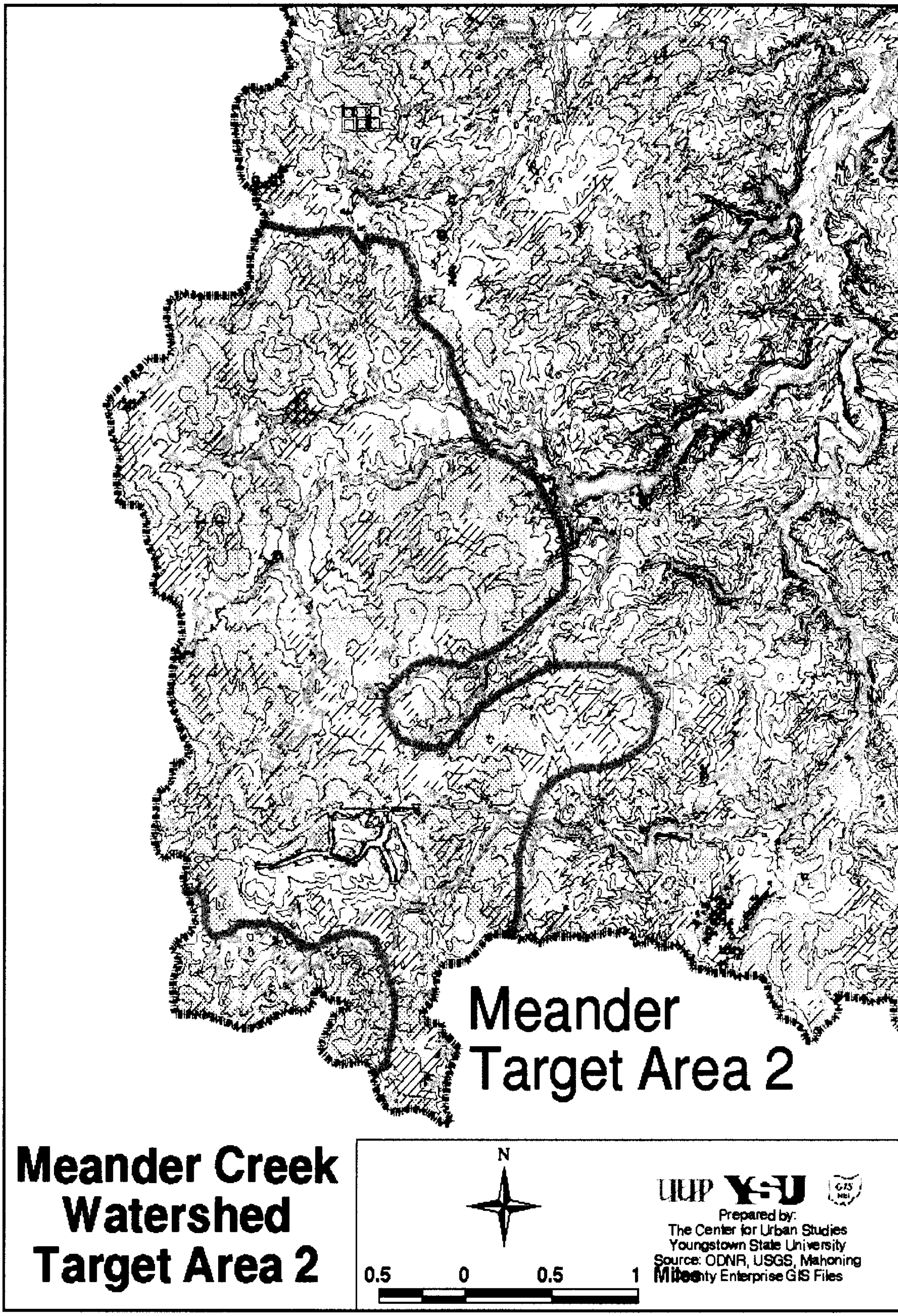


Figure 4.6 Map of Meander Creek Target Area 2

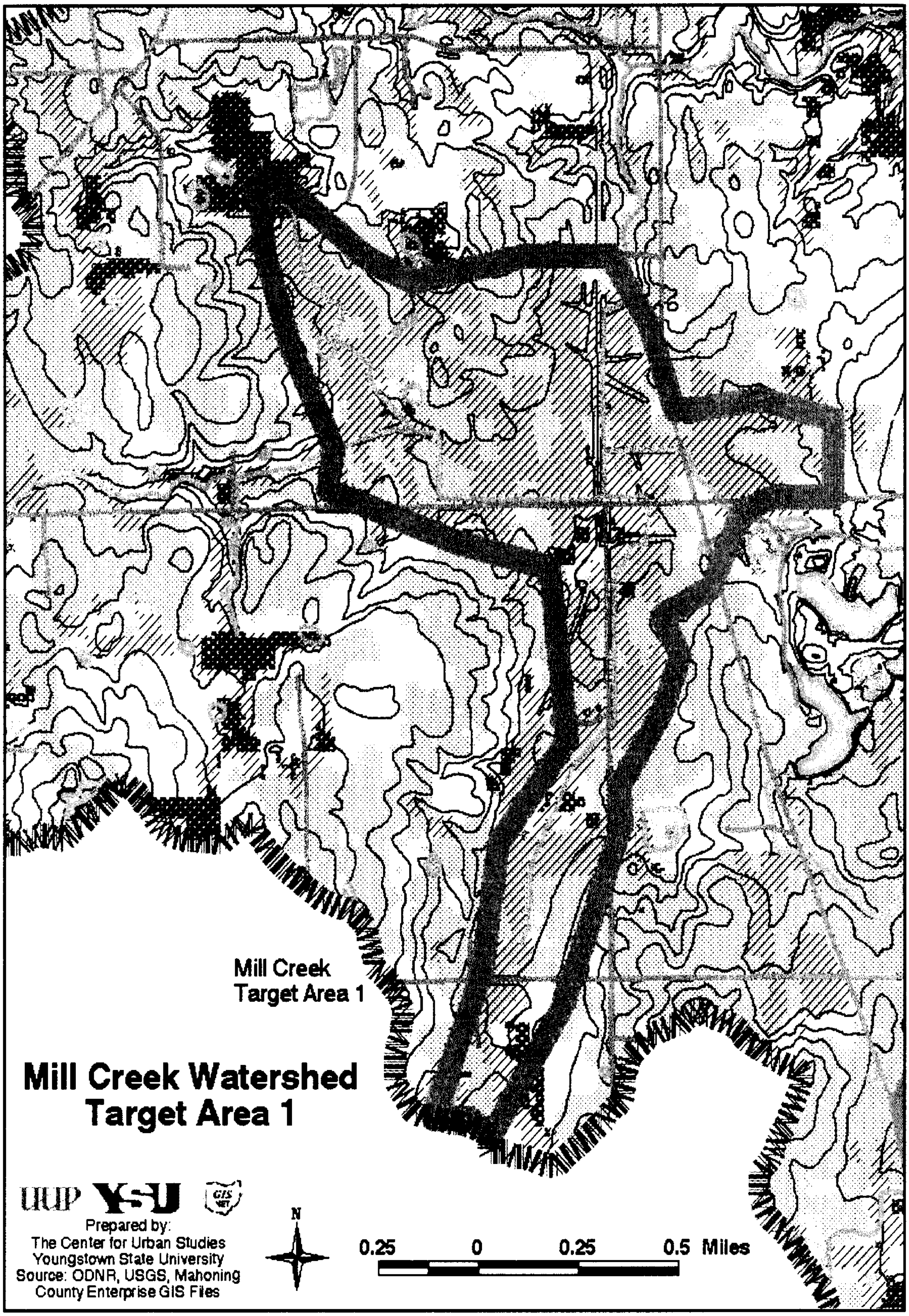


Figure 4.7 Map of Mill Creek Target Area 1

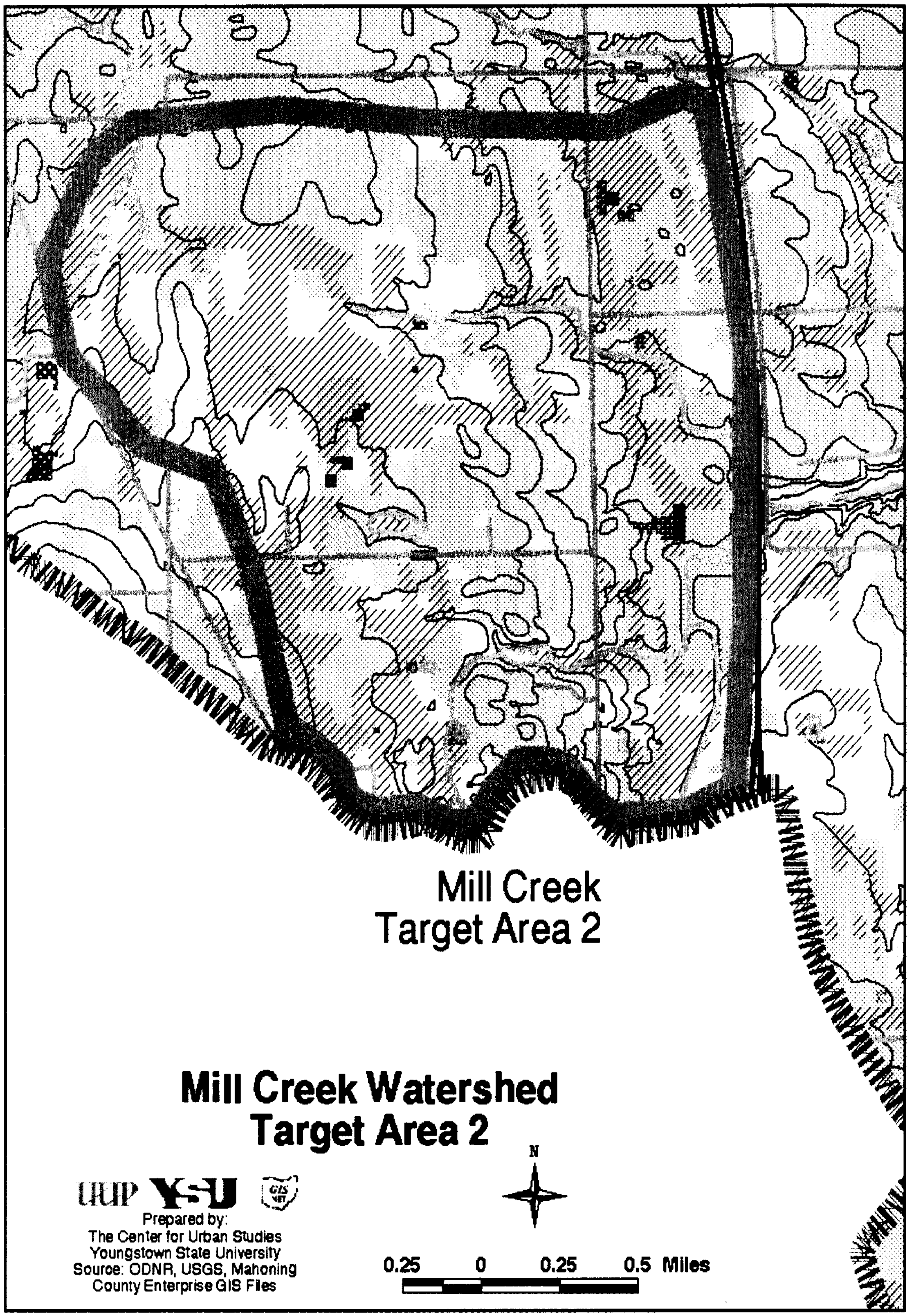


Figure 4.8 Map of Mill Creek Target Area 2

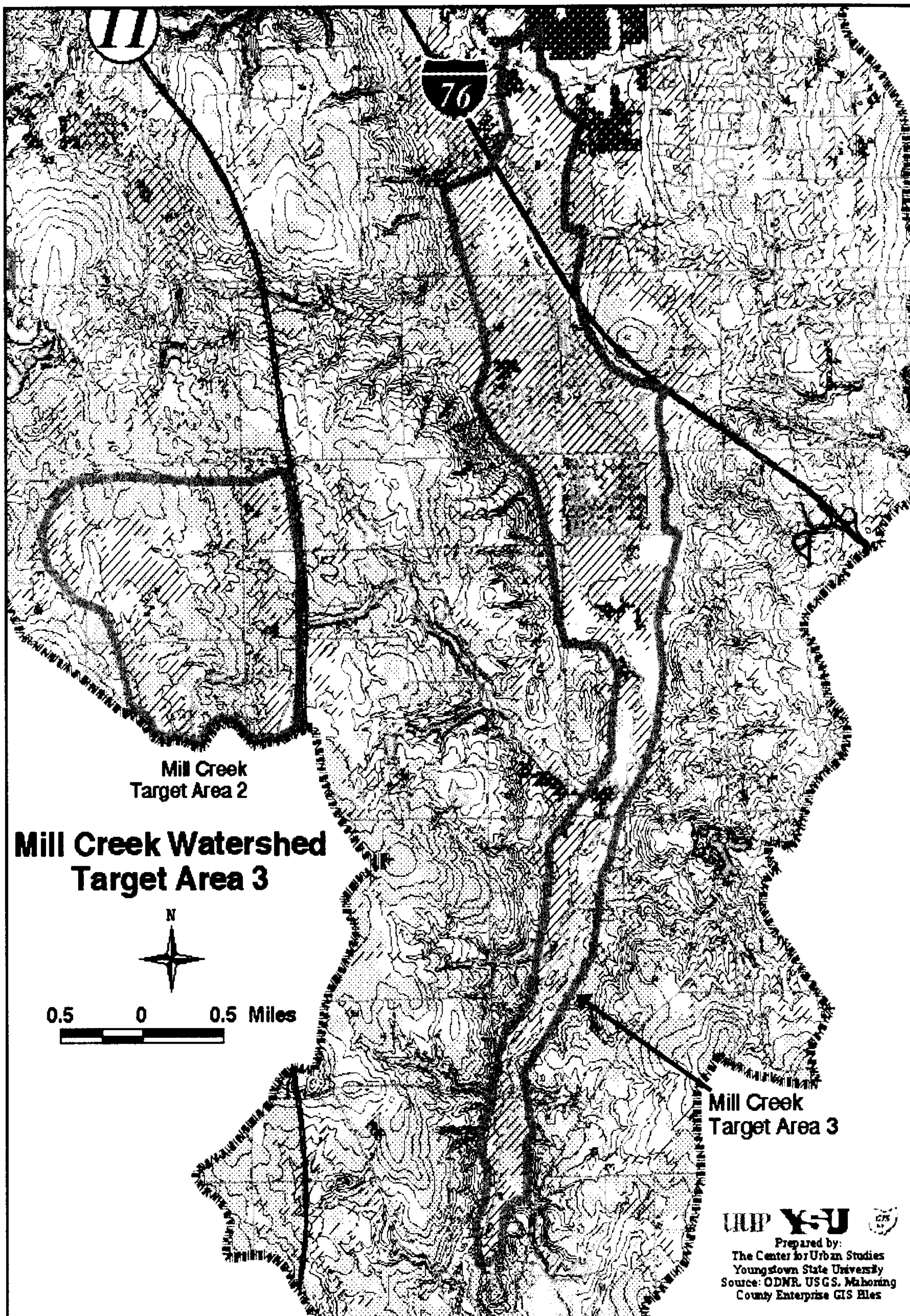


Figure 4.9 Map of Mill Creek Target Area 3

4.3 Description of Candidate Areas

Five smaller (65-200 acre) Candidate Areas were chosen from the Target Areas, and were evaluated for wetland mitigation potential using the ranking system. The distribution of the Candidate Areas within the study area is shown in Figure 4.10. Meander Creek Candidate Areas 1, 2, and 4 came from Meander Creek Target Area 1 and Meander Creek Candidate Area 3 came from Meander Creek Target Area 2. Mill Creek Target Area 1 produced the lone Candidate Area from Mill Creek.

The Candidate Areas are described below and the maps in the following figures are annotated with figure numbers and NWI nomenclature to show the location of each photograph and wetland accompanying the map, respectively:

- Meander Creek 1: Although shown in the GIS overlay as forested, the aerial photographs revealed the forested area was actually younger saplings and thick underbrush on partially state-owned land. (See Figure 4.11 and the photographs in Figures A.1 – A.3 in the Appendix)
- Meander Creek 2: The area has a perennial stream running through an active farm, with the farmer already protecting a portion of the riparian zone. (See Figure 4.12 and the photographs in Figures A.4 – A.5 in the Appendix)
- Meander Creek 3: A 10-acre section of this area may be a wetland that has yet to be delineated and contains predominantly hydric soils throughout. (See Figure 4.13 and the photographs in A.6 – A.8 in the Appendix)
- Meander Creek 4: The smallest of the areas; a perennial stream bisects the exclusively hydric forested and farmed land. (See Figure 4.14 and the photographs in Figures A.9 – A.11 in the Appendix)

- Mill Creek 1: A perennial stream has been diverted around the property with hydric farmland that lacks signs of consistent cultivation. (See Figure 4.15 and the photographs in Figures A.12 – A.13 in the Appendix)

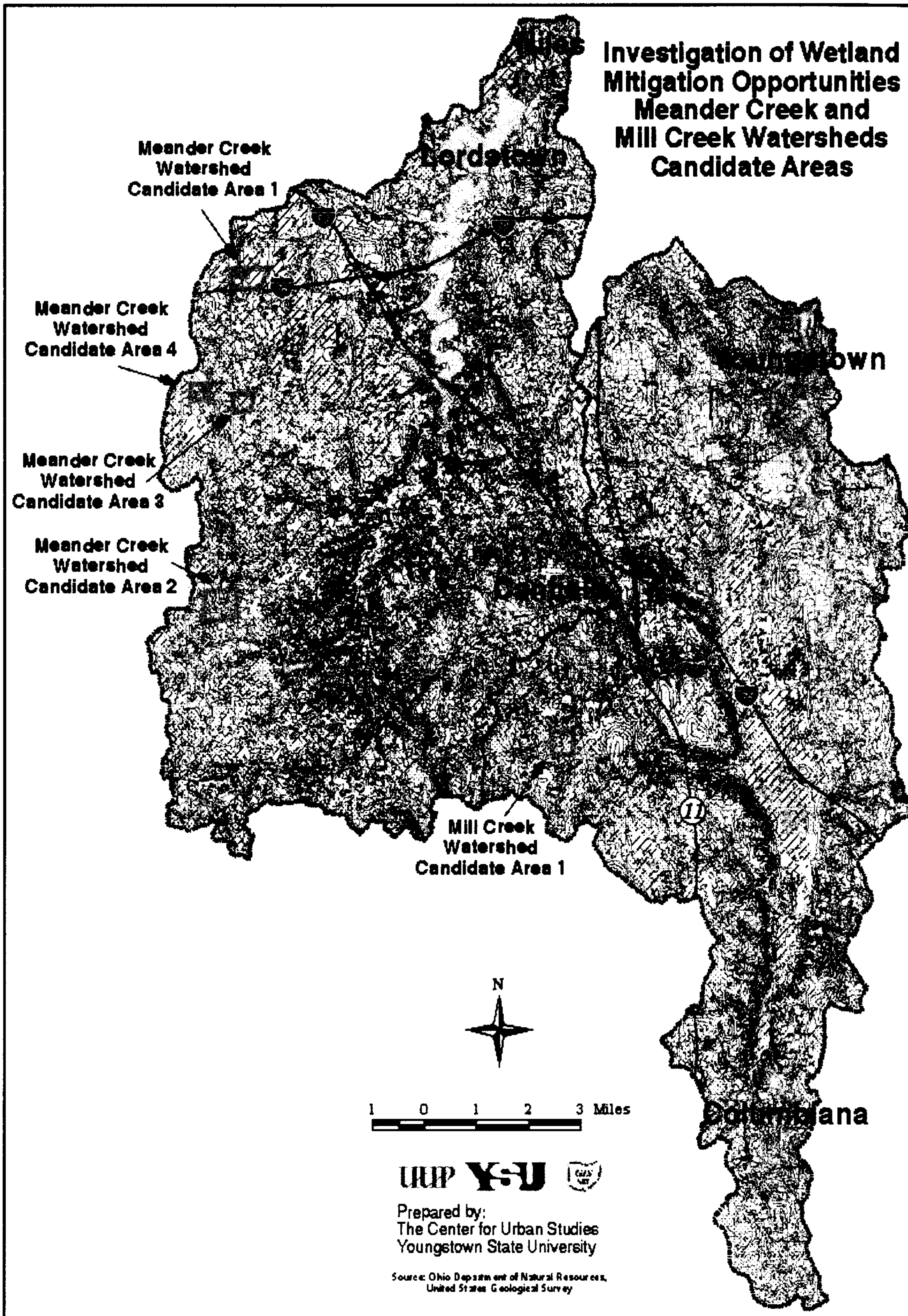


Figure 4.10 Map of Candidate Areas Identified within the Study Area

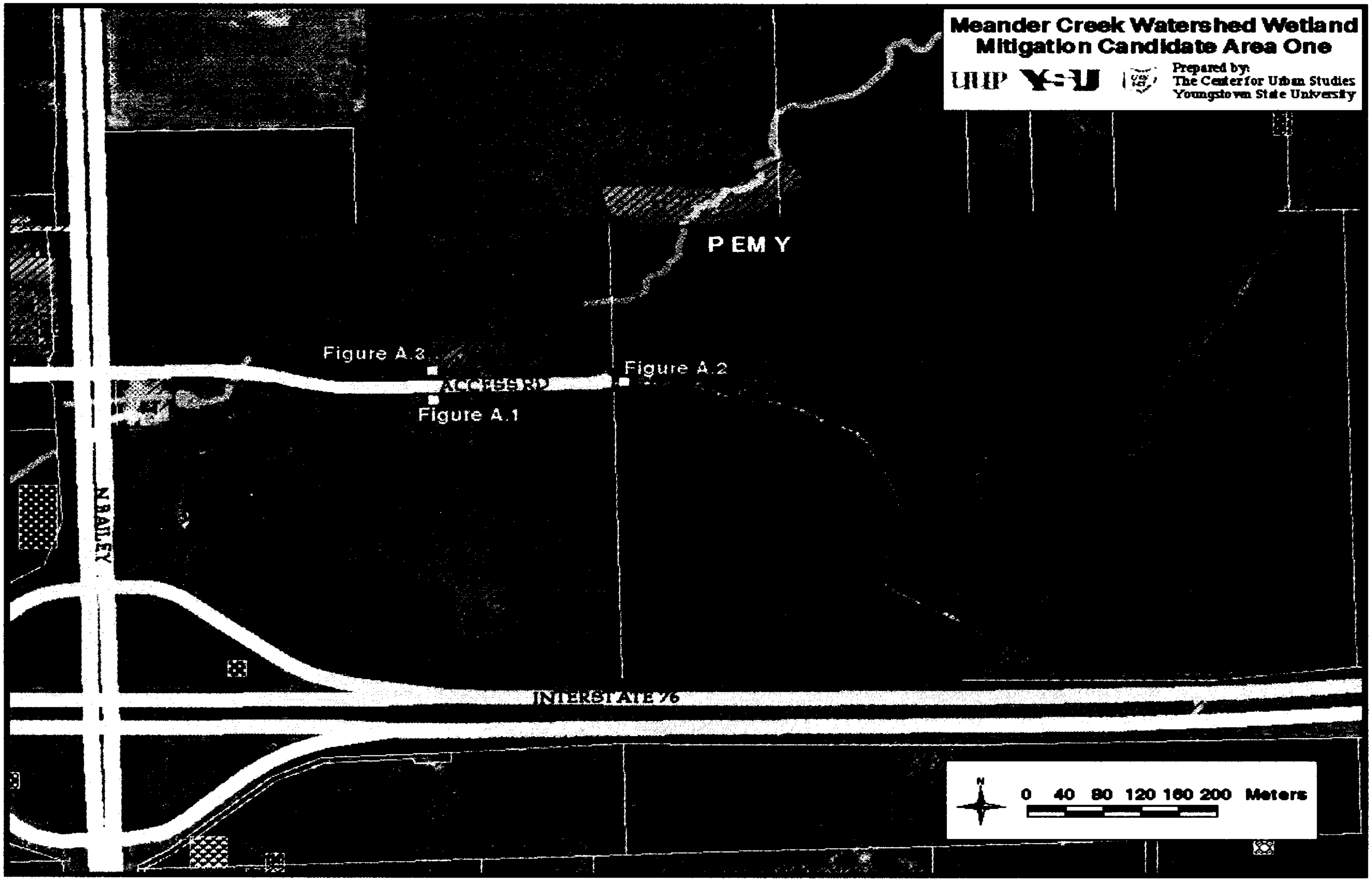


Figure 4.11 Map of Meander Creek Candidate Area 1

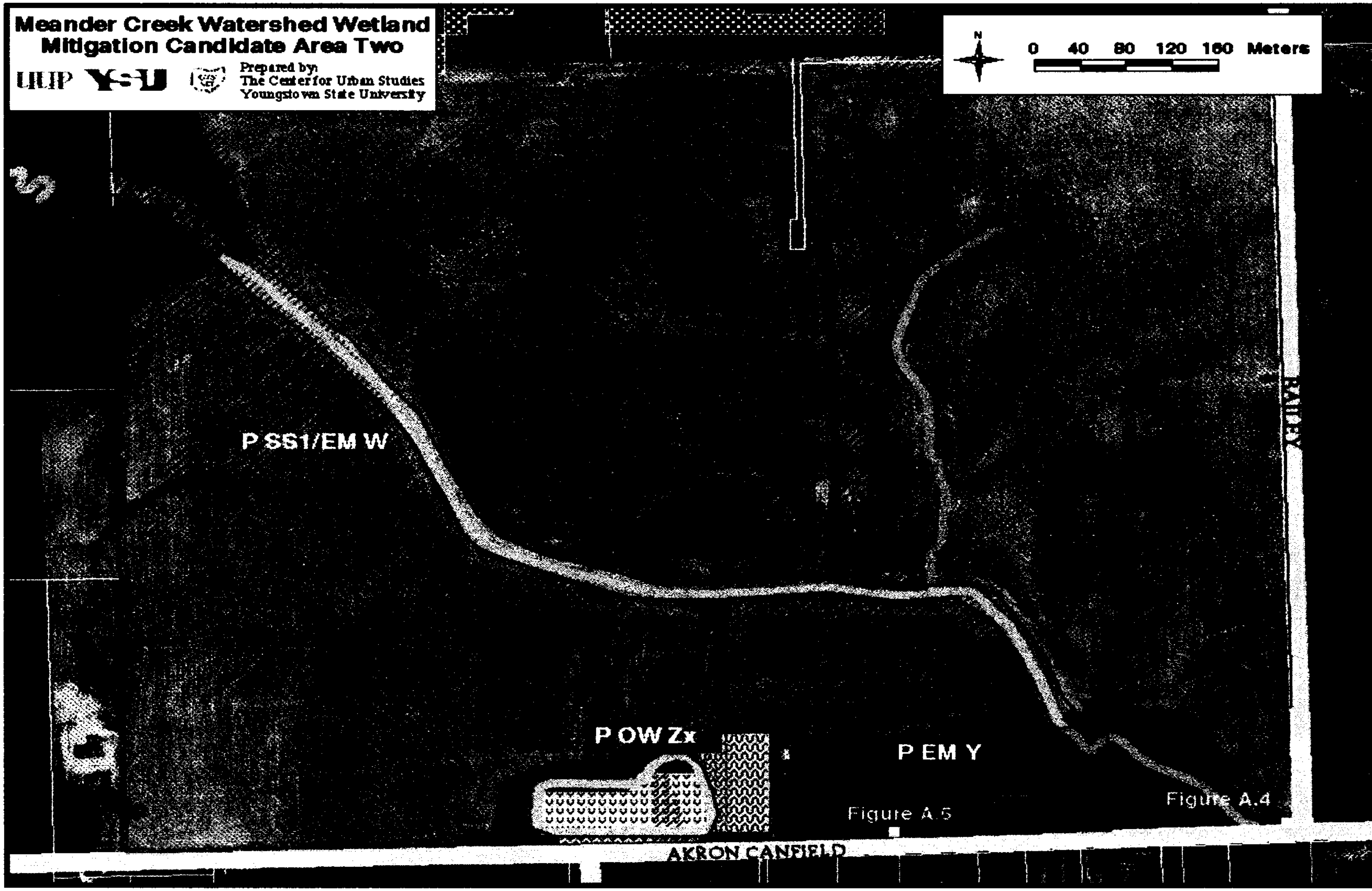


Figure 4.12 Map of Meander Creek Candidate Area 2

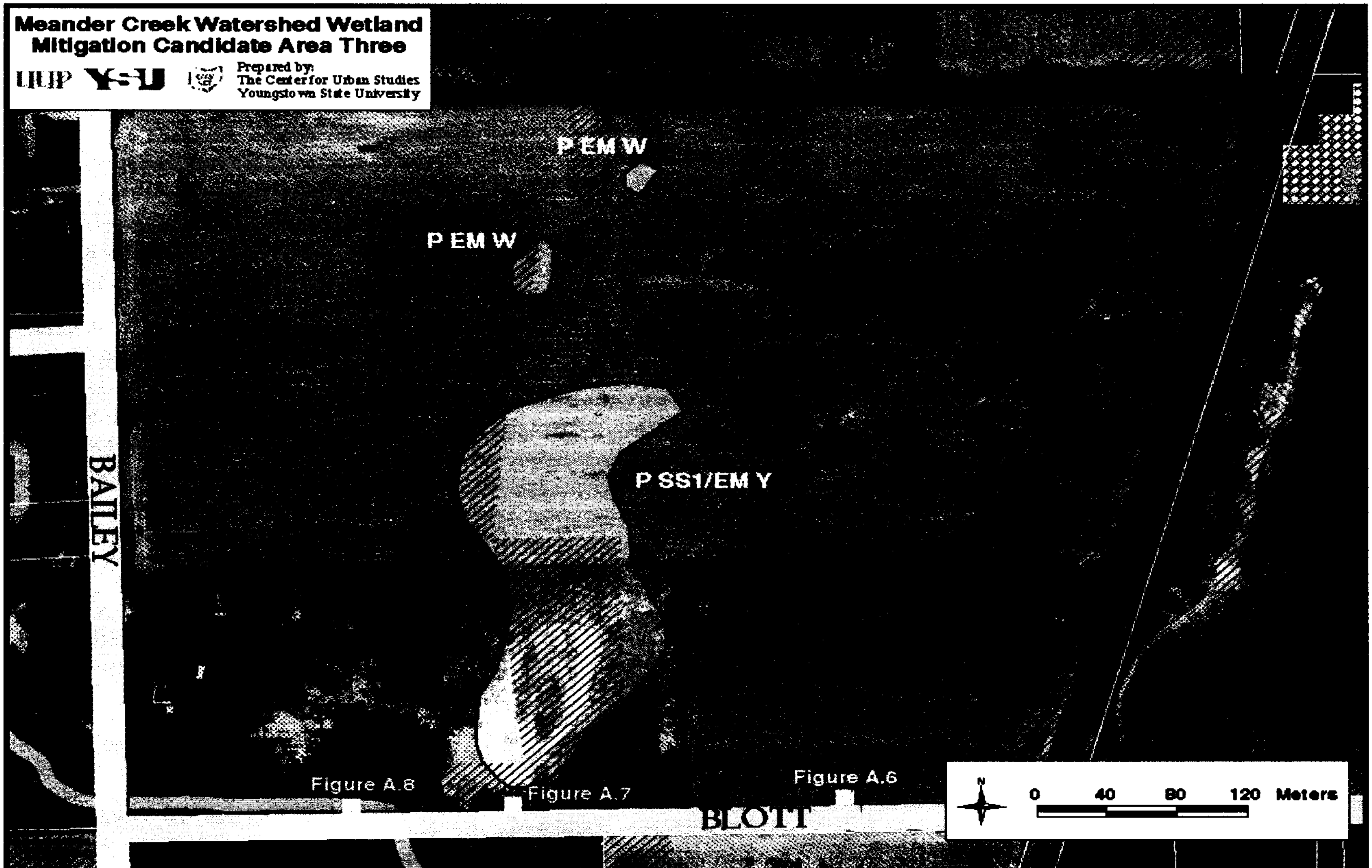


Figure 4.13 Map of Meander Creek Candidate Area 3

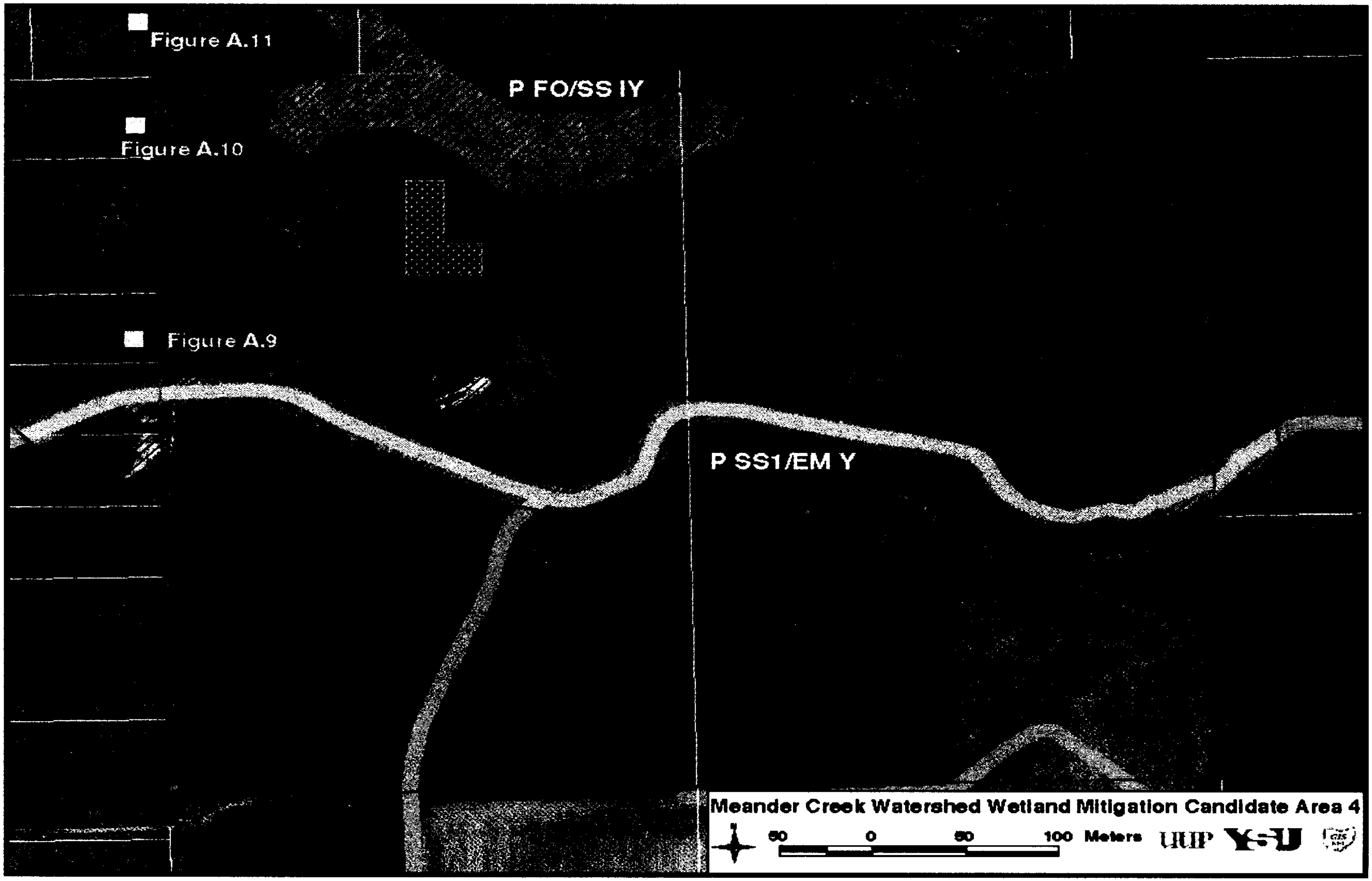


Figure 4.14 Map of Meander Creek Candidate Area 4

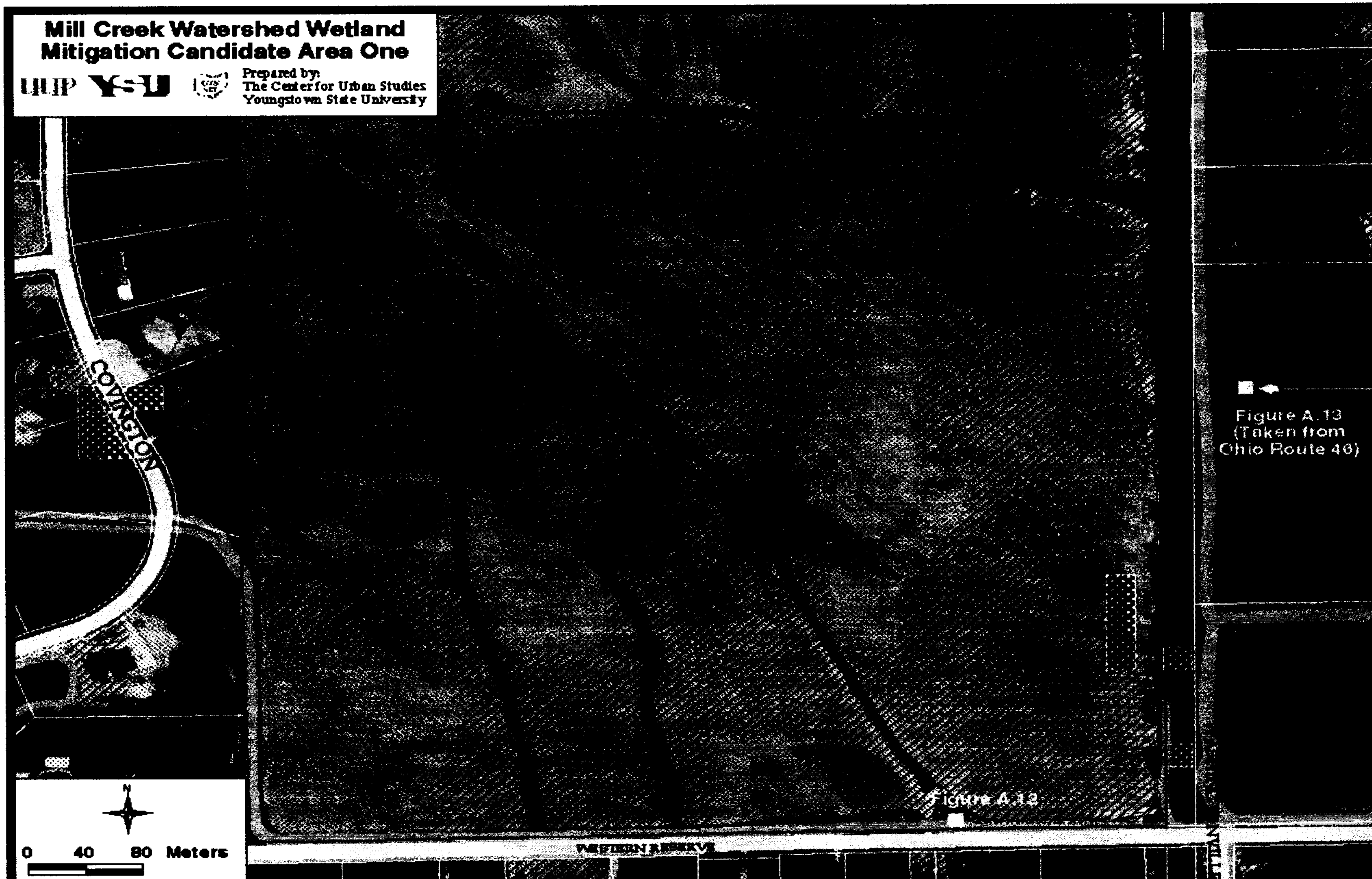


Figure 4.15 Map of Mill Creek Candidate Area 1

4.4 Candidate Area Site Descriptions, Background Information, and Ranked Scores

Using the portion of the NWI legend shown in Figure 4.16, wetland ecosystems in the selected Candidate Areas are characterized as Palustrine, supporting forested and mostly emergent vegetation. The GIS-based application of the ranking system generally agreed with the field observations. However, a few discrepancies were noted. Field observations revealed the following:

- Meander Creek Candidate Area 2 showed conditions differing both favorably and unfavorably for mitigation. Although Meander Creek Area 2 already contains a protected riparian zone on the property, the site is currently an active farm.
- Meander Creek Candidate Areas 1 and 3 had conditions differing favorably for mitigation. Although the GIS showed forested in Meander Creek Candidate Area 1, mostly wooded brush on state-owned property was encountered during field investigations. In Meander Creek Candidate Area 3, cattails in standing water were found at the site which necessitated adjusting the proximity to existing wetlands score from < 1 mile to contiguous.
- Meander Creek Candidate Area 4 and Mill Creek Candidate Area 1 concurred with the GIS evaluation.

Adjustment of the ranking score based on field observations was only deemed necessary for Meander Creek Candidate Area 3. Final site description/background information and the corresponding ranked scores for the five Candidate Areas are shown in Tables 4.4 – 4.13. Although the GIS-based approach worked well and was generally very accurate, these discrepancies illustrate the obvious need for field investigations to either confirm or modify the interpretation of the map overlay.

ECOLOGICAL SYSTEM	P - Palustrine								
No Subsystem									
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	FL - Flat	ML - Moss/Lichen	EM - Emergent	SS - Scrub/Shrub	FO - Forested	OW - Open Water/ Unknown Bottom
Subclass	1 Bedrock	1 Cobble/Gravel	1 Submergent Algal	1 Cobble/Gravel	1 Moss	1 Persistent	1 Broad-leaved Deciduous	1 Broad-leaved Deciduous	
	2 Boulder	2 Sand	2 Submergent Vascular	2 Sand	2 Lichen	2 Nonpersistent	2 Needle-leaved Deciduous	2 Needle-leaved Deciduous	
		3 Mud	3 Submergent Moss	3 Mud		3 Narrow-leaved Nonpersistent	3 Broad-leaved Evergreen	3 Broad-leaved Evergreen	
		4 Organic	4 Floating-leaved	4 Organic		4 Broad-leaved Nonpersistent	4 Needle-leaved Evergreen	4 Needle-leaved Evergreen	
			5 Floating	5 Vegetated Pioneer		5 Narrow-leaved Persistent	5 Dead	5 Dead	
			6 Unknown submergent	6 Vegetated Non-pioneer		6 Broad-leaved Persistent	6 Deciduous	6 Deciduous	
			7 Unknown surface				7 Evergreen	7 Evergreen	

MODIFYING TERMS

In order to more adequately describe wetland and aquatic habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME Non-Tidal		WATER CHEMISTRY pH Modifiers for all Fresh Water	SPECIAL MODIFIERS	
A Temporary	H Permanent	a Acid	b Beaver	h Diked/Impounded
B Saturated	J Intermittently Flooded	t Circumneutral	d Partially Drained/Ditched	r Artificial
C Seasonal	K Artificial	I Alkaline	f Farmed	s Spoil
D Seasonal Well-drained	Z Intermittently Exposed/Permanent			x Excavated
E Seasonal Saturated	W Intermittently Flooded/Temporary			
F Semipermanent	Y Saturated/Semipermanent/Seasonals			
G Intermittently Exposed	U Unknown			

Figure 4.16 Relevant Portion of NWI Legend

Table 4.4 Site Description/Background Information for Meander Creek Candidate Area 1

Candidate Area Site Description & Background Information

1. Candidate Area ID Meander 1
2. Parcel ID 50-014-0-004.00-0, 50-014-0-001.0-0
3. Coordinates or Location Description

   80° 52' 48'' W 41° 6' 36'' N

   Watershed Meander Creek Sub-watershed Morrison Run
4. Size 142.18 acres
5. Are NWI wetlands on-site? **[Yes]** No

   NWI 7.5-minute quadrangle: Lake Milton

   If yes, Type of Wetland

   ___ Open Water (OW)
   ___ Scrub/Shrub (SS)
   ___ Forested (FO)
   X Isolated (EM)

   List all NWI designation(s)
   (i.e. PSS6 - Palustrine, Scrub/shrub, Deciduous)

   PEMY - Palustrine Emergent Saturated/Semipermanent/Seasonals
6. Have OWI wetlands been delineated on-site? Yes **[No]**

Table 4.5 Ranked Score for Meander Creek Candidate Area 1

Meander Creek Candidate Area 1 Ranking Scheme

How well can the environment under review support the development of a wetland?

1) Hydrology	55%
2) Soils	35%
3) Environment capable of supporting hydrophytic vegetation	10%

W	R			W x R	Questions Addressed
35%	**Major Source of Hydrology**				1
	[10]	Perennial			
	7	Intermittent			
	4	Ephemeral (storm event)			
	1	Groundwater discharge			
25%	**Soil Types Present in Candidate Area**				2
	67	% Hydric	× 10 =	6.7	
	0	% Hydric inclusions	× 6 =	0	-
	33	% Non-hydric	× 1 =	0.33	
			Total:	7.03	
20%	**Proximity to Delineated OWI Wetlands or Streams**				1,2,3
	10	Contiguous		(% allocation)	5%, 10%, 5%
	[5]	< 1 mile			
	1	> 1 mile			
15%	**Average Slope**				1
	[10]	0 - 0.5%			
	7	0.5 - 1%			
	2	> 1%			
5%	**Mitigation Buffer from Disturbed Areas**				3
	[10]	> 30 m			
	8	21 - 30 m			
	6	11 - 20 m			
	2	< 10 m			

Field Evaluation:

Concurs with GIS evaluation? Yes [No*]

* List conditions favorably for mitigation

GIS shows forested however, mostly wooded brush found

Partly state-owner property

*List conditions unfavorably for mitigation

Final Score** = Σ W x R =** **8.26**

**Includes adjustments warranted by field observations

Table 4.6 Site Description/Background Information Meander Creek Candidate Area 2

Candidate Area Site Description & Background Information

1. Candidate Area ID Meander 2
2. Parcel ID 23-006-0-005.00-0
3. Coordinates or Location Description

   80° 53' 24'' W   41° 1' 48'' N

   Watershed Meander Creek   Sub-watershed Unnamed
4. Size 196.61 acres
5. Are NWI wetlands on-site? **[Yes]** No

   NWI 7.5-minute quadrangle: Lake Milton

   If yes, Type of Wetland

X	Open Water (OW)
X	Scrub/Shrub (SS)
	Forested (FO)
X	Isolated (EM)

   List all NWI designation(s)

   (i.e. PSS6 - Palustrine, Scrub/shrub, Deciduous)

   PEMY - Palustrine Emergent Saturated/Semipermanent/Seasonals

   $P\frac{SS1}{EM}W$ - Palustrine Broad-leaved Deciduous & Emergent Intermittently Flooded/Temporary

   POWZx - Palustrine Open Water Intermittently Exposed/Permanent Excavated
6. Have OWI wetlands been delineated on-site? **[Yes]** No

Table 4.7 Ranked Score for Meander Creek Candidate Area 2

Meander Creek Candidate Area 2 Ranking Scheme

How well can the environment under review support the development of a wetland?

1) Hydrology	55%
2) Soils	35%
3) Environment capable of supporting hydrophytic vegetation	10%

W	R				W x R	Questions Addressed
35%	**Major Source of Hydrology**					1
	[10]	Perennial				
	7	Intermittent				
	4	Ephemeral (storm event)				
	1	Groundwater discharge				
25%	**Soil Types Present in Candidate Area**					2
	27	% Hydric	× 10 =	2.7		
	49	% Hydric inclusions	× 6 =	2.94		-
	24	% Non-hydric	× 1 =	0.24		
			Total:	5.88		
20%	**Proximity to Delineated OWI Wetlands or Streams**					1,2,3
	10	Contiguous			(% allocation)	5%, 10%, 5%
	[5]	< 1 mile				
	1	> 1 mile				
15%	**Average Slope**					1
	10	0 - 0.5%				
	7	0.5 - 1%				
	[2]	> 1%				
5%	**Mitigation Buffer from Disturbed Areas**					3
	[10]	> 30 m				
	8	21 - 30 m				
	6	11 - 20 m				
	2	< 10 m				

Field Evaluation:

Concurs with GIS evaluation? Yes [No*]

* List conditions favorably for mitigation

Farmer protects riparian zone on property

*List conditions unfavorably for mitigation

Active farm

Final Score = Σ W x R =** 6.77

**Includes adjustments warranted by field observations

Table 4.8 Site Description/Background Information Meander Creek Candidate Area 3

Candidate Area Site Description & Background Information

1. Candidate Area ID Meander 3

2. Parcel ID 50-0018-0-006.00-0

3. Coordinates or Location Description

   80° 52' 48'' W 41° 4' 48'' N

   Watershed Meander Creek   Sub-watershed North Fork Creek

4. Size 71.83 acres

5. Are NWI wetlands on-site? **[Yes]** No

   NWI 7.5-minute quadrangle: Lake Milton

   If yes, Type of Wetland
   - X Open Water (OW)
   - X Scrub/Shrub (SS)
   - __ Forested (FO)
   - X Isolated (EM)

   List all NWI designation(s)
   (i.e. PSS6 - Palustrine, Scrub/shrub, Deciduous)

   PEMW - Palustrine Emergent Intermittently Flooded/Temporary

   $P\frac{SS1}{EM}Y$ - Palustrine Broad-leaved Deciduous & Emergent Saturated/Semipermanent/Seasonals

6. Have OWI wetlands been delineated on-site? **[Yes]** No

Table 4.9 Ranked Score for Meander Creek Candidate Area 3

Meander Creek Candidate Area 3 Ranking Scheme

How well can the environment under review support the development of a wetland?

1) Hydrology	55%
2) Soils	35%
3) Environment capable of supporting hydrophytic vegetation	10%

W	R			W x R	Questions Addressed
35%	**Major Source of Hydrology**				1
	10	Perennial			
	7	Intermittent			
	[4]	Ephemeral (storm event)			
	1	Groundwater discharge			
25%	**Soil Types Present in Candidate Area**				2
	34	% Hydric	× 10 =	3.4	
	47	% Hydric inclusions	× 6 =	2.82	-
	19	% Non-hydric	× 1 =	0.19	
			Total:	6.41	
20%	**Proximity to Delineated OWI Wetlands or Streams**				1,2,3
	[10]	Contiguous		(% allocation)	5%, 10%, 5%
	[~~5~~]	< 1 mile			
	1	> 1 mile			
15%	**Average Slope**				1
	[10]	0 - 0.5%			
	7	0.5 - 1%			
	2	> 1%			
5%	**Mitigation Buffer from Disturbed Areas**				3
	[10]	> 30 m			
	8	21 - 30 m			
	6	11 - 20 m			
	2	< 10 m			

Field Evaluation:

Concurs with GIS evaluation? Yes [No*]

* List conditions favorably for mitigation

Cattails in standing water strongly favor wetlands on-site

Proximity score adjusted from < 1 mile to Contiguous

*List conditions unfavorably for mitigation

Final Score = Σ W x R =** 7.00

**Includes adjustments warranted by field observations

Table 4.10 Site Description/Background Information Meander Creek Candidate Area 4

Candidate Area Site Description & Background Information

1. Candidate Area ID Meander 4

2. Parcel ID 50-003-0-010.00-0, 50-003-0-011.0-0

3. Coordinates or Location Description

   80° 54' 0'' W   41° 4' 48'' N

   Watershed Meander Creek   Sub-watershed North Fork Creek

4. Size 65.35 acres

5. Are NWI wetlands on-site? **[Yes]** No

   NWI 7.5-minute quadrangle: Lake Milton

   If yes, Type of Wetland

	Open Water (OW)
X	Scrub/Shrub (SS)
X	Forested (FO)
X	Isolated (EM)

   List all NWI designation(s)

   (i.e. PSS6 - Palustrine, Scrub/shrub, Deciduous)

   $P\frac{FO}{SS}1Y$ - Palustrine Forested & Scrub/Shrub Alkaline Saturated/Semipermanent/Seasonals

   $P\frac{SS1}{EM}Y$ - Palustrine Broad-leaved Deciduous & Emergent Saturated/Semipermanent/Seasonals

6. Have OWI wetlands been delineated on-site? **[Yes]** No

Table 4.11 Ranked Score for Meander Creek Candidate Area 4

Meander Creek Candidate Area 4 Ranking Scheme

How well can the environment under review support the development of a wetland?

1) Hydrology	55%
2) Soils	35%
3) Environment capable of supporting hydrophytic vegetation	10%

W	R			W x R	Questions Addressed
35%	**Major Source of Hydrology**				1
	[10]	Perennial			
	7	Intermittent			
	4	Ephemeral (storm event)			
	1	Groundwater discharge			
25%	**Soil Types Present in Candidate Area**				2
	39	% Hydric	× 10 =	3.9	
	61	% Hydric inclusions	× 6 =	3.66	-
	0	% Non-hydric	× 1 =	0	
			Total:	7.56	
20%	**Proximity to Delineated OWI Wetlands or Streams**				1,2,3
	[10]	Contiguous		(% allocation)	5%, 10%, 5%
	5	< 1 mile			
	1	> 1 mile			
15%	**Average Slope**				1
	10	0 - 0.5%			
	7	0.5 - 1%			
	[2]	> 1%			
5%	**Mitigation Buffer from Disturbed Areas**				3
	[10]	> 30 m			
	8	21 - 30 m			
	6	11 - 20 m			
	2	< 10 m			

Field Evaluation:

Concurs with GIS evaluation? [Yes] No*

* List conditions favorably for mitigation

____

____

*List conditions unfavorably for mitigation

____

____

Final Score = Σ W x R =** **9.26**

**Includes adjustments warranted by field observations

Table 4.12 Site Description/Background Information Mill Creek Candidate Area 1

Candidate Area Site Description & Background Information

1. Candidate Area ID Mill Creek 1

2. Parcel ID 26-031-0-001.00-0

3. Coordinates or Location Description

   80° 46' 12'' W 40° 59' 24'' N

   Watershed Mill Creek Sub-watershed Indian Run

4. Size 104.80 acres

5. Are NWI wetlands on-site? Yes **[No]**

   NWI 7.5-minute quadrangle: ________

   If yes, Type of Wetland

   ______ Open Water (OW)

   ______ Scrub/Shrub (SS)

   ______ Forested (FO)

   ______ Isolated (EM)

   List all NWI designation(s)

   (i.e. PSS6 - Palustrine, Scrub/shrub, Deciduous)

6. Have OWI wetlands been delineated on-site? **[Yes]** No

Table 4.13 Ranked Score for Mill Creek Candidate Area 1

Mill Creek Candidate Area 1 Ranking Scheme

How well can the environment under review support the development of a wetland?

1) Hydrology	55%
2) Soils	35%
3) Environment capable of supporting hydrophytic vegetation	10%

W	R				W x R	Questions Addressed
35%	**Major Source of Hydrology**					1
	10	Perennial				
	7	Intermittent				
	4	Ephemeral (storm event)				
	1	Groundwater discharge				
25%	**Soil Types Present in Candidate Area**					2
	66	% Hydric	× 10 =	6.6		
	4	% Hydric inclusions	× 6 =	0.24		-
	30	% Non-hydric	× 1 =	0.3		
			Total:	7.14		
20%	**Proximity to Delineated OWI Wetlands or Streams**					1,2,3
	10	Contiguous			(% allocation)	5%, 10%, 5%
	5	< 1 mile				
	1	> 1 mile				
15%	**Average Slope**					1
	10	0 - 0.5%				
	7	0.5 - 1%				
	2	> 1%				
5%	**Mitigation Buffer from Disturbed Areas**					3
	10	> 30 m				
	8	21 - 30 m				
	6	11 - 20 m				
	2	< 10 m				

Field Evaluation:

Concurs with GIS evaluation? **Yes** No*

* List conditions favorably for mitigation

____

____

*List conditions unfavorably for mitigation

____

____

Final Score = Σ W x R = 8.83**

**Includes adjustments warranted by field observations

The ranked scores of all Candidate Areas are listed in Table 4.14 with corresponding field observations differing either favorably or unfavorably for wetland mitigation.

Table 4.14 Final Ranked Summary of Candidate Areas

Rank	Candidate Area			Score		
	Hydrology	Soils[1]	OWI Proximity	Slope	Buffer	Area
1	Meander Creek 4			9.26		
	Perennial	39% 61%	Contiguous	> 1 %	> 30 m	65.35 acres
2	Mill Creek 1			8.83		
	Perennial	66% 0%	Contiguous	0.5 – 1%	> 30 m	104.80 acres
3	Meander Creek 1[2]			8.26		
	Perennial	67% 0%	< 1 mile	0 – 0.5%	> 30 m	142.18 acres
4	Meander Creek 3[3]			7.00		
	Ephemeral	34% 47%	Contiguous[3]	0 – 0.5%	> 30 m	71.83 acres
5	Meander Creek 2[4]			6.77		
	Perennial	27% 49%	< 1 mile	> 1 %	> 30 m	196.61 acres

[1] % hydric
% non-hydric with hydric inclusions
[2] GIS showed forested yet mostly wooded brush on partly state-owned property
[3] Cattails in standing water found on-site and proximity score adjusted from < 1 mile to contiguous
[4] Favorably protected riparian zone, however actively farmed

This list is the product of the procedure employed to rank sites between 65 and 200 acres as viable wetland mitigation opportunities. The ranking implies the order in which the owners of individual parcels within the Candidate Areas should be approached to further evaluate potential wetland mitigation sites. This will require discussions of landowner interest and further field investigations.

4.5 Methodology Appraisal

The program effectively reduced the Study Area to regions where the three factors conducive to mitigation exist. A strong correlation between the GIS overlay map and actual field observations was obtained. The ranking scheme proved effective in accurately evaluating the criteria most important to successful wetland mitigation. The process does not consider the price or availability of land. Issues such as real estate value, willingness of the landowner to devote the land to mitigation, and tax incentives for donation and protection of wetlands, all complicate the context in which the execution of a mitigation project occurs. Embedded in the screening and ranking system, there is an indirect implication of reduced costs for development of constructed wetlands at the highest ranked sites. That is, it will almost always be less expensive to build constructed wetlands on sites that have all of the natural features typical of wetlands. For such sites, the factors do not have to be artificially constructed or imported from another source.

In addition to hydric soils, a reliable source of water, and suitable land cover, several other factors enhance the likelihood that a mitigated wetland will remain successful (sustained more than 5 years), thereby reducing development and maintenance costs. These include proximity to an abundant hydrophytic vegetation seed bank, a buffer from already developed (disturbed) areas, and gentler slopes. To include landowner preferences in the ranking system would increase subjectivity and detract from the objectivity inherent in a procedure based primarily on physical data. Such issues are left to the business and marketing aspects of wetland mitigation. The scientific approach to identifying potential mitigation sites produces not only a ranked "wish list" of parcels but also a catalog of wetland features distinguishing their relative strengths and limitations.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Executive Summary

GIS-based screening and ranking procedures were developed to aid in the identification of sites with high potential for wetland mitigation in the Mill Creek, Yellow Creek, and Meander Creek watersheds. The procedures use well established, publicly available data sets, including soil type, land cover, waterways, and topography. The Target Areas produced in the initial screening process represent a little over 17,000 acres (13 %) out of over 130,000 acres in the Study Area. Meander Creek watershed has the highest potential for mitigation, followed by Mill Creek. The Yellow Creek watershed has a low potential for mitigation.

From the Target Areas, five Candidate Areas ranging in size from 65 to 200 acres were selected for a trial application of the ranking system. The ranking system consists of a weighted scoring system developed in conjunction with professionals familiar with wetland mitigation. The score reflects the presence of factors (e.g., hydric soils, perennial water supply, flat topography) conducive to the development of a wetland. Scores for the five Candidate Areas ranged from 6.77 to 9.26 (out of 10). The ranking system appears to be an effective tool for evaluating the strengths of prospective mitigation sites.

It is recommended that the AWARE Wetland Mitigation Committee use the ranking system developed in this study to evaluate many more Candidate Areas within the three watersheds. This will yield a ranked list which can serve as a starting point for approaching landowners to discuss the acquisition of land parcels for wetland mitigation.

In this way, the screening and ranking procedures may contribute to the development of an effective Wetland Mitigation Plan by AWARE.

5.2 Assessment of Methodology

5.2.1 Strengths

The underlying strength of the procedure is its versatility. The procedure could be easily adapted to include successively smaller Candidate Areas with each iteration. The numbers and/or sizes of areas retained with each iteration can be varied with the ranking system still being applicable. The procedure can also be applied to any other watershed or region for which GIS data are available to locate the most promising mitigation opportunities as well as simultaneously mapping locations for the possible presence of existing wetlands yet to be delineated. The ranking system also serves to characterize potential areas identified. Identification of riparian zones, corridors, etc., possessing qualities worth protecting is an additional benefit of the process.

From the land management perspective, the process becomes a blueprint to wetland policy management. From a developer's, wetland scientist's, or engineering consultant's standpoint, the process can contribute to planning, justification, and conceptual design for all phases of wetland development with little pre-existing knowledge or extensive field investigations. Since publicly available data are used, the results are adequately reliable to identify areas worthy of more intensive field investigations, leading to actual design feasibility studies. The ranking not only gives a "wish list" for mitigation, it also portrays which factors affecting mitigation exist on each site, and the degree to which they are present. Thus, the context in which potential mitigation sites fit into the surrounding landscape is more clearly defined.

5.2.2 Limitations

Limitations of the screening and ranking procedures stem primarily from the fact that they fall short of predicting whether the mitigation sites can actually be acquired from the landowner. Ultimately, the owner's preferences often control the feasibility of conducting wetland mitigation on a site, regardless of how appealing the physical characteristics of the property may be. Besides a landowner's willingness to sell, other examples of interests that cannot easily be predicted include a developer's willingness to earmark land for mitigation and the ability of the wetland designer. These concerns are a function of market-controlled cost factors, which this procedure avoids attempting to objectively address. Although the screening/ranking procedure identifies naturally occurring factors conducive to wetland development, good engineering is still needed to create a successful mitigated wetland.

5.3 Future Applications

Despite the relatively few limitations, the methodology has the versatility to serve as a relatively objective decision-making tool for a wide range of applications. A sampling of these applications follows:

- Park district faced with the problem of evaluating several properties donated to the district in terms of selecting the property with the greatest chance of creating a wetland as an addition to current park features.
- The methodology can be applied iteratively to different sized Target and Candidate Areas to produce a more comprehensive list of potential mitigation sites within a study area by simply varying the size requirements.

- Initial screening process could be used to assist in the more sizable task of identifying and delineating all wetlands in a study area.

Used properly, this procedure provides a powerful tool for a variety of technical disciplines and provides a solid foundation for assessing wetland mitigation opportunities.

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APPENDIX

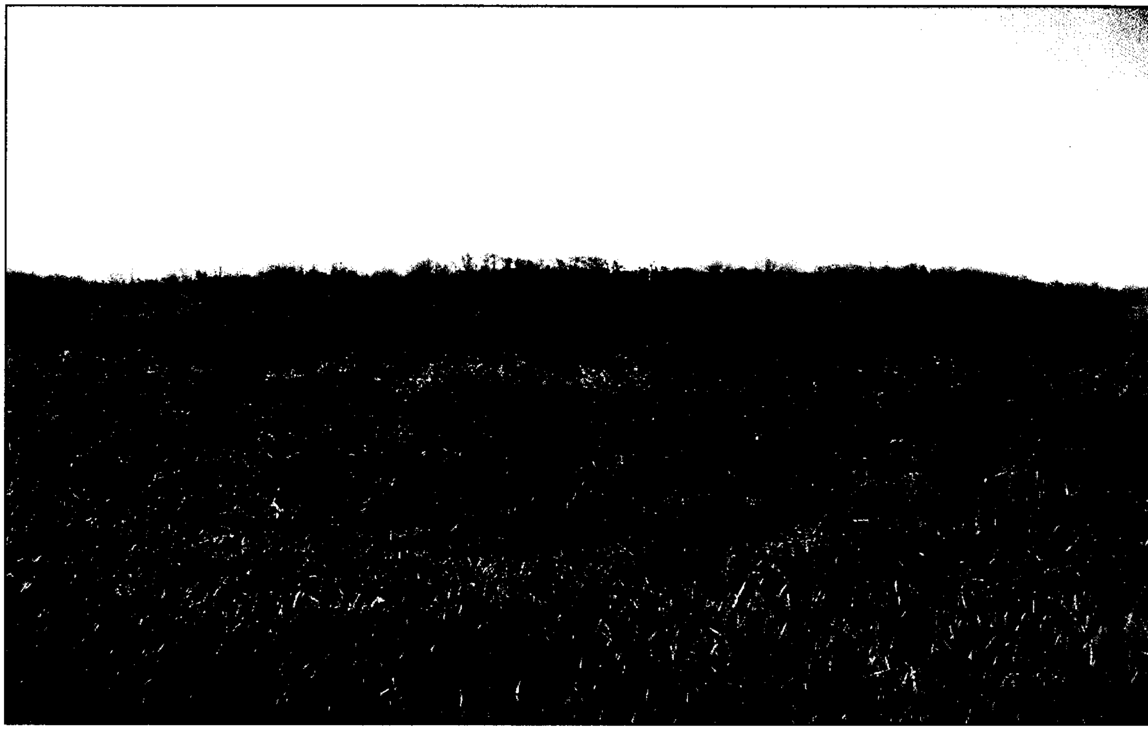

Figure A. 1 Meander 1 looking south from access road – state owned property

Figure A.2 Meander 1 looking east from end of access road – private property


Figure A.3 Meander 1 looking north from access road – state owned property


Figure A.4 Meander 2 looking northwest from U.S. 224 at local riparian zone

Figure A.5 Meander 2 looking north from U.S. 224 at active farmland

Figure A.6 Meander 3 looking northwest from Blott Road

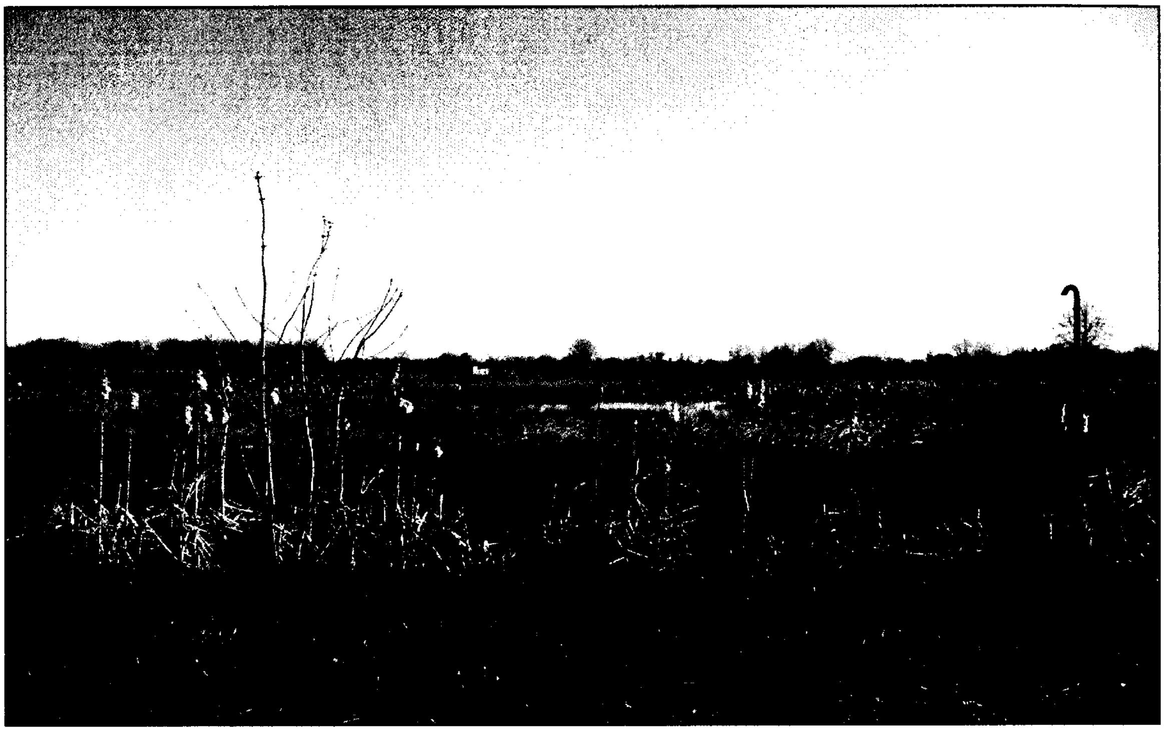

Figure A.7 Meander 3 looking north from Blott Road

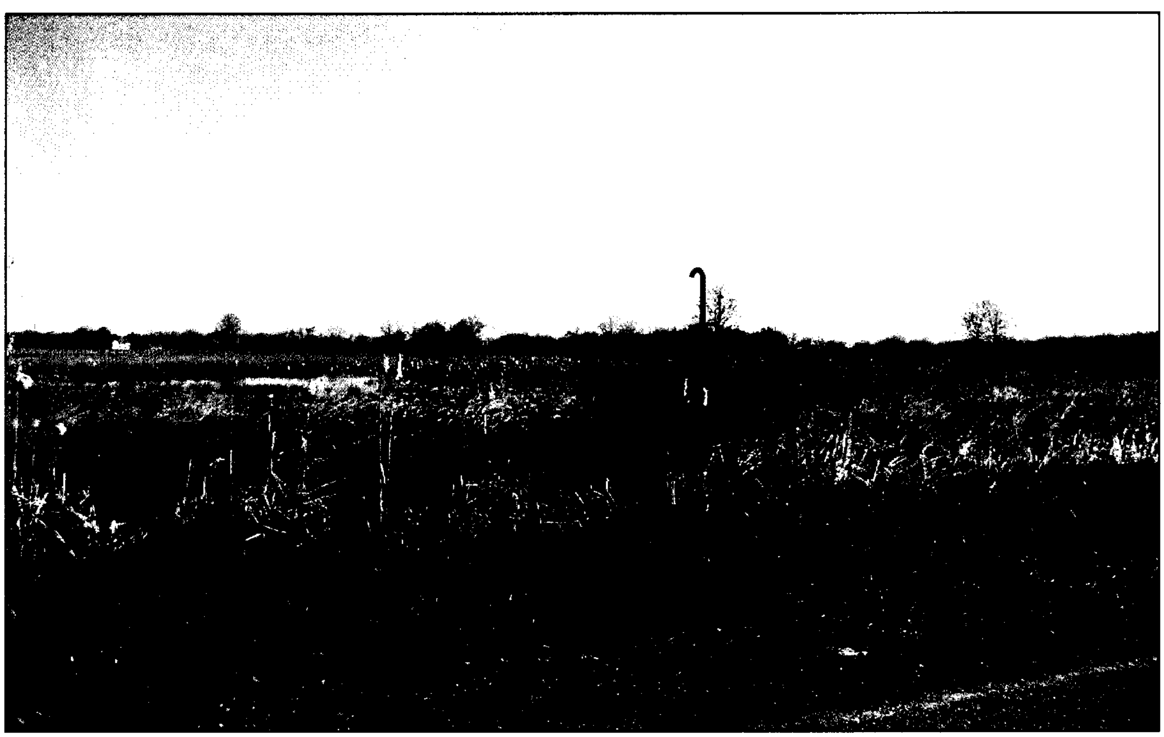

Figure A.8 Meander 3 looking northeast from Blott Road

Figure A.9 Meander 4 looking east from Duck Creek Road. Candidate Area boundary is east of residence

Figure A.10 Meander 4 looking east from Duck Creek Road

Figure A.11 Meander 4 looking east from Duck Creek Road down private access road

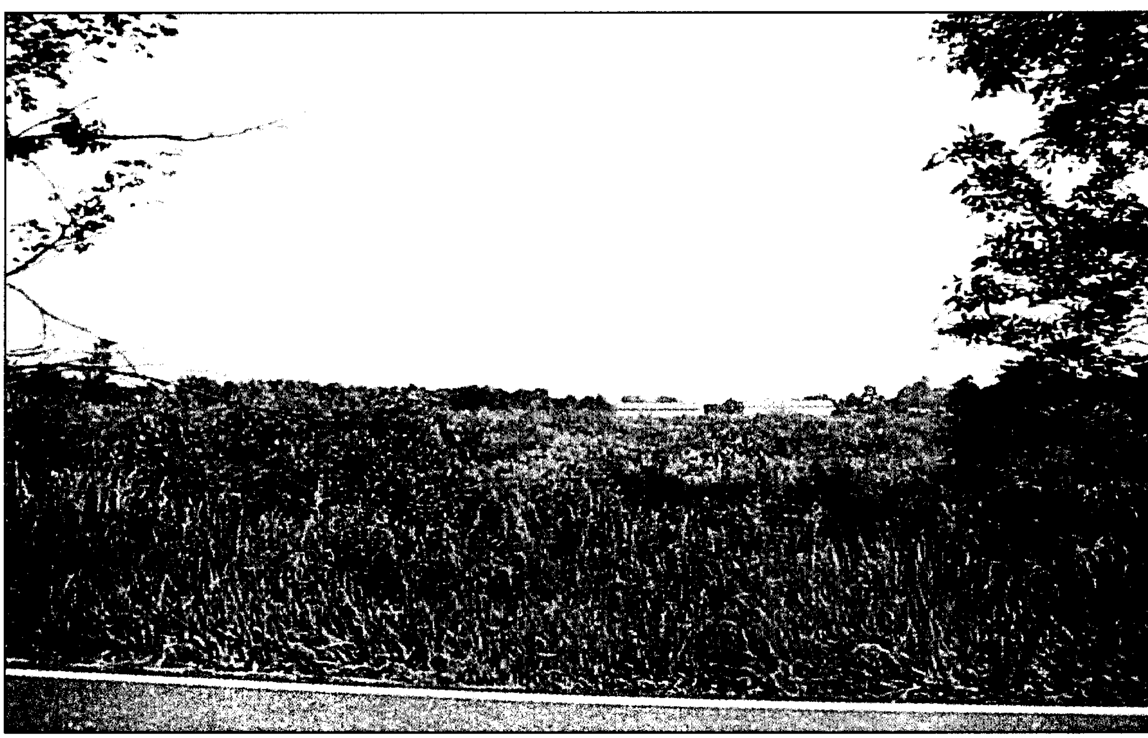

Figure A.12 Mill Creek 1 looking north of Western Reserve Road

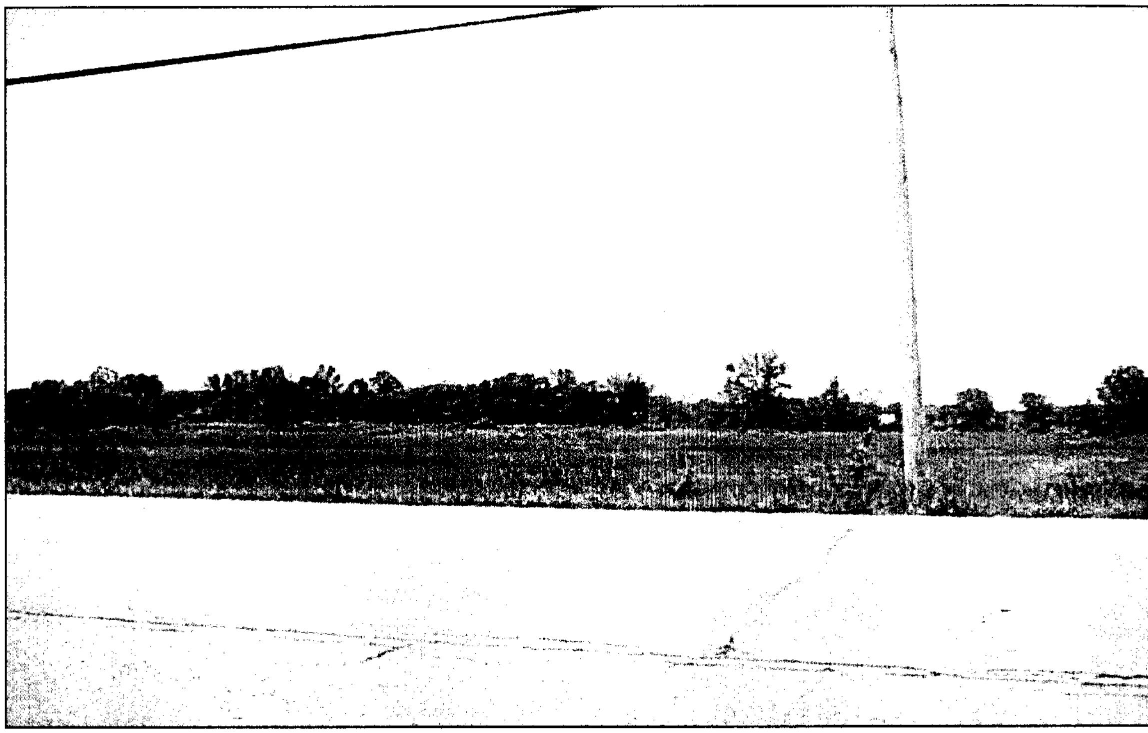

Figure A.13 Mill Creek 1 looking west from Ohio Route 46