**ABSTRACT**

ESSIC, JEFFERSON FORREST. Applications of Geographic Information Systems for Growth Management Planning and Water Quality Protection in the Coastal Region of North Carolina. (Under the direction of Hugh A. Devine.)

Research efforts conducted in coastal areas of North Carolina and other regions have documented numerous examples of negative impacts to estuarine water quality as a result of unplanned and unmanaged development. However, new construction is continuing at a rapid pace in these areas, forcing local planners to make complex decisions regarding land uses and protection of cultural and natural resources.

A Geographic Information System (GIS) is a computer-driven tool that has proven valuable in assisting with this decision making process. GIS technology provides the means to efficiently collect, store, and retrieve vast amounts of spatial data. Then, this information may be visually displayed in a manner that supports better understanding and analysis of the physical environment and the potential impacts of growth.

There have been many instances during the past decade in which GIS has been used to meet the educational and informational needs of citizens and local officials who want to ensure a strong economy and healthy environment is planned for the future of their community. Most of these projects have originated at the state level, either through the North Carolina Cooperative Extension Service, or other agencies.

A number of zoning options and growth management planning measures have recently been recommended that coastal government officials should consider for promoting stewardship and protecting important natural resources while continuing

to maintain economic vitality. This paper focuses on the application of GIS for analyzing and implementing many of those strategies with emphasis on local responsibility.

In particular, the natural suitability of cluster development for Currituck County, North Carolina, is examined with GIS. Attention to growth management planning in this coastal county is critical since the population is projected to increase over 73 percent from 1990 to 2020. GIS data layers from the North Carolina Center for Geographic Information and Analysis, as well as digitized Federal Emergency Management Agency Flood Insurance Rate Maps, are used to determine the extent of Primary Conservation Areas in the county. In addition, Secondary Conservation Areas are identified over a 610-acre tract of land suitable for cluster development with digital orthophotography.

# APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS FOR GROWTH MANAGEMENT PLANNING AND WATER QUALITY PROTECTION IN THE COASTAL REGION OF NORTH CAROLINA

By

**JEFFERSON FORREST ESSIC**

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**APPROVED BY:**

Rodney L. Huffman    Gene E. Daniels

Hugh A. Devine
Chair of Advisory Committee

## BIOGRAPHY

Jefferson (Jeff) Forrest Essic was born May 13, 1972 in Mocksville, NC, and lived in northern Davie County with his parents west of Farmington until 1990. He decided to attend N.C. State University after participating in the Resource Conservation Workshop in 1989. In 1994, he received his B.S. degree in Conservation with a soil and water concentration, and was then admitted to study Natural Resource Administration, concentrating in Spatial Information Systems at N.C. State University.

Essic has worked for Stratford Landscape, NCSU Dept. of Housing and Residence Life, (Night Staff), NCSU Dept. of Soil Science (Lab Technician), NCSU Natural Resources Library, New River State Park, NCSU College of Forest Resources (Teaching Assistant), and the Cooperative Extension Service (GIS Technician).

Essic has many interests, hobbies, and pastimes, too numerous and various to list. But in all things, he strives to put God first in his life, followed by friends, family, and others.

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## LIST OF ABREVIATIONS

APES……………………………………….………...Albemarle-Pamlico Estuarine Study

CAMA……………………………………..……Coastal Area Management Act of 1974

CCMP………………………..……….Comprehensive Conservation Management Plan

CES……………………………………………………...Cooperative Extension Service

DCM……………………………………………….…Division of Coastal Management

DFIRM………………………………...…………Digital Federal Insurance Rate Map

ESRI……………………..………………….Environmental Systems Research Institute

FEMA…………………………………………..Federal Emergency Management Agency

FIRM……………………………….………………….Federal Insurance Rate Map

GIS……………………………..……………………Geographic Information System

NC CES………………….....………………North Carolina Cooperative Extension Service

NC CGIA...…………….North Carolina Center for Geographic Information and Analysis

NWI……………………………………………………….National Wetlands Inventory

Project NEMO...............................................Nonpoint Education for Municipal Officials

SFHA……………………………………...………………...Special Flood Hazard Area

TDR………………………………………………….Transfer of Development Rights

WECO……………..………………..Watershed Education for Communities and Officials

# INTRODUCTION

## Background and Objectives

The Albemarle-Pamlico estuarine region is located within 36 northeastern North Carolina counties and 19 cities and counties in southeastern Virginia. In 1987, the Albemarle-Pamlico Estuarine Study, or APES, was initiated as part of the Environmental Protection Agency's National Estuary Program to identify problems and develop long-term management solutions for the region's water resources. Sediment, toxins, nutrients, fecal coliform contamination, dioxin, and low dissolved oxygen are the major water quality impairments in the region as a result of nonpoint source runoff. Recommended management actions as a result of the APES work were presented in 1994 in the APES Comprehensive Conservation Management Plan, or CCMP (Waite et al. 1994).

The North Carolina Cooperative Extension Service (NC CES) launched a program in September 1993 that has sought to fulfil the goals and objectives of the CCMP as well as Extension's own State Major Program initiatives. Titled, "Improving Water Quality in the Albemarle-Pamlico Estuarine Region," and funded by the United States Department of Agriculture, this program has provided water quality education and outreach to many people, motivating them to become actively involved in public policy development and implementation. Many NC CES specialists and agents have worked very hard on numerous activities of this program to empower the local policymakers and the public with knowledge and skills aimed toward protecting water resources (Danielson and White 1996). In 1994, Currituck County, North Carolina, was identified as an ideal locality for an NC CES water quality improvement project within the Albemarle-Pamlico estuarine region. The project was initially envisioned to become an adaptation of Connecticut's Project NEMO (Nonpoint Education for Municipal Officials, discussed in a later section) for North Carolina. Correspondence between the Currituck County planning staff and Extension personnel revealed that the county officials needed assistance and information for planning how to allow continued high rates of growth without sacrificing valuable natural and cultural resources, as recommended by the CCMP (McCracken and Simoneau 1994-1995).

The county's search for solutions also prompted APES funding in 1994 for Randall Arendt to create hypothetical open-space and clustered development plans for locations in three counties within the Albemarle-Pamlico estuarine region, including Currituck (Appendix 1). Arendt is a nationally known landscape design consultant with the National Lands Trust, Inc. and the Center for Rural Massachusetts. He has also co-authored several texts including Rural by Design: Maintaining Small Town Character (1994) and Conservation Design for Subdivisions (1996) which prescribe many design strategies for preventing adverse landscape consequences as a result of intense development. Currituck County has a zoning option for cluster and open space development, but tools are needed such as Arendt's work and this study to encourage its use (Simoneau 1995).

Therefore, this study examines and demonstrates the potential for Geographic Information Systems (GIS) to meet the modeling needs identified from Arendt's work, Project NEMO, the water quality improvement goals of the NC CES and the CCMP, and the 1996 Currituck County Land Use Plan. GIS applications and readily available data are discussed that will help planners and other local officials in North Carolina's coastal region better analyze and understand information in order to make land use decisions that fall within the guidelines of growth management.

This work is designed to address the objectives of the CCMP which call for increased use of GIS technology to support local efforts toward responsible stewardship of wetlands, natural areas, watercourses, wildlife habitats, farmland, and historic sites, which leads to future economic sustainability. The expanded role of NC CES in assisting smaller local governments with GIS-based land use planning and water pollution prevention is also examined.

## GIS Literature Review

Environmental Systems Research Institute (ESRI), a premier software developer for GIS applications, defines GIS as,

> "An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information," (ESRI 1990).

The activities described in this definition were, prior to the advent of GIS, commonly performed using paper maps. But GIS has the capability to perform data intensive activities at much faster speeds and with much more precision, especially as technological advances continue. GIS is well suited for any application that involves the use of spatial information, one of which is land use planning. In addition, constantly improving hardware and software performance coupled with decreasing purchase and labor costs are making GIS more attractive and feasible for local governments with relatively small budgets (Norman 1996).

*GIS as a Tool for Land Use Planning in North Carolina*

With APES funding, the North Carolina Center for Geographic Information and Analysis (NC CGIA) has developed approximately sixty digital data layers for the North Carolina Corporate Geographical Database. NC CGIA, NC Division of Water Resources, and NC Division of Coastal Management (DCM) conducted workshops in December, 1996 for governmental agencies and planning or environmental related organizations. Their focus was to help participants learn about GIS technology and costs, available data, and methods of application. Of the 208 total workshop registrants, the significant majority indicated that while they did not then have a GIS, its implementation into their area of work was expected to begin within the ensuing two years. Meanwhile, registration forms revealed that the current GIS users were applying the technology toward cadastral mapping, land-use planning, infrastructure management, and emergency preparation purposes. Needs were expressed by the workshop participants for better ways to use GIS for communicating spatially related community problems and solutions to public officials. Also needed is assistance in developing infrastructure and demographic data, as well as more detailed or completed layers of hypsography, floodplains, water resources, traffic counts, and land use/land cover data (Stefanski 1996).

Only a few examples currently exist in North Carolina of state level assistance to local governments for performing land use planning with GIS. In 1995, DCM compiled and distributed a packet of GIS-based data for each of the twenty counties within the jurisdiction of the Coastal Area Management Act of 1974 (CAMA). This action was in response to recommendations by the Coastal Futures Committee. The databases were compiled from the NC CGIA's corporate database, and included economic, demographic, water resource, land resource, infrastructure, and other pertinent information. This effort was designed to assist counties and municipalities prepare their CAMA-mandated Land Use Plans, which are written every five years. By enabling the use of a broad range of geographical information, it is hoped that concerned citizens and planners will have a better knowledge of land uses and environmental relationships surrounding them. This should lead to Land Use Plans that are more appropriate and accepted. Counties, like Currituck, that have no GIS available while preparing their Land Use Plans would not otherwise have easy access to this critical data for planning (Stichter 1995).

Another project funded by APES examined the ability of GIS for suitability-analysis for land use planning in the coastal region. This effort resulted in the production of two videos that demonstrate the application of GIS to identify land suitable for development needs now and by the year 2010, based on projected population estimates. Also demonstrated is how GIS may expedite the CAMA permitting process for development (NC CGIA and APES 1990, 1992). However, the extent for much of the data used in these analyses is limited to Carteret County, and some information such as cadastral data is not currently available in digital form for all of North Carolina's coastal counties.

*GIS as a Tool for Land Use Planning by the Cooperative Extension Service*

The Cooperative Extension Service, or CES, is supported by land-grant universities in each state, territory, and the District of Columbia. By engaging in many multifarious programs, the CES strives to improve the quality of life for the public by providing research-based information in response to citizen and community issues and needs (NC Cooperative Extension Service 1997). In order to achieve this objective, educational techniques are sought which will stimulate interaction and facilitate understanding among all participants. GIS has proven, in many instances, to be an excellent tool for assisting with the analyses and educational mapping needs of CES projects. The following discussion examines the past role GIS has played in several specific CES projects.

The Connecticut CES and Sea Grant College Program have developed a project titled Nonpoint Education for Municipal Officials, or Project NEMO. This program is designed to help professional and volunteer municipal officials understand the links between land use and water quality degradation. The role of GIS in Project NEMO is to demonstrate and communicate possible management options for minimizing land use impacts on water quality. The program is divided into three steps that rely on GIS techniques. First, GIS maps of topography and drainage systems are used to illustrate the water cycle, the watershed concept, and the need for watershed management. Secondly, land use/land cover data is used to show current patterns of development and common water quality problems associated with runoff from various types of land usage. And finally, a comparison of present and future levels of impervious surfaces are shown, based on GIS analysis of current zoning classifications and satellite land cover data. This gives town officials a look at the potential levels of impervious cover within their jurisdiction, which as NEMO educators explain, directly leads to a decline in water quality. By incorporating natural resource-based planning with economic growth, the educational thrust of NEMO has been very well received and has generated more conscientious planning and better-informed decision-making among citizens and community leaders (Arnold 1994a, Arnold et al. 1993).

Likewise, Rhode Island and New Hampshire each have university CES programs that employ GIS to help local government planning. With the help of GIS and Cooperative Extension, issues, such as impacts of variable width riparian buffers, and effects of future land uses on stream nutrient loading from non-point sources, have been studied for concerned local citizens (Schloss and Mitchell 1996, Joubert et al. 1996). GIS has been valuable as an outreach tool for local decision-makers to better understand water resource relationships between land uses and water quality.

To date, the NC CES has utilized GIS technology in only a few, yet quite successful, endeavors. Between 1987 and 1993, a multi-disciplinary team from North Carolina State University, headed by Extension specialists, was formed to help citizens and county officials in Gaston County, North Carolina, with water and air quality problems. GIS was used during the entire project for its analytical and educational capabilities. Data sources were identified and methods developed to translate data to digital format, as well as manage, analyze, display, and then transfer the data sets to the county for continued use. The data sources varied, were disparate, and most had to be manually digitized. Once the database was complete, overlay and buffer analyses were performed to examine spatial distributions of potential pollution sources and their proximity to areas of concern. GIS enabled the display of this information, as well as the results of nonpoint source pollution modeling for the Long Creek watershed located in Gaston County (Devine 1990, Line and Coffey 1992). The final database was turned over to county Extension agents, and is being used for natural resource assessment, management, and educational efforts (Smutko et al. 1992).

The Craven County Wastewater Management Advisory Committee employed GIS in 1995 to develop and display soil suitability classifications for on-site wastewater treatment and land application. Using Natural Resource Conservation Service detailed digital soil data, the county's soils were classified by hydrologic characteristics into eight color-coded suitability groups. Thematic maps showing this information were created for each county township and used for public demonstration and communication at meetings held across the county by Extension personnel and the advisory committee. These maps greatly helped citizens and local officials understand the relationship between soil conditions and wastewater treatment issues. The final product was a ten-year wastewater management plan for Craven County that was approved by a citizen's advisory board.

Finally, a pilot program titled Watershed Education for Communities and Officials, or WECO, uses GIS to help local officials understand water quality problems in their jurisdiction and work to address those problems with management and policy initiatives. Strongly inspired by the successes of Project NEMO, this project brought together extension specialists, local agents, and interested citizens of the White Oak River watershed to form an Advisory Board in 1996. The group prioritized their water quality concerns, reviewed technical material and developed management and policy options. These recommendations were presented to local government officials and policymakers. So far, GIS has been used to quantify and communicate environmental conditions pertaining to the White Oak River watershed. Thematic maps have helped identify watershed boundaries, political jurisdictions, hydrologic units, and areas with water quality problems. The maps have also been useful for stimulating discussion about water quality issues and causes of impairment. It is anticipated that in the near future, WECO will employ GIS functions to support analysis of various management and policy options, including the derivation of cost/benefit estimates for best management practices. An extensive database has been compiled for the White Oak River watershed that includes land use/land cover, soil, water quality data, stream classifications, demographics, and aquatic habitat information, thus providing a rather complete description of the watershed's environmental conditions (Danielson and White 1996).

**Planning Literature Review**

The number of visitors and permanent residents coming to the coastal region of North Carolina continues to increase every year. Of the twenty CAMA counties, several are projected to nearly double in population by the year 2020 (Table 1). While this growth is welcomed by many, county and municipal planners in the coastal region have the very challenging task of finding ways for this growth to continue without severely degrading the natural and cultural resources. That is because these resources have been, and will likely continue to be, strong attracting forces for the region's economic development.

**Table 1.** *United States Census population figures for 1990, and projected population growth through 2020 for North Carolina's CAMA regulated coastal counties (NC Office of State Planning 1997).*

| CAMA COUNTY | U.S. Census 1990 Pop. | Projected Population 2,000 | 2,010 | 2,020 | Growth 1990-2020 | % Growth | Estimated Pop/Mi$^2$ 1995 |
|---|---|---|---|---|---|---|---|
| **BEAUFORT** | 42,283 | 44,401 | 45,436 | 45,879 | 3,596 | 8.50% | 52.35 |
| **BERTIE** | 20,388 | 20,826 | 20,411 | 19,972 | -416 | -2.04% | 29.51 |
| **BRUNSWICK** | 50,985 | 69,653 | 84,454 | 97,920 | 46,935 | 92.06% | 71.04 |
| **CAMDEN** | 5,904 | 6,687 | 7,058 | 7,391 | 1,487 | 25.19% | 26.24 |
| **CARTERET** | 52,553 | 62,161 | 70,648 | 78,091 | 25,538 | 48.59% | 108.41 |
| **CHOWAN** | 13,506 | 14,448 | 15,196 | 15,923 | 2,417 | 17.90% | 81.27 |
| **CRAVEN** | 81,613 | 89,845 | 97,431 | 104,071 | 22,458 | 27.52% | 123.37 |
| **CURRITUCK** | 13,736 | 17,658 | 20,756 | 23,807 | 10,071 | 73.32% | 60.44 |
| **DARE** | 22,746 | 29,177 | 36,327 | 43,438 | 20,692 | 90.97% | 67.48 |
| **GATES** | 9,305 | 10,117 | 10,774 | 11,533 | 2,228 | 23.94% | 28.76 |
| **HERTFORD** | 22,523 | 22,272 | 21,652 | 21,017 | -1,506 | -6.69% | 63.52 |
| **HYDE** | 5,411 | 4,921 | 4,607 | 4,308 | -1,103 | -20.38% | 8.5 |
| **NEW HANOVER** | 120,284 | 156,196 | 179,810 | 202,050 | 81,766 | 67.98% | 701.53 |
| **ONSLOW** | 149,838 | 156,414 | 181,767 | 207,980 | 58,142 | 38.80% | 192.86 |
| **PAMLICO** | 11,368 | 12,320 | 12,872 | 13,272 | 1,904 | 16.75% | 35.22 |
| **PASQUOTANK** | 31,298 | 34,844 | 37,715 | 40,614 | 9,316 | 29.77% | 146.71 |
| **PENDER** | 28,855 | 39,694 | 48,251 | 56,553 | 27,698 | 95.99% | 39.82 |
| **PERQUIMANS** | 10,447 | 10,945 | 11,352 | 11,693 | 1,246 | 11.93% | 43.08 |
| **TYRRELL** | 3,856 | 3,696 | 3,483 | 3,287 | -569 | -14.76% | 9.78 |
| **WASHINGTON** | 13,997 | 13,412 | 12,501 | 11,555 | -2,442 | -17.45% | 39.57 |

*Growth Management Planning*

A 1995 report titled Blueprint to Protect Coastal Water Quality (hereafter referred to as *the Blueprint*) presents "growth management" as,

> " ... a set of plans, tools, options, and resources ... that simultaneously work to maintain or improve water quality, promote sustainable economic growth, and preserve the character of the local community," (p. 1).

The Blueprint, prepared by Land Ethics and The Center for Watershed Protection for the North Carolina Division of Environmental Management and for the Neuse River Council of Governments, recognizes that maintaining high water quality must form the foundation of all growth management strategies in coastal North Carolina. According to the Blueprint, the current economic structure of the coastal region will fail without good water quality. As planners work to strike a balance between growth and resource protection, they must set growth management goals, or objectives, that everyone will agree are important benchmarks to strive toward. Four specific management priorities aimed toward water quality protection and continued economic strength are recommended in the Blueprint as the following:

- Maintain sensitive estuarine habitats that contribute to the seafood economy.
- Maintain and restore the quality of shellfish beds.
- Maintain estuarine water quality.
- Maintain recreational water quality.

In order to achieve these objectives, it is important that local government officials apply the measures and techniques listed in Tables 2 and 3, according to the Blueprint.

**Table 2.** *Collective framework for preventing water quality degradation (Land Ethics and Center for Watershed Protection 1995).*

| | |
|---|---|
| Use watershed-based planning | Limit erosion during construction |
| Protect sensitive areas | Treat septic systems and stormwater runoff quality |
| Establish buffer networks | Implement and maintain coastal protection measures |
| Reduce impervious cover in site design | |

**Table 3.** *Growth management tools recommended for accomplishing framework measures (Land Ethics and Center for Watershed Protection 1995).*

| | |
|---|---|
| Overlay zoning | Greenbelts |
| Transferable Development Rights | Watershed Impervious Limits |
| Marina Siting and Design | Sensitive Habitat Protection Ordinances |
| Forest Conservation | Septic System Siting Criteria |
| Shoreline and Wetland Buffers | Cluster Zoning |
| Modified Street Standards | Modified Parking Standards |
| Site Clearing Standards | Stormwater Treatment |
| Marina Pumpouts | Septic System Inspection and Maintenance |
| Septic System Alternatives | Regional CAMA Planning |
| Wastewater Authority | Stormwater Authority |
| Wastewater/Stormwater Authority | Water Quality Authority |

The application of GIS to facilitate planning, designing, and implementing many of the above recommendations is considered in the Discussion segment. However, cluster development and open space design is examined in the following section.

### *Cluster Development/Open Space Design*

In rapidly growing rural and suburban communities across the United States, citizens, planners, and other local decision makers are becoming increasingly concerned about the sprawling effects of modern conventional subdivisions and are looking more favorably toward traditional development patterns. Conventional subdivision projects since the 1950’s have typically consisted of developments with individual lot sizes of one acre or greater. This pattern has resulted in tremendous loss of uninterrupted open spaces, and consequently, a loss of prime land for agriculture, forests, wildlife habitat, and recreational opportunities. Instead, the landscape is fragmented into small widely scattered pieces of natural and developed segments, all managed differently, and all contributing toward a suburban sprawl, eating away our future land resources and open space.

One solution as proposed by the Blueprint is for local officials to allow and encourage cluster development zoning. According to the Blueprint,

> "Cluster zoning is a technique by which development can be concentrated in one or more areas of a site, allowing the protection of sensitive resource areas and conservation of open space. Cluster zoning works with the existing gross development density of a site, and modifies the minimum lot size requirements to achieve the clustering of development," (Tool #10).

A California court has similarly defined cluster development as:

> " ... grouping dwellings to increase dwelling densities on some portions of the development area in order to have other portions free of buildings ... the plan is to devise a better use of undeveloped property than that which results from proceeding on a lot-to-lot basis. Control of density in the area to be developed is an essential part of the plan. The reservation of green, or at least open, spaces in a manner differing from the conventional front or back yard is another ingredient," (Pivo et al. 1990).

Basically, cluster development is intended to allow the same number of housing structures on a parcel of land as a conventional plan would specify, while the individual lot sizes are reduced to allow for larger open spaces and less environmental impact.

The benefits of cluster development design over low-density sprawl are many. Perhaps most important is the fact that natural features such as wetlands, forested and agricultural lands, flood plains, or other general open spaces can all be protected and enjoyed by the public now and in the future. This also helps wildlife habitat and movement corridors remain intact. Additionally, cluster development is more aesthetically pleasing with fewer landscape disruptions from houses or other structures.

Cluster development may also lessen the effects of non-point source runoff in a watershed by reducing the amount of needed impervious surfaces such as streets, sidewalks, and driveways. In fact, according to Schueler (1994), imperviousness may be decreased by 10 to 50%, depending on the original design layout. Conventional subdivision codes typically specify wide streets, sidewalks on both sides of the street, and large parking areas that frequently go unused. This increases impervious surface area and greatly decreases the amount of space for storm water infiltration into the soil. Remote sensing and GIS studies have shown that impervious surface cover in many parts of the United States has increased 50% since World War II. Also revealed is that 65% of all impervious surface is "habitat" for automobiles (Schueler 1997). Water quality degradation typically begins once a watershed reaches approximately 10% impervious cover (Table 4). Riparian buffers may extend this threshold to approximately 15%. The severity of these effects quickly multiplies as impervious area grows.

**Table 4.** *Effects on water quality when 10% of watershed is impervious cover (Schueler 1997).*

| | | | |
|---|---|---|---|
| Storm runoff | increases (10%) | Temperature | increases |
| Flood peak | increases | Pollution | increases |
| Stream widening | increases | Habitat quality | decreases |
| Pool/riffle structure | decreases | Plant/animal diversity | decreases |
| Dry weather flow | decreases | Spawning | decreases |
| Fish/shellfish/beach closures | increase | Food quality/diversity | decreases |

Cluster development, however, reduces storm water runoff, pollutant loads, and soil erosion amounts since less land surface is disturbed as compared to typical conventional development. A larger percentage of the site's runoff is concentrated for more effective treatment while the overall size and extent of best management practices needed for effective water quality control may be reduced. Additional water quality protection may be achieved within a cluster development through the installation of other special design measures. These include brick, crushed stone, or pervious pavement in low traffic areas, streets designed to drain naturally through vegetated swales rather than directed down curbs and pipes, and building sites located where grading and filling is minimized and the natural topography may be maintained (Arnold 1994b).

Several studies and reports, besides the Blueprint, have recently recognized the value and need for open space preservation in coastal North Carolina. In 1994, the North Carolina Coastal Land Trust and the North Carolina Coastal Federation published a report titled Building a Sustainable Landscape: The Benefits and Costs of Non-Regulatory Reform. One of the policy considerations for local planners was,

> "In many cases in North Carolina, the permanent protection of open space and unique natural areas will redirect development but not reduce the overall level of development."

A number of examples of successful development ventures were cited in the document, for their generous protection or accessibility to open spaces, and the correspondingly high property values for lots adjacent to those open spaces.

According to the report, dedicated open space can provide significant economic benefits to a region by improving the tourism industry and the overall quality of life for citizens and employees. North Carolina's tourism industry has been built upon the state's high level of natural beauty, but this can be easily lost if poor development planning completely consumes the resources which made the state a popular destination for visitors. Also, people living and working in an area with ample open space may enjoy good water quality for industrial and household use, healthier fisheries, opportunities for outdoor recreation, and visually pleasing landscapes (NC Division of Water Quality 1996).

However, many developers remain skeptical of the economic benefits that proponents claim can be derived from cluster development. Their primary reservation is – will smaller lots sell? Yet, increasingly, open space is becoming more valuable and is being used successfully to attract homebuyers. Cluster development also yields significant economic savings to the developer because it requires less site preparation as well as lower infrastructure and utility installation and maintenance costs. As a result, some home builders have put their infrastructure and utility cost savings into better home construction, and the houses are now appreciating at faster rates than houses in conventional developments (Schueler 1997).

Many intangible benefits further contribute to higher resale values for clustered homes as opposed to conventionally designed sites. Residents living in cluster subdivisions enjoy a stronger sense of community and increased recreational opportunities (Biver and Bohlen, 1994). On-site historic or unique landmarks are often preserved and may even be used as focal points for the development community. Mass transit systems are more economically viable when residences are less dispersed over a wide area (NC Division of Water Quality 1997).

Currently, most small towns and rural local government zoning codes allow only conventional development methods, and in recent decades, have increased rather than decreased minimum required lot sizes. This trend, coupled with a lack of large-scale open space requirements, has served to stimulate the homogenous sprawl patterns common to suburban areas. Such zoning codes do not preserve the area's rural character as usually intended by minimum lot zoning requirements (Arendt 1988).

The small, yet growing number of local governments that have some form of a cluster development zoning option for developers, such as Orange and Wake Counties in North Carolina, make it a voluntary option. These counties have adopted flexible subdivision regulations that allow smaller lot sizes and setbacks, while requiring that useable open space is set aside permanently (North Carolina Planning Newsletter 1996). Moreover, a 1992 study by the Metropolitan Washington [D.C.] Council of Governments found that of 39 local governments which support cluster development programs, 95% of them make it a voluntary option for new developers. Very important features of such a zoning option are the lot density allowances, required building setbacks, and the minimum percentages of open space, which must be permanently held from construction. The average design dimensions and requirements specified by the 39 open space zoning programs varied (Table 5). An average of 37% of all new subdivisions followed a cluster design. Surprisingly, eight of the 39 programs, or 20%, had yet to attract a single cluster proposal, according to the report (Schueler 1994).

**Table 5.** *Comparison of single family home, one-acre lot dimensions for conventional vs. cluster development zoning regulations (Schueler 1994).*

| Site Factor | Detached single family residence | Detached Cluster |
|---|---|---|
| Min. site size | 5 acres | 5 acres |
| Max. size density | 1 home/acre | 1 home/acre average |
| Min. lot size | 40,000 $ft^2$ | 10,000 $ft^2$ |
| Min. front lawn | 150 ft. | 75 ft. |
| Min./Total Side lawn | 25 ft./60 ft. | 10 ft./25 ft. |
| Min. rear lawn | 40 ft. | 25 ft. |
| Building footprint | 5% of lot | 18% of lot |
| Open space required | none | 33% of site |

Many landscape designers and land-use planners support cluster development, including Randall Arendt. Rather than using the term “cluster development,” Arendt prefers “Conservation” or “Creative” Development because of the natural protection afforded through open space planning and innovative design around the existing environment. One of his conservation subdivision designs for a site in Currituck County was a major stimulant for this study (Appendix 1).

Arendt (1996) recommends a two-stage approach to designing conservation subdivisions. Each stage has four important steps. The “background stage” involves 1) understanding the locational context, 2) mapping special features, 3) prioritizing objectives, and 4) integrating the information layers. The four steps of the “design stage” are 1) identify conservation areas, 2) locate home sites, 3) align streets and trails, and 4) draw the lot lines.

The top design priority for a conservation subdivision is to develop the site around unique and valuable natural features, protecting them as open space. Therefore, the most critical step is the identification of the land area that is to be protected. Special features which should be identified include wetlands, 100-year flood zones, steep slopes, hydric soils, significant wildlife habitats, important woodlands, prime farmlands, scenic views into and out of the site, buffers around waterways, and significant historic, archaeological, and cultural locations.

Arendt separates protected, or conserved, areas into two classes – primary and secondary. Primary conservation areas are defined as places where regulatory wetlands, floodplains, steep slopes, and hydric soils exist. All of these features have been mapped by federal programs to at least a 1:24,000 scale. Secondary conservation areas are less definitive, but comprise the other landscape characteristics listed above that give a development site its special appeal. Some secondary conservation resources are more or less significant than others; and, within each type, there are varying degrees of value. For example, young, diseased, or degraded woodlands are less desirable to protect than mature or rare stands. The final decisions about which land areas to classify as primary and secondary conservation zones must be made by landowners, developers, conservationists, local planners, government officials, and other interested citizens (Arendt 1996).

Currently available data and common GIS hardware and software are used in the following procedure to begin the process of delineating primary and secondary conservation zones for Currituck County, North Carolina.

# METHODS

## Study Area -- Currituck County, North Carolina

Currituck County is North Carolina's most northeastern county, lying geographically South of the cities of Virginia Beach and Chesapeake, Virginia, and North of Dare County, North Carolina (Figure 1). The Currituck Outer Banks, as well as Knotts Island and Gibbs Woods communities, are separated from the mainland by Currituck Sound, and are more easily accessible by highway from Dare County or the Virginia mainland.

The county boasts unique cultural, economic, and natural resources. In recent years, this has attracted a huge influx of residential development. In fact, the 1995 estimated population of the county was 15,818, which represents a growth rate of 15.2 percent since 1990. Currituck County's population is expected to grow over 73 percent by the year 2020 (see Table 1). This rate of growth is within the top ten percent of North Carolina's 100 counties (NC Office of State Planning 1997).

The Currituck Outer Banks section has become an especially popular destination for seasonal visitors in the last 10-15 years. Only five families lived in the Corolla community on the Outer Banks twenty years ago. Since then, over 2,000 new homes have been built along the 22-mile strip of barrier island. Many are valued at over $1 million, yet are occupied only during the summer when the Outer Banks' population surges from 380 permanent residents to over 17,000. Lured by "wild" horses, beautiful beaches, and luxurious developments, visitors from the north often wait for hours in stalled traffic to get to the Outer Banks. Access will be improved, and the growth trend

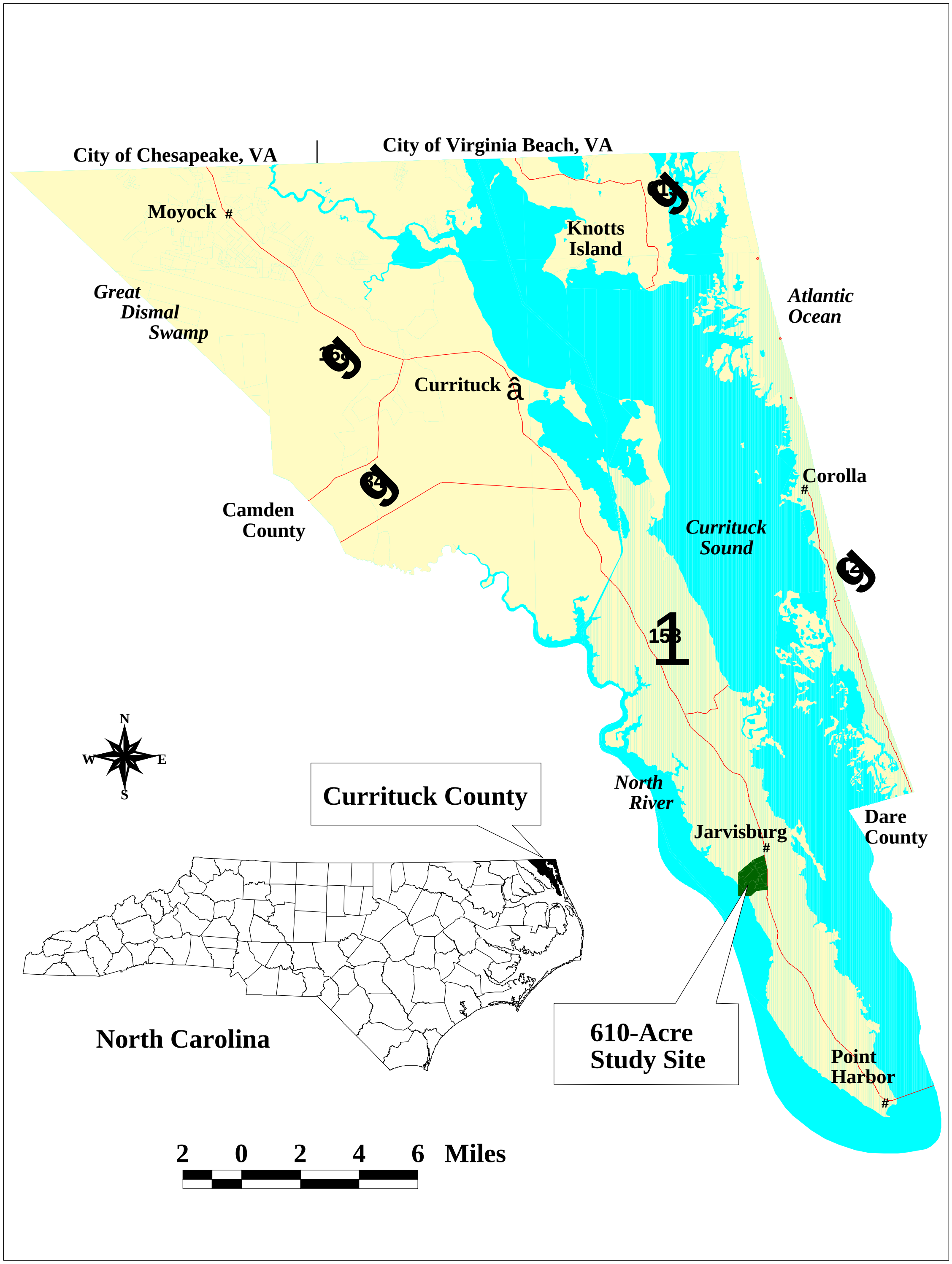


**Figure 1. Currituck County, North Carolina.**

will likely continue, following completion of a planned mid-county bridge across the Currituck Sound (Wilson 1995)

Although Currituck County's mainland is predominantly rural with no incorporated towns, there are many concerns related to the rate of growth in the county, conversion of prime agricultural land to residential and resort-style development, and the impacts of such development on the environment.  The county's top industry is agriculture, followed by tourism.  These two industries have a mutual relationship, since visitors boost the local economy while enjoying the agronomic landscape and flavorful lifestyle of native coastal residents.  Tourists and newcomers are also attracted to Currituck County's diverse and historically bountiful wildlife, waterfowl, and fisheries, as well as the many recreational opportunities available (Sawyer 1988, Kight and Sawyer 1993).  The future success of these industries and the quality of life for citizens will depend on careful planning to protect the vitality of the county's land, water, and cultural resources.

**Database Development**

Currituck County's terrain has no steep slopes, so only wetland, flood zone, and soil data are used in this study for delineating primary conservation areas.  GIS allows this task to be easily performed on a county-wide scale.  Secondary conservation areas and potential development areas are identified for a small 610-acre tract of land, previously deemed suitable for cluster development by the county planning staff.

The same features representing primary conservation areas (poor soils, wetlands, and flood zones) are also the primary natural inhibitors for development in Currituck County, although construction is frequently allowed within flood zone areas (Simoneau 1997).

GIS analyses were performed to quantify overlap of these land features, to determine the total amount of primary conservation areas throughout the county, and to identify the secondary conservation areas within the 610-acre study site. The first step in this process was database development. The following sections describe how the necessary data were created or collected, while Table 6 summarizes these and other important data sets necessary for the analyses.

**Table 6.** *GIS coverages used for identification analyses of primary and secondary conservation areas.*

| Coverage Name | Scale | Source | Structure | Size (Megabytes) |
|---|---|---|---|---|
| Roads | 1:24,000 | NC Dept. of Trans. | Line | 0.711 |
| Hydrology | 1:100,000 | NC CGIA | PloyLine | 1.830 |
| County boundaries | 1:100,000 | NC CGIA | PolyLine | 0.058 |
| NWI Wetlands | 1:24,000 | NC DCM | Polygon | 1.972 |
| NWI Creeds quadrangle | 1:24,000 | NWI | Polygon | 0.181 |
| NRCS Soil Units | 1:20,000 | NC CGIA | Polygon | 5.766 |
| FEMA Flood Zones | 1:24,000 | digitized | Polygon | 0.279 |
| Digital Orthophoto | 1:40,000 | ASI Landmark, Inc. | Raster | 24.780 |
| Study area land use/land cover | -- | digitized | Polygon | 0.041 |

*Flood Zone Digitizing*

One of the major objectives of this CES project was to explore the development of a digital flood zone database for local government planning efforts. There are a number of advantages to maintaining flood zone classification data with GIS including easier identification of flood prone areas during the planning stages of development and quicker identification of hazard areas upon the occasion of impending floods. The consequences of flooding may involve losses of life and property, so most land use planning efforts in the coastal region closely examine potential flood hazards.

The introduction to the 1996 Federal Emergency Management Agency (FEMA) publication titled Q3 Flood Data Users Guide (Appendix 2) provides excellent background and detailed information about the National Flood Insurance Program. With this program, areas susceptible to 100-year flood events throughout the United States have been identified using the US Corps of Engineers HEC-1 and HEC-2 computer simulation models to calculate surface water profiles and Special Flood Hazard Areas, or SFHAs. Federal Insurance Rate Maps, called FIRMs, are printed and distributed by FEMA showing the delineated SFHAs.

The benefits of GIS technology for data storage and analysis led to FEMA's creation of Digital FIRMs (DFIRMs). The agency announced standards for DFIRM production in 1993. The rapidly increasing use of GIS and the advantages offered by digital flood zone data, especially for disaster recovery operations, later prompted FEMA to develop the Q3 Flood Data product in 1996. Q3 Flood Data are less costly and quicker for FEMA to produce than DFIRMs, but data quality and content is sacrificed (Appendix 2).

Local governments which employ DFIRM or Q3 Flood Data as a layer within their GIS database collection are eligible to receive a better flood insurance community rating, and thus perhaps allow residents to be eligible for cheaper insurance premiums. This incentive, offered by FEMA to encourage greater DFIRM and Q3 Flood Data usage, was a major reason why the acquisition of digitized flood zone information was a top priority for Currituck County officials. The data are needed for planning reasons, and it is hoped that the insurance rate savings may boost support for further GIS hardware, software, and data acquisition needs.

Flood zone information for Currituck County is depicted on forty-nine hardcopy FIRM panels. SFHAs, areas where flood insurance is unavailable (Table 7), and primary highways were digitized from these FIRM maps in 1995. At that time, there was knowledge of neither FEMA's standards for DFIRM digitizing, nor of their future Q3 Flood Data digitizing project, which includes Currituck County.

**Table 7**. *Explanation of digitized map feature designations for Currituck County's FEMA flood zone coverage (FEMA 1995).*

| Map Designation | Explanation |
|---|---|
| Zone A | Areas of 100-year flood; base flood elevations and flood hazard factors not determined. |
| Zone A3 – A6 | Areas of 100-year flood; base flood elevations and flood hazard factors determined. |
| Zone V6 – V7 | Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined. |
| Zone C | Areas of minimal flooding. |
| EL 5 – 13 | Base flood elevation in feet where uniform within zone. |
| Insurance Not Available (separate coverage) | Flood insurance not available for new construction or substantially improved structures . . . in designated coastal barriers. |

Vector digitizing was performed using Strategic Mapping, Inc.'s ATLAS*GIS™ software and a CalComp Drawing Board™ digitizer. Since the FIRMs contain no coordinate or projection definitions, correctly georeferencing each FIRM panel was problematic. Therefore, bounding coordinates for each map panel were determined by digitizing and referencing the county's FIRM Index Map. Coordinates for the FIRM Index Map were derived from the NC CGIA digital county boundary data for North Carolina.

This method resulted in imprecise matching of many panel corners, however. Other digitizing problems were non-matching map features across adjoining map panels and varying panel scales, labeled as “Approximate.” When such inconsistencies were encountered, digitizing adjustments were made based on other map feature locations. For example, FIRM panel boundaries around panels 0070C and 0090C do not match. This problem was met by assuming a correct panel boundary location based on adjoining map boundaries and features.

Once digitizing was completed, it was desirable to perform subsequent analyses using ESRI’s ARC/INFO™ software on a UNIX platform. However, the ATLAS*GIS™ Import/Export utility had difficulty exporting the entire flood zone data layer into an ARC/INFO™ *.E00 exchange format file. Therefore each flood zone type (A, C, and V), Insurance Not Available areas, and primary highways were selected out and exported into separate *.E00 exchange files. The UNIX based ARC/INFO™ version 6.0 was unable to import these files however. The files instead had to be imported into ESRI’s PC ARC/INFO™, and then re-exported with no data compression, so they could be imported into the UNIX version of ARC/INFO™. The APPEND function of ARC/INFO™ was used to again place the four flood zone types into one single coverage. It was found that unless the dangle length and fuzzy tolerance parameters were set very low (0.000001) when using the CLEAN function, many dangling arcs and unwanted polygons would develop.

Over one thousand links were created within the flood zone data coverages as they were adjusted or “rubbersheeted” using the “Conflation” map editing tool in

ArcTools™ software package.  Flood zone delineations were matched with all roads on the FIRMs, as well as with hydrologic and shoreline features.  Data quality for the final product is comparable to FEMA's Q3 Flood Data maps, especially near roadways.  This Currituck County flood zone coverage may be used for regional, county-wide, or slightly larger scale planning needs.  However, warnings emphasized in Appendix 2 about limiting the scale of map analysis and interpretation of DFIRMs and Q3 Flood Data to no higher than 1:24,000 should also be carefully heeded by users of the Currituck County data.

*Wetland Data Acquisition*

Wetland data originated from the United States Fish and Wildlife Service's National Wetlands Inventory, or NWI.  This agency has delineated, classified, and mapped the wetlands for a large portion of the United States at 1:24,000 scale using primarily aerial photography.  A detailed classification system is used to identify the type of wetland each polygon represents, and this information is included in the polygon attribute table.  Also included are "Yes" and "No" labels indicating whether or not each polygon's classification is considered wetland.

The wetland data were obtained for this study directly from the North Carolina Division of Coastal Management (DCM).  When the ARC/INFO™ exchange file was imported, a noticeable section was missing in the north central portion of the county. Upon further investigation through DCM and NWI, it was learned that this empty block represented the "Creeds" quadrangle for which there was no photography available when the 1995 NWI map was being compiled.  However, the quadrangle was mapped in 1982 using 1973 photography. Kurt Snider at NWI found a digital version of the 1982 map for use in this analysis. Copies of the 1995 NWI data and the older Creeds quadrangle data have been kept separate in the database. However, to expedite the delineation of the primary conservation areas and overlay process of the soil and flood zones data, it was necessary to combine the Creeds quadrangle with the other NWI wetland data. The ARC/INFO™ UNION command was used for this task, producing a coverage that appears to be accurately joined and consistently attributed across both data sets.

*Soil Data Acquisition*

Countywide digital soil data for Currituck County became available in early 1997 from the North Carolina Center for Geographic Information and Analysis and was purchased by the county for use in this study. The soil coverage was digitized from the 1:20,000 scale soil maps in the Soil Survey of Currituck County. This document was published in 1982 by the United States National Cooperative Soil Survey, a program that is now administered by the Natural Resources Conservation Service, or NRCS. Each polygon in the coverage is coded with the soil mapping unit it represents.

County planning and health department staff have developed a list of soil types which are suitable, suitable after modification, or unsuitable for development (Table 8). ESRI's ArcView GIS™ Version 3.0 software was used to quantify the area of each soil mapping unit by querying the soil data coverage to select corresponding polygons. The total area of the selected polygons was then calculated.

**Table 8.** *Currituck County soil map units arranged according to their suitability for development, as determined by county planning and health departments.*

| Soil Name | Map Symbol | Acres | % of County | % of Co. minus water |
|---|---|---|---|---|
| **POTENTIALLY SUITABLE FOR DEVELOPMENT** | | | | |
| Altavista | AaA | 2990.97 | 1.05% | 1.80% |
| Augusta* | At | 4219.44 | 1.48% | 2.54% |
| Bojac | BoA | 2584.39 | 0.91% | 1.55% |
| Conetoe | CnA | 8480.74 | 2.97% | 5.10% |
| Dragston* | Ds | 4901.25 | 1.72% | 2.95% |
| Munden* | Mu | 2555.48 | 0.90% | 1.54% |
| Pasquotank* | Pa | 1508.72 | 0.53% | 0.91% |
| State | StA, StB | 3310.79 | 1.16% | 1.99% |
| Tomotley* | To | 7703.91 | 2.70% | 4.64% |
| Wando | WnB | 467.25 | 0.16% | 0.28% |
| | **Totals:** | **38722.93** | **13.57%** | **23.30%** |
| * Generally unsuitable, but may be modified for development | | | | |
| **HYDRIC/UNSUITABLE FOR DEVELOPMENT** | | | | |
| Beaches-Newhan | BN | 1714.92 | 0.60% | 1.03% |
| Cape Fear | Ca | 6103.64 | 2.14% | 3.67% |
| Conaby | Cb | 1988.96 | 0.70% | 1.20% |
| Corolla | CoB, CrB | 2193.96 | 0.77% | 1.32% |
| Currituck | Cu | 25693.35 | 9.01% | 15.46% |
| Dare | Da | 14136.68 | 4.95% | 8.51% |
| Dorovan | Do | 11283.89 | 3.95% | 6.79% |
| Duckston | Dt | 1286.02 | 0.45% | 0.77% |
| Dune land–Newhan | Du, DwD | 1557.71 | 0.55% | 0.94% |
| Newhan | NeC, NhC | 2392.78 | 0.84% | 1.44% |
| Nimmo | No | 2477.29 | 0.87% | 1.49% |
| Osier | Os | 563.70 | 0.20% | 0.34% |
| Ousley | OuB | 374.30 | 0.13% | 0.23% |
| Ponzer | Po | 11376.88 | 3.99% | 6.84% |
| Portsmouth | Pt | 9021.94 | 3.16% | 5.43% |
| Roanoake | Ro | 28623.87 | 10.03% | 17.22% |
| Udorthents | Ud | 11.92 | 0.00% | 0.01% |
| Wahee | Wa | 763.18 | 0.27% | 0.46% |
| Wasda | Ws | 5922.99 | 2.08% | 3.56% |
| water | w | 119100.01 | 41.74% | |
| | **Totals:** | **246587.99** | **86.43%** | |
| | **Totals minus water:** | **127487.98** | | **76.70%** |
| | **Grand Totals:** | **285311.10** | **100.00%** | |

*Digital Orthophotograph Acquisition*

A 610-acre study site, located between the North River and US Highway 158, southwest of the Jarvisburg intersection (see Figure 1), was selected for detailed analysis by the county planning staff. The site is ideally suited for cluster style development should the property owners decide to develop because it has both highway and river frontage, large ownership parcels, visual and natural appeal, and is prone to a conventional style development pattern. Although the tract is divided among several different property owners, its analysis as an entire hypothetical conservation development site is necessary for considering various landscape features present in Currituck County. This procedure also makes the study more relevant for community-wide planning efforts (Simoneau 1997).

A digital orthophotograph of the site was obtained from ASI Landmark, Inc., of Cary, North Carolina, for identifying secondary conservation areas. ASI Landmark, Inc. took aerial photography of the entire county in March 1995. The photographs were scanned, rectified, edgematched, and made available for use in this study by the fall of 1996. The image was received as a 24.415-megabyte BIL file, and was converted to an ARC/INFO™ grid using the IMAGEGRID command. The LATTICECLIP command was used to remove data from the image that was outside the study area. This reduced the grid size to 10.521 megabytes.

The orthophotograph is best viewed in ArcView™ GIS 3.0 as an image, with a grayscale cell color classification. An attempt was made to classify the land features using various methods within ESRI's GRID and ArcView™ GIS 3.0 Spatial Analyst Extension, as well as ERDAS Imagine™ Version 8.2 software. However, because the imagery is black and white (Band 1) the resulting classifications were all very inaccurate.

**Locating Primary and Secondary Conservation Areas**

Following database development, the next step was to locate the primary and secondary conservation areas in Currituck County. Primary conservation areas were found by combining the soil, wetland, and flood zone coverages into a single coverage using the ARC/INFO™ Version 7.0.4 UNION command. A coverage representing only land areas was created by selecting out all the water polygons from a 1:100,000 scale coverage of the county's hydrology. This land coverage was next INTERSECTed with the unioned coverage in order to remove the open water features. Finally, query and statistical tools of ArcView™ GIS 3.0 were used to generate the resulting acreage of primary conservation areas.

For identifying secondary conservation areas on the 610-acre study parcel, it was necessary to digitize the land use/land cover information since automated classification methods with the digital orthophotograph proved unsatisfactory. "Heads-up" or on-screen digitizing was thus performed using ArcView GIS™ 3.0 software with the digital image used as a backdrop (Nale 1996). Six general classifications were used to represent the various identifiable landscape features within the study area on the image. Potential cluster development sites were then carefully identified, based on the following design considerations: 1) minimize water quality degradation in the North River, 2) maintain the open space view from U.S. Highway 158 as much as possible, and 3) allow agricultural and forest management practices to continue.

## RESULTS

The union of the soil, wetland, and flood zone coverages created a single coverage with 23,475 individual polygons for identifying the county's primary conservation areas (Figure 2). Each polygon represents one of the eight categories listed in Table 9. The total areas of poor soils, wetlands, and flood zones in the county are shown in Table 10.

One problem with this procedure is that none of the original three coverages have the exact same georeferenced positions (Figure 3). The soil cover is displaced by about 485 feet from the land cover, while the flood zones coverage is displaced by 2.4 inches and the wetlands coverage is displaced by 0.6 inch. As a result, some data was clipped away, but more noticeable is that many narrow sliver polygons were created along the county boundary and shorelines. These slivers occur where original coverage data for either flood zones, wetlands, or soils do not extend, producing blank labels in the union coverage.

It was found that 87.07% of Currituck County's land area has natural limitations to development. Of this, 45.51%, or 39.62% of the county, has been classified as NWI wetland, poor soil for development, *and* susceptible to a 100-year flood event. Large portions of the county's geographical center, Knotts Island, and the Western side of the Outer Banks are classified with all three limitations.

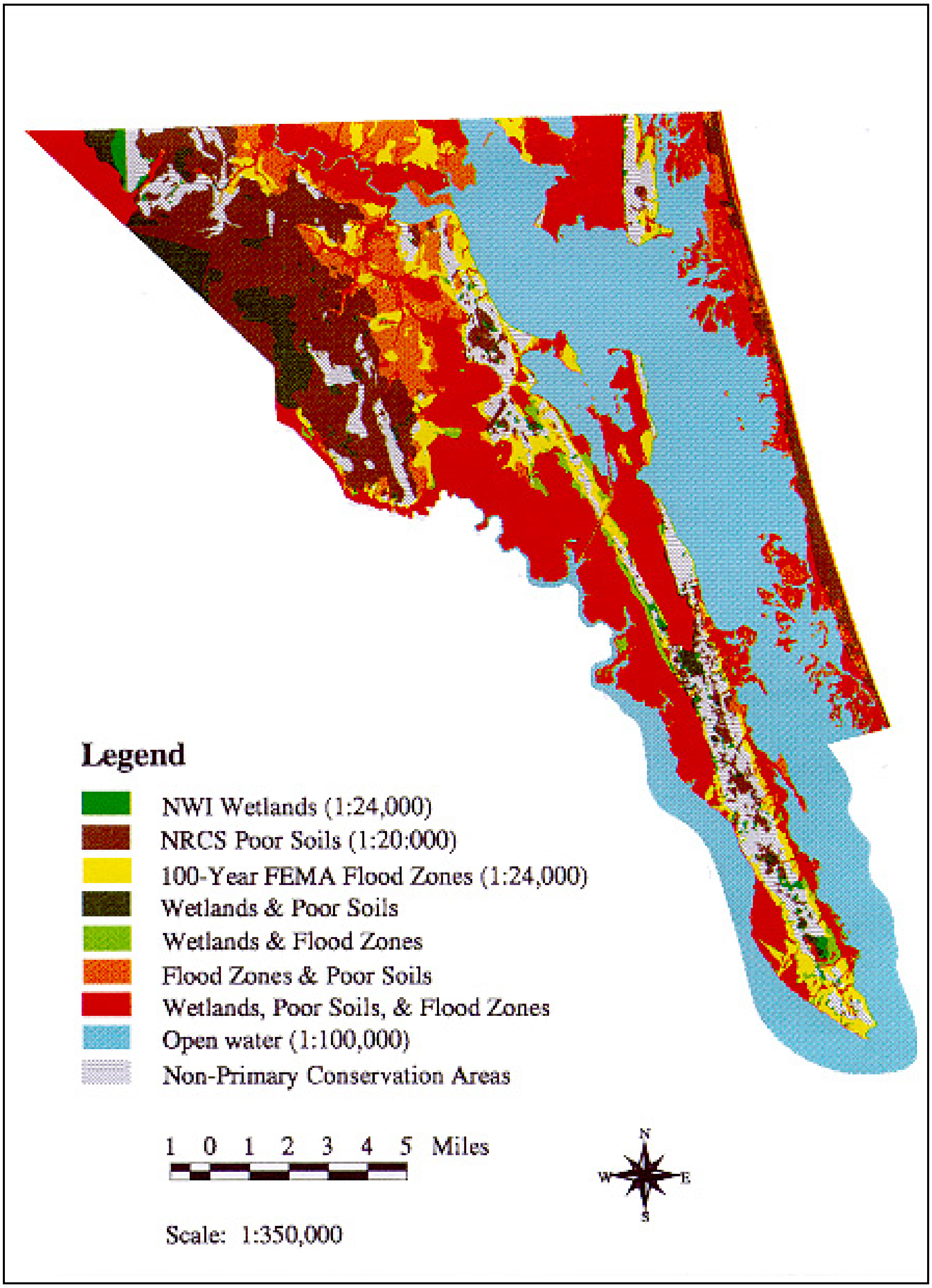


**Figure 2. Primary Conservation Areas of Currituck County, NC.**

**Table 9.** *Extent of primary conservation areas, summarized by polygon labels.*

| | Primary Conservation Areas | | | | | | |
|---|---|---|---|---|---|---|---|
| **Development Limiting Labels of Polygons** | **NWI Wetlands & Creeds** | **Poor Soils** | **100-Year Flood Zones** | **Acres** | **% of Grand Total** | **% of County** | **Number of Polygons** |
| NWI Wtlnds only | Yes | No | No | 1,420.38 | 0.97% | 0.84% | 516 |
| NRCS Soils only | N | Y | N | 32,048.79 | 21.86% | 19.03% | 1,333 |
| FEMA Fld Z only | N | N | Y | 11,721.29 | 7.99% | 6.96% | 1,807 |
| Wtlnds & Fld Z | Y | N | Y | 3,583.28 | 2.44% | 2.13% | 1,344 |
| Soils & Fld Z | N | Y | Y | 21,468.83 | 14.64% | 12.75% | 7,989 |
| Wtlnds & Soils | Y | Y | N | 9,491.40 | 6.47% | 5.64% | 1,020 |
| Wtlnds, Soils, Fld Z | Y | Y | Y | 66,719.45 | 45.51% | 39.62% | 7,572 |
| | | | **Total:** | **146,453.42** | **99.89%** | **86.97%** | **21,581** |
| **Sliver Segments** | | | | | | | |
| | Y | "" | "" | 2.58 | 0.00% | 0.00% | 99 |
| | "" | Y | "" | 0.09 | 0.00% | 0.00% | 358 |
| | "" | "" | Y | 0.00 | 0.00% | 0.00% | 0 |
| | N | Y | "" | 12.37 | 0.01% | 0.01% | 69 |
| | N | "" | Y | 16.03 | 0.01% | 0.01% | 20 |
| | Y | N | "" | 0.10 | 0.00% | 0.00% | 2 |
| | Y | "" | N | 16.78 | 0.01% | 0.01% | 7 |
| | "" | N | Y | 0.00 | 0.00% | 0.00% | 0 |
| | "" | Y | N | 0.00 | 0.00% | 0.00% | 0 |
| | Y | Y | "" | 15.86 | 0.01% | 0.01% | 159 |
| | Y | "" | Y | 92.59 | 0.06% | 0.05% | 60 |
| | "" | Y | Y | 5.19 | 0.00% | 0.00% | 6 |
| | Creeds "" | Y | Y | 0.00 | 0.00% | 0.00% | 22 |
| | | | **Total:** | **161.60** | **0.11%** | **0.10%** | **802** |
| **Grand Total of Primary Conservation Areas:** | | | | **146,615.02** | **100.00%** | | **22,383** |
| **Total County Land Area:** | | | | **168,387.96** | | **87.07%** | |

**Table 10.** *Total acreage and percentage figures of primary conservation areas.*

| **Data Coverage** | **Total Acres** | **% of Pri. Cons. Areas** | **% of County** |
|---|---|---|---|
| NWI Wetlands & Creeds Quad. | 81,342.76 | 55.48% | 48.31% |
| NRCS Hydric/Unsuit. for Dev. | 127487.98 | 86.95% | 76.70% |
| 100-Year FEMA Floodzones | 103,606.69 | 70.67% | 61.53% |
| **Primary Conservation areas:** | **146,615.02** | | **87.07%** |
| **Total Area of Currituck County:** | **168,387.96** | | |

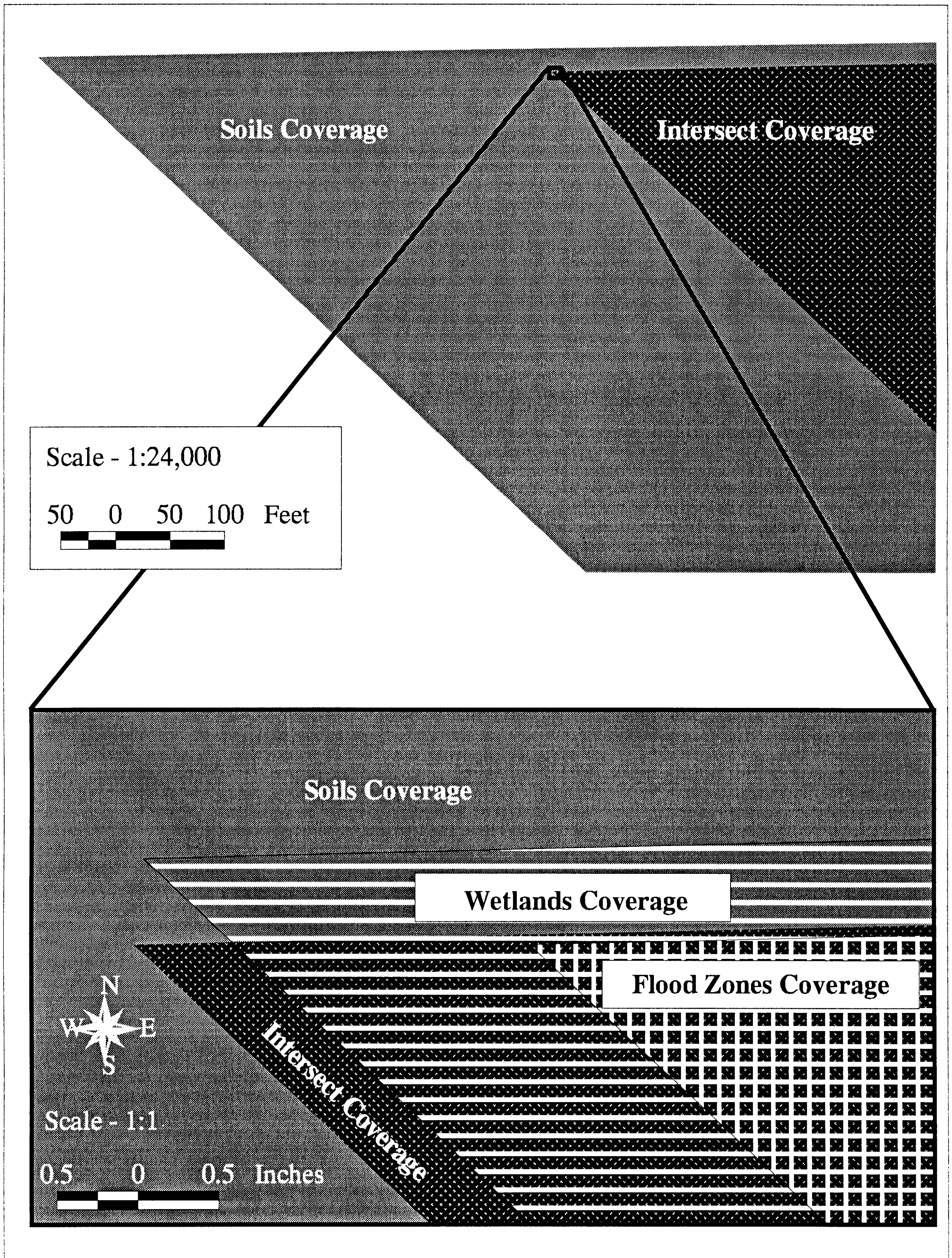


Figure 3. Georeferencing differences between coverages of soils, wetlands, flood zones, and the intersected land coverage used to remove open water. Shown is the northwest corner of the county.

Poor soils are the single dominant natural limitation to development, covering 76.70% of the county, based on NRCS data. Poor soils also comprise the largest percentage (21.86%) of unsuitable area that is not labeled with another impairing classification. Such areas are found mostly in the northwestern portion of the county and along the Outer Banks.

NWI classified wetlands are scattered throughout the county. Covering 48.31% of the county's land area, wetlands are least prevalent of the three primary conservation features. Areas classified as wetland also extend the least outside the bounds of the other two development limiting features (0.97%).

FEMA delineated flood zones cover 61.53% of the county's land, 7.99% of which are outside areas classified as poor soil and wetland. The northwestern portion of the county is not as susceptible to a 100-year flood event to as large an extent as the rest of the county. However, wetlands and poor soils still restrict most development potential there.

Nearly thirteen percent of the county is not classified against development. This land is found mostly along a strip extending in a North-South direction down the middle of the mainland, which is the U.S. Highway 158 corridor. Other non-primary conservation areas are found largely on portions of Knotts Island, and some land around Currituck and northwest of Moyock.

The digital orthophotograph for the 610-acre study site selected for more detailed study is shown in Figure 4 with only primary conservation areas overlaid. The site's land use/land cover classifications as digitized from the image is shown in Figure 5. The predominant land cover is cleared fields, followed by woodlands. Many of the woodland

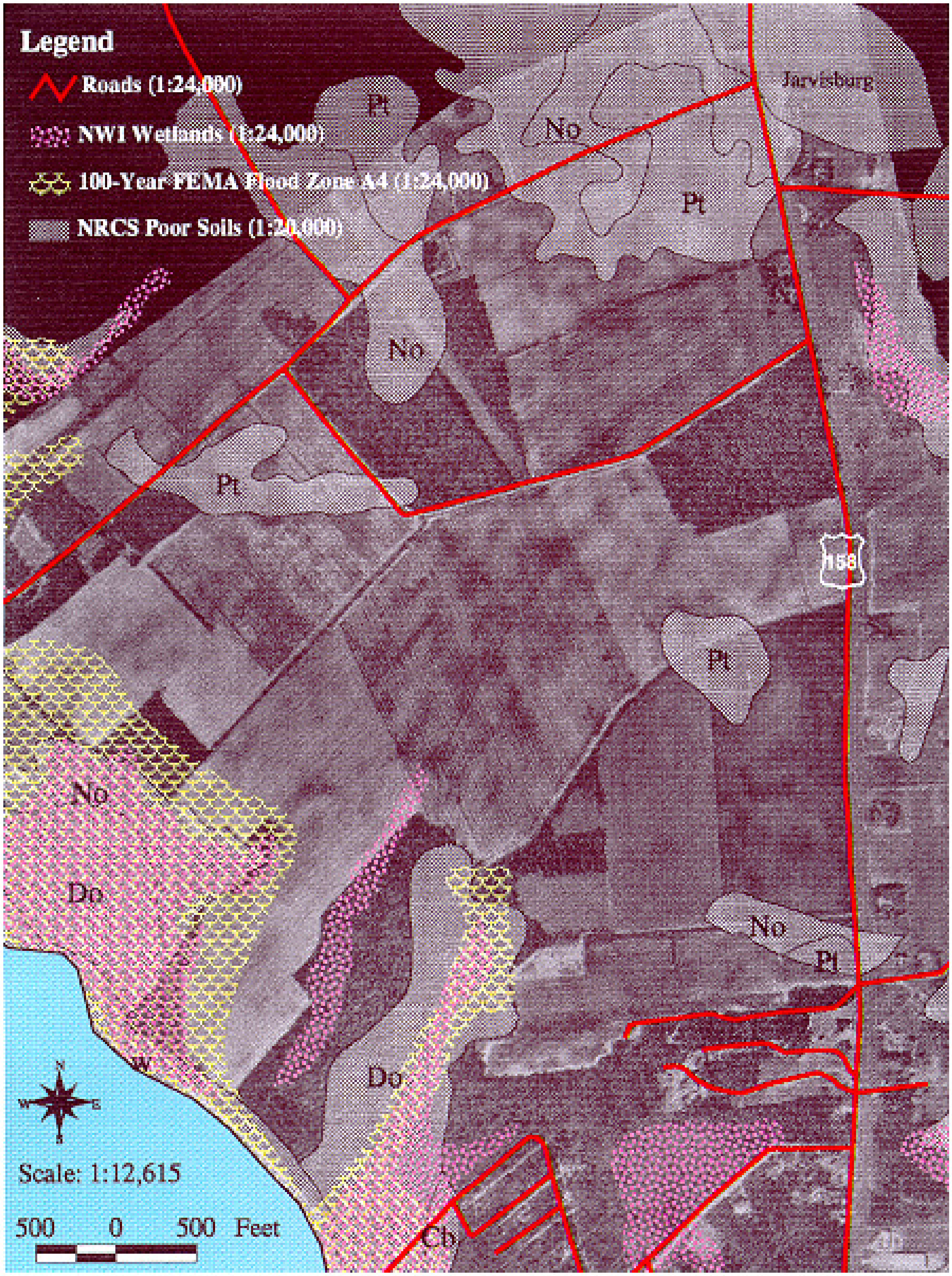


**Figure 4. Primary Conservation Areas within the 610-acre study site, Currituck County, NC.**

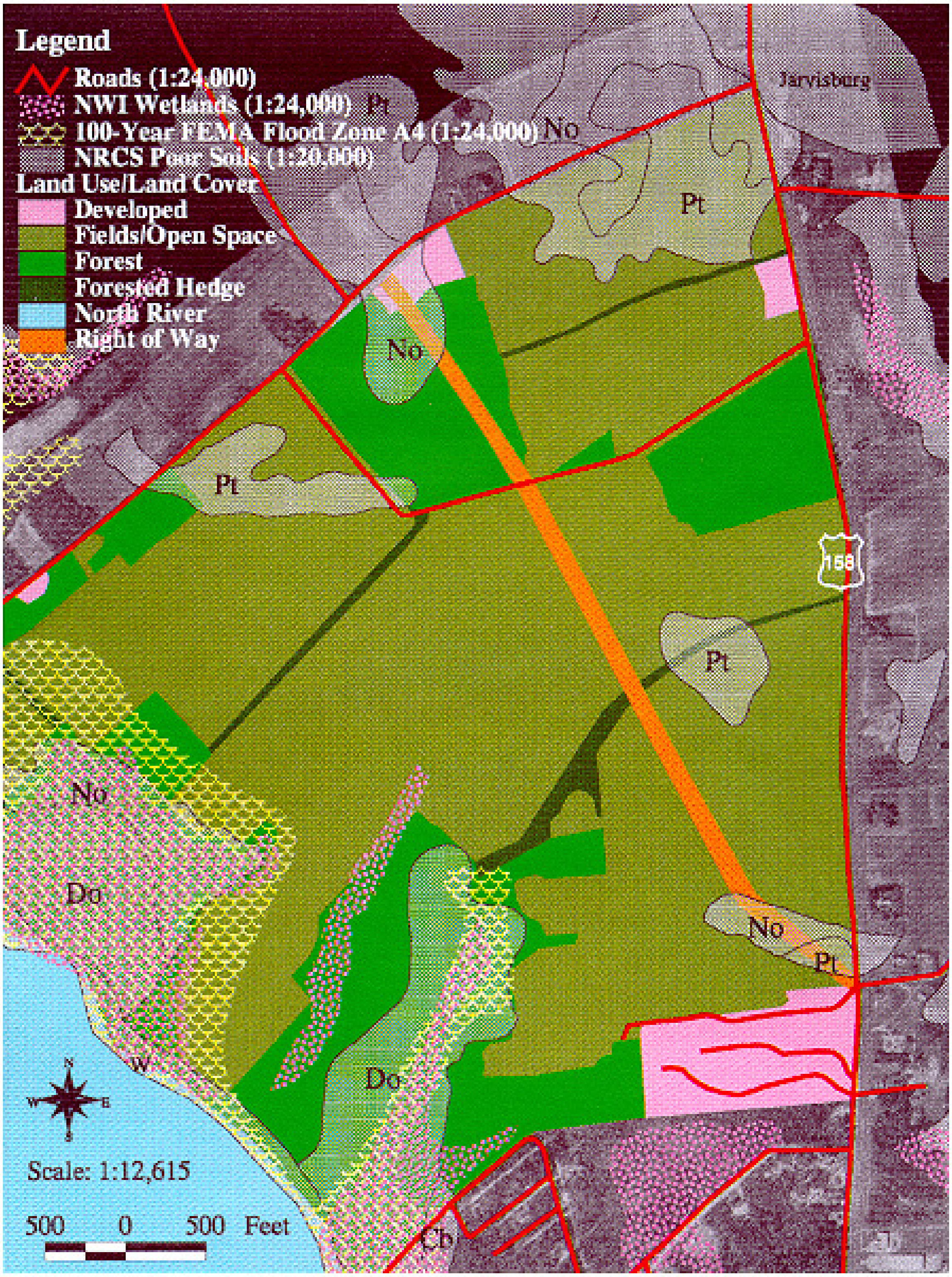


**Figure 5. Primary conservation areas and land use/land cover classifications within the 610-acre study site, Currituck County, NC**

areas are also primary conservation areas.  Portsmouth and Nimmo soils, which are unsuitable for development, are scattered around the site at various locations, isolated from other primary conservation features.

The best places for new cluster development were found to be around the forest/field interface, and in the corners of the fields bordered by trees and vegetative buffers (Figure 6).  Existing roads along the forested hedges between fields provide ample access to the southern and western sections of the property.  A right of way for electric lines bisects the fields and forests and should be utilized as a wide corridor of open space.

## DISCUSSION

While this analysis shows that only 12.93% of the land area in the county is naturally suited for development, there are various optional measures and considerations that have been and will continue to be taken to mitigate this amount.  Sewage lines and alternative on-site waste treatment systems may be available where poor soil limits the use of septic systems.  Wetlands may be filled to create additional construction sites, pending proper regulatory approval.  Currituck County allows construction in 100-year flood zones since flood insurance from FEMA is available.  However, many natural limitations to development remain.  Cluster development is therefore appropriate for Currituck County since only small portions of potential development sites need to be suitable for building.

With the available data, it was easier to delineate potential cluster development sites rather than secondary conservation areas.  However, secondary conservation areas may be assumed to exist outside of potential development sites.  Although Figure 6 depicts a first

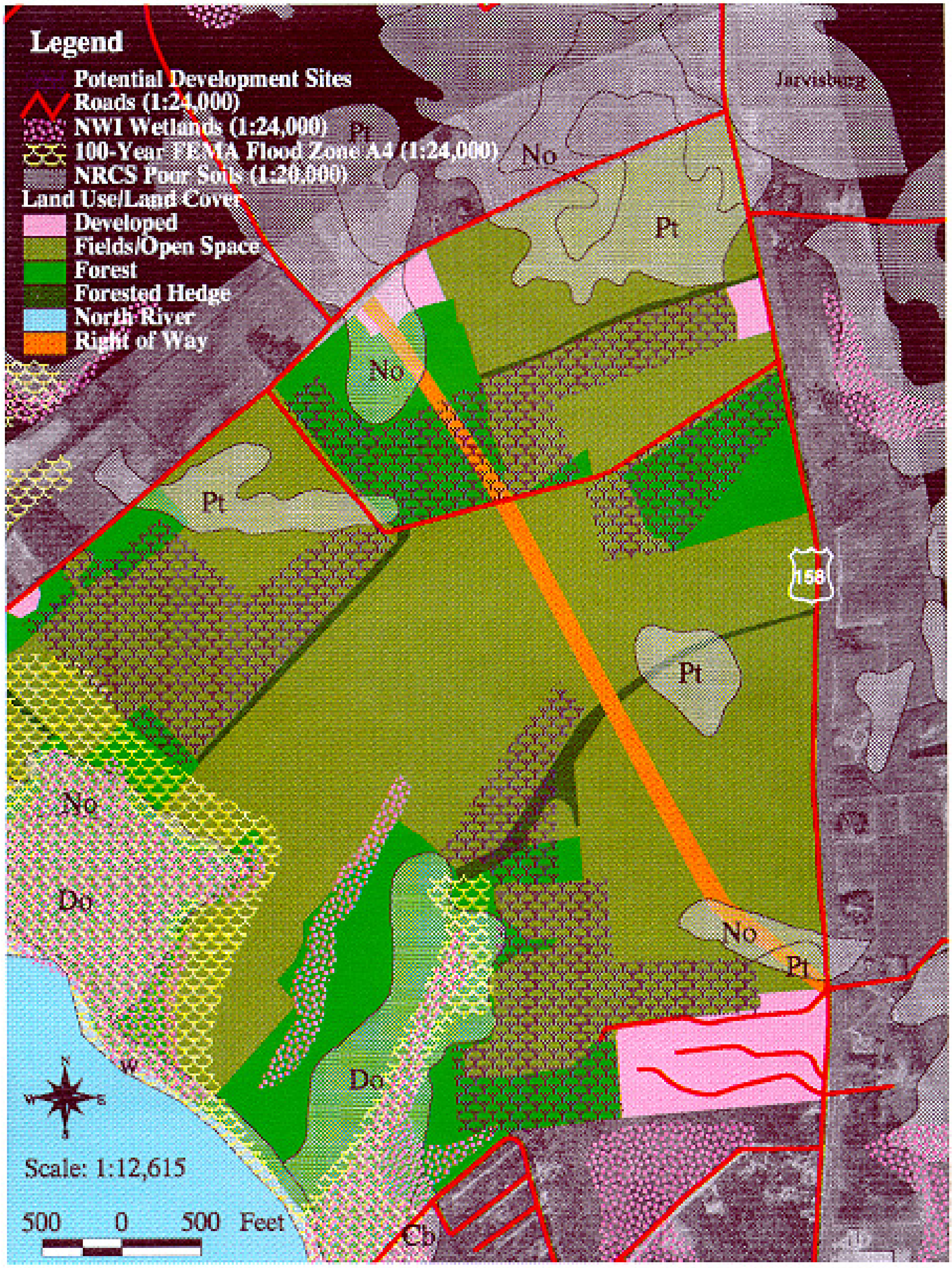


**Figure 6. Primary Conservation Areas and Land Use/Land Cover Classifications, and Potential Development Sites within the 610-acre study site, Currituck County, NC.**

approximation of the potential development sites, without landowner input, site visits, and consultation with local authorities, developers, conservationists, and landscape designers, these areas are difficult to exactly delineate. This is particularly true for the 610-acre study site in that almost all of the site's natural landscape features appear to fit the criteria for secondary conservation areas. Nonetheless, the wide-spread presence of primary and secondary conservation areas reveals that cluster development and open space design is appropriate for this site.

It was also found that more specific GIS analyses can be applied to local land use planning with these data based on the information needs of planners. For instance, the total acreage and location of "soils suitable for development" verses "suitable with modification" may be found (see Table 7). Also, thematic maps may be made of wetlands or flood zones using the more detailed classification attributes available with the data.

There are many opportunities for error while creating digital soils, wetlands, and flood zone datasets. For example, most of these data are interpreted from aerial photography, hand drawn onto hardcopy maps, and manually digitized. The 148-meter displacement of the Currituck County soils data indicates an error probably in photograph rectification and/or coordinate calculations. Also, more accurate map panel coordinates for the flood zone data could have been found using a digital United States Geological Survey 7.5 minute quadrangle grid available from NC CGIA. All the data used are of very general scale and are created using extensive aerial photograph interpretation and computer modeling. Therefore, caution must be taken especially when interpreting information about the landscape features shown in Figures 4 and 5. The intended scale of the data shown in these figures (1:24,000) is nearly half the actual scale shown (1:12,615). This means that interpretations of primary conservation area locations are twice as likely to be inaccurate than if the data were displayed at 1:24,000 scale. Persons taking this data to local citizens need to be familiar with the collection processes (found in the metadata) and error possibilities. However, despite the uncertainty, this data is useful for providing preliminary screening analysis and indications of possible development limitations.

For this study, FEMA flood zone data was manually digitized from FIRMs, but increasingly, more automated procedures are being used to generate water resource data needed for analyses. Robbins and Phipps (1996) have developed promising methods that use GIS as a data input, calculations, and output interface for watershed planning with the HEC-1 and HEC-2 hydrologic models. Both standard and customized ARC/INFO™ procedures enable modeling 2- through 100-year storm events for floodplain management and storm water infrastructure design. A number of steps are involved, including the creation of a Digital Elevation Model and a contour line coverage with intervals of two feet or less, as base maps. Necessary field data must be collected for streams, pipes and culverts, manholes, and catch basins, using a Global Positioning System data recorder. Calculations for Natural Resource Conservation Service runoff curve numbers, times of concentration, and lag times, as well as watershed boundary delineations, all become automated procedures with GIS, instead of performed manually as is traditional. This data is fed into the HEC-1 model to generate runoff hydrographs -- output needed for determining flood extents. But first, ARC/INFO™ routines are used to model stream channel dimensions and generate cross sections, which are combined with other required attributes and HEC-1 output, and run in the HEC-2 model. GIS then provides easy display of the output, that before had to be manually interpreted from raw numbers. This approach provides community leaders and engineers with an accurate and comprehensive detailed model of their storm water management system and areas that remain susceptible to flooding. The ARC/INFO™ linkage with HEC-1 and HEC-2 models has been successfully demonstrated for an urban watershed in Charlotte, North Carolina. The result was a 25 percent cost savings compared to budgets for similar projects in the past, along with better quality control and vastly improved data management capabilities.

To maximize the potential of cluster development zoning in providing necessary housing while keeping open space and natural resources, Pivo et al. (1990) created a list of guidelines for local decision makers to consider when writing cluster development zoning codes. These guidelines are intended to hopefully increase the attractiveness and suitability of cluster zoning for developers. The following considerations pertain only to locating cluster districts and projects, and individual project planning. They are designed for application in rural areas, but are not appropriate for all communities. Putting these guidelines into practice may appear daunting, but with the proper databases (zoning, land use/land cover, infrastructure, and demographics at a minimum), implementation is facilitated using GIS functionality and modeling. Pivo's list includes:

1. Rural cluster zoning is most suitable in rural-to-suburban transition areas where it can preserve small-scale farming and open space while providing needed housing.
2. Cluster district boundaries should be drawn in relation to the boundaries of existing agricultural areas and environmental systems.

3. The total amount of development in the zoning district should be limited through gross density requirements that protect and maintain existing rural character, open space systems, and water resources, and control traffic volumes and road building.
4. Control the siting of cluster projects in order to minimize impacts on neighbors, infrastructure systems, and the surrounding environment.
5. Standards should be established for minimum and maximum project sizes so projects are large enough to support viable open spaces but small enough to prevent the residential cluster development from overwhelming the surrounding area.
6. The primary component of the project site is the open space system. The system should be a network of spaces designed to be usable for their intended purposes and permanently protected or explicitly designated for future development. Requirements for ongoing maintenance, management, and use are advisable. Preparation and implementation of an open space management plan should be required.
7. There should be a pattern of cluster areas established within the project site. Residential development should be confined to these areas. The cluster areas should be integrated into the site without causing significant impacts on neighboring properties and without interrupting the continuity of existing and planned agricultural and related users.
8. The net density of the cluster areas in the project should be matched as closely as legally permissible to the land requirements for rural lifestyles. In particular, private open spaces should be large enough for rural household activities, such as raising animals, keeping orchards, and gardening.
9. The number of homesites per cluster area should be limited. Within the cluster, there should be a minimum of four and a maximum of eight homesites, a cluster core and access corridor to accommodate vehicles, utilities, and commonly owned facilities, and a pathway to the project open space system. Cluster areas should be visually and physically separated from one another and roadways by open space buffers.

## GIS for Other Growth Management Planning Tools

Like cluster development planning, most of the other growth management tools proposed by the Blueprint (Land Ethics and Center for Watershed Protection 1995) might also be more easily planned and administered using GIS. Although many of these tools would require state and/or local enabling authority, primarily through local zoning ordinance changes, they are potential solutions for improving and maintaining the high environmental quality of North Carolina's coastal region. The following discussion presents the Blueprint's brief description of each tool and how GIS functionality may be applied toward their implementation.

> "*Overlay zoning* is a tool used by planners to identify certain geographical areas which require special recognition or protection. The overlay zone is normally established to discern a specific resource or geographical condition which is to be protected or simply identified. The overlay zone is superimposed over existing zoning wherever the condition is present. Actual development standards applied within an overlay zone would be tailored to the unique needs of the resource being protected," (Tool #1).
>
> *Sensitive resource protection ordinances* are drafted primarily for specific resources which may be adversely impacted by development. Examples in North Carolina coastal communities include Areas of Environmental Concern (AECs) as well as specific resources such as tidal and nontidal wetlands, coastal shorelines, habitats for rare and endangered plant and animal species, and stream valleys," (Tool #6).

GIS is perfectly suited for overlay zone and sensitive resource mapping and analysis. Many environmentally sensitive areas are currently represented in statewide geographic databases. Planners may use this data to visualize the extent of such areas, and identify zones that need special protection. This overlay zoning or a sensitive habitat protection information could be provided to local officials, land owners, developers, planners, and others to facilitate appropriate planning and development. Cooperative Extension Service experience indicates that this type of analysis and application is most effective at the local level. Development would not necessarily have to be completely restricted within these areas, but perhaps only allowed at reduced densities, or on the other hand, clustered. Such spatial differences in development criteria may also be easily displayed with GIS. As growth spreads encroaching closer to sensitive habitats, it is important for data about these resources to be readily available so that everyone will be more aware of their locations and value. For example, the close proximity of proposed development projects to AECs might not be fully realized in the early planning stages without GIS data to display such information.

> "Natural buffers between land and water are highly productive and diverse systems which provide many important function and benefits. One of the most important benefits is that of improving water quality in receiving waterbodies. Buffers act as a sort of natural scrubber, preventing excess nutrients from entering waterways and wetland areas. They act as filters by using the captured nutrients for growth. *Shoreline and wetland buffers* are not only vital to improving water quality, but they provide habitat for fish and wildlife," (Tool #9).

> *Greenbelts* are areas of open space or significantly reduced development density surrounding existing communities. A greenbelt provides the opportunity to preserve agricultural land, recreational areas, and significant natural resources in close proximity to a town or city. Preserved natural areas work to buffer waterbodies from development impacts. A greenbelt may be achieved through zoning, creative development planning, and land acquisition or a combination of these approaches," (Tool #2).

The water quality and recreational benefits from streamside buffers and green ways are widely appreciated and accepted.  Not only do shoreline and wetland buffers support strong ecological health, they also improve property values, especially when accented by trails and greenbelts, according to the Blueprint.  Recent efforts by Xiang et al. (1993, 1996) have shown successful and cost-effective methods for finding ideal buffer widths and optimal trail corridors using GIS.  Soil, slope, land use/land cover, and hydrology data are needed to perform their analytical procedure of calculating and mapping variable buffer widths.  The application of this procedure to the coastal region would probably necessitate using wetland data also.  The procedure has proven effective for evaluating proposed and existing buffer regulations. Once buffer areas are determined, additional data such as geology and locations of other special natural attractions are used to determine the best trail alignment for a green way.  This is done by dividing the area into grid cells and assigning values to each cell according to the suitability of that location for a trail.  GIS is also used to inventory existing green way trails within urban areas and find possible connection corridors (Branch 1997).

> "Setting *limits for* the total amount of *impervious surfaces* that may be constructed in a watershed can reduce the overall impact of stormwater runoff from paved surfaces to receiving bodies of water," (Tool #4).

> "The quality of stormwater runoff can be improved through the use of stormwater BMPs that are installed with new development, or stormwater retrofits that are installed in existing developments.  In coastal states, the most common *stormwater [treatment]* practices are infiltration basins, swales, filter strips, created wetlands, and retention ponds," (Tool #14).

Impervious surfaces increase the needs for storm water management because imperviousness hinders or prevents the natural infiltration of rainfall into the soil (see Table 4). In the coastal region, this routinely causes problems such as shallow flooding, reduced groundwater recharge, polluted excess flow into drainage canals, and decreased salinity levels in estuaries and other tidal water bodies. In response to such problems, GIS has been used in many instances to provide reliable estimates of urban impervious surface percentages (Arnold and Gibbons 1996) and has proven very useful for the planning and maintenance of storm water infrastructure and management systems. Phipps (1996) shows how small communities may develop comprehensive storm water management programs that comply with necessary regulations using GIS. The first step involves estimating impervious surface coverage. This information is not only useful for storm water planning, but may also indicate the major locations of impervious areas, and the need for changed policies regarding site design standards, road widths, and the amount of required paved surface for new development. Phipps recommends using digitized aerial photography to delineate impervious cover. Furthermore, a local storm water utility may use this data for billing property owners who contribute large runoff volumes or to give credits to those who have installed BMPs. Storm water infrastructure inventory and maintenance needs are also more effectively met with GIS.

> "*Transfer of development rights* (TDRs) is another tool that a community can use to preserve open space and safeguard environmentally sensitive areas. TDR programs function with the designation of 'sending' and 'receiving' zones within a community. The sending zones are the areas identified for open space and resource protection, and the receiving zones [are] the

> designated growth areas.  There is no current state legislation enabling TDRs in North Carolina," (Tool #3).

According to the Blueprint, a TDR program allows a landowner to sell the right to develop even if development is prohibited on his or her property, thereby protecting the land's equity value.  Many states, including Maryland, have examples of effective TDR programs, but as noted, this tool is presently not allowed in North Carolina.  While the technique does place significant time requirements on planning department staff, GIS would be very valuable to them for maintaining detailed databases of land uses, sensitive areas, "sending areas," and "receiving areas."

> "Forested woodlands provide a variety of benefits to communities, including recreational opportunities, aesthetic values, economic benefits from timber management, and important habitat areas.  Forests located along streams and creeks (riparian corridors) play a key role in protecting water quality and maintaining a healthy balance of flora and fauna…[*Forest conservation* is essential for] protecting the air we breathe and the water we drink," (Tool #7).

Planners and developers need to be highly knowledgeable about woodland locations since, according to the Blueprint, retaining existing trees on a residential or commercial site increases property values and enhances the rate at which units are sold or leased. Mitchell (1995) has shown how in urban settings, GIS allows excellent visualization and analysis of forest cover so that contiguous wildlife movement corridors, green ways, and other ecologically sensitive areas may be identified and protected.  Also, forests at risk of disease or land clearing activities, or in need of additional tree plantings and species improvement, may be identified.  From there, responsible government agencies and/or concerned citizens may assist the landowner with properly managing their resources so that severe economic and environmental losses are not suffered.

The Blueprint also advocates that coastal counties and municipalities should join together and engage in more regional planning efforts (Tool #18). One of the advantages of this approach is that the planning focus can be more easily placed on a watershed scale, which is preferred over restricting the focus area to arbitrary jurisdictional boundaries. Also recommended is the establishment of storm water, wastewater, and water quality authorities to address specific concerns within communities (Tools #19-22). Such authorities would be well served by GIS for education, information, planning, implementation, and other management needs.

Additional growth management strategies for protecting water quality suggested by the Blueprint are proper siting of marinas (Tool #5), septic systems (Tool #8), and septic system alternatives (Tool #17). Using GIS functionality, sites of minimal cumulative impacts may much more easily be identified. All of these GIS applications help lead to more informed decision-making and to more cost-effective water resource management.

Recently released software called "What If? Planning Support System" appears capable of performing many valuable modeling and analysis functions for planners using GIS data. According to the software developers, the program, ". . . can be used to determine *what* would happen *if* certain policy choices are made and assumptions concerning the future are correct." Infrastructure expansion, alternative land-use plans, and zoning ordinances are a few of the scenarios that can be modeled to better understand their impacts. Population and housing projections, resource allocation constraints, infrastructure, the assumed future industrial outlook, and land use controls are some of the parameters that may be input to generate maps and reports of land use options (Klosterman 1997).

**Conclusions**

This study has examined how GIS may be used to more precisely and efficiently perform growth management planning at the local government level. The execution of growth management tools such as those suggested by the Blueprint is going to become increasingly critical for ensuring the protection of coastal North Carolina’s rich natural resources, cultural heritage, economic vitality, and quality of life. One of the advantages of growth management planning strategies is that it allows community residents to have the flexibility of deciding themselves what they want their land to look like in the future. Whereas wetlands, flood zones, and poor soils were used in this analysis to designate primary conservation areas, citizens may choose to be more or less restrictive in what they want to see developed and protected with cluster development design. GIS can assist with the process of defining and identifying conservation zones within each planning jurisdiction. From there, the agreed upon development patterns for the future may be included in the county’s Land Use Plan or a master plan for the area, and used to guide new growth (Simoneau 1997).

GIS is becoming more widely recognized as an excellent technological tool for better understanding land use patterns, resulting issues and problems, and then for finding solutions (Christensen 1996). Land managers, as well as everyone seeking spatial information, need to be taking more advantage of the classification, database analysis, layering, and visualization features of GIS in order to thoroughly evaluate land use scenarios and policy options. As land use planning trends shift nationally from federal to local authorities, from regulatory requirements to non-regulatory incentives, and from piecemeal conservation to looking at whole system relationships, the importance of using GIS to allow engagement of all stakeholders and to make educated decisions is becoming increasingly important (Noonan 1997).

Also increasing in importance is the need for services provided by Cooperative Extension whereby all citizens may be better informed about how to carry out their daily activities in a way that will have a positive effect on others. In North Carolina, where water quality issues have recently gained greater attention, the CES is seeking to find ways of educating the local leaders and the general public about their responsibilities for ensuring that everyone has safe and adequate water supplies. Working to meet this goal, the "Improving Water Quality in the Albemarle-Pamlico Estuarine Region" program has reached many, using means that have included GIS analyses and maps.

Land use practices directly affect water quality, and that is one reason why planning is important and why improved technological methods should be used to assist planners. The implementation of growth management tools is needed in many prospering communities, and especially in Currituck County. This study has shown how GIS may be used by planners and others there and elsewhere to gain a greater understanding of the best ways to apply various planning techniques such as cluster development zoning. Again, issues of scale and accuracy levels must be considered any time that GIS data is used, especially for site-specific interpretation. This unfortunately introduces uncertainty into GIS applications, but the technology is still a vast improvement over past information management systems.

Traditionally, GIS assistance has been provided to county and municipal governments from the state level. However, local decision-makers hold responsibility for guiding their own future, and the future of generations to come. Therefore, they need direct access and more frequent employment of data and information that will lead to improved decision making. Change is inevitable, but hopefully through careful planning, education, and respect for others and the resources we all share, our decisions will lead us toward an enjoyable and sustainable future.

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# APPENDIX 1

## Conservation Subdivision Design for a site in Currituck County,

## "Old Fields, Swamp Forest, and Archaeological Sites on the Sound"

**By: Randall Arendt**

# Old Fields, Swamp Forest, and Archaeological Sites on the Sound

## Introduction

This 50-acre site is situated along the lower reaches of the North Landing River as it enters Currituck Sound, part of the huge Albemarle-Pamlico estuarine system that dominates the low country of northeastern North Carolina (see Figure 7.2.1). This extensive estuary provides vital resources for the farming, recreation and fishing industries that form the region's economic base, are the foundation of the regional economy. As family farms continue to de-cline in number, much of the land they formerly occupied is gradually being converted to new subdivisions serving commuters to the Hampton Roads area of Chesapeake, Norfolk, and Virginia Beach, Virginia, and both vacationers and retirees who are drawn by the area's peaceful atmosphere, plentiful fishing, and quietly attractive coastal scenery.

This part of North Carolina is also particularly rich in archaeological and historical resources, reflecting the close relationship of older cultures and peoples with the Sound. The property examined in this case study demonstrates how new development can be readily accommodated in a practical way that protects historic and prehistoric resources, and also respects the natural and scenic qualities that continually draw visitors and new residents to this remarkable corner of the state.

Currituck County is experiencing tremendous development pressure due to its location between Hampton Roads, Virginia and North Carolina's Outer Banks. With 1200 feet of frontage on the Sound and its close proximity to the Virginia state line, this site is almost certain to be subdivided within the near future. On coastal properties such as this one, the typical development pattern is for the valuable waterfront lots to be "stripped off' and sold first. Afterwards, the remaining backland is gradually developed according to standard suburban subdivision practices but, without views of the Sound and with limited water access, these interior lots command far lower prices than do those on the water. Furthermore, the resulting pattern of standard houselots and streets is completely out of character with the traditional rural landscapes it replaces.

In contrast, by thoughtfully siting the same number of homes on selected parts of a property, and by preserving the remaining land as an amenity for all the residents to enjoy, conservation subdivision design can enable landowners and developers to meet or exceed the net financial return likely to be produced by conventional development plans. To ensure that the conservation subdivision plan will realize the full development potential offered by this property, a maximum-yield layout following conventional "cookie-cutter" design methods is drawn up for this purpose, based on lot standards in the existing zoning ordinance. This standard" pattern is illustrated in the "Yield Plan" (Figure 7.2.2) and in the aerial sketch of that layout (Figure 7.2.3).

The maximum density allowed in this part of the County is one house per 40,000 square feet of land, with a minimum lot width of 125 feet. All lots must contain an adequate area of dry upland soils to accommodate septic drain fields. However, as public water is available, private wells are not needed. Finally, street standards limit cul-de-sacs to 1000 feet in length, for emergency access reasons. These regulations also require that at least five percent of the total parcel area must be left as usable open space, no less than half of which must consist of buildable land. Within this required open space there must also be at least 20,000 square feet of land providing public water access. Under these conditions, 33 lots could be created on this property, seven of which could have water frontage. This lot count is then used as the target to be achieved using the conservation subdivision design process.

## Site Analysis Phase

The conservation subdivision design process begins with a fairly thorough site analysis and investigation of the local context. This property, like many in the area, is comprised largely of wetlands and farm fields. The traditional land-use pattern, which shows up very clearly on aerial photographs, is determined by the large, irregular areas of swamp and hardwood forest with high water tables at or near the surface. Farm fields are located on upland areas of sandy loam, and are often drained by ditches that help remove excessive moisture from the seasonally wet soils. Farm boundaries follow the natural landscape units, with roads and homes generally located on the highest points.

At one time this property was part of a larger farm, but it now contains a single contemporary house near the water and a few small watermelon fields. Almost half the site is covered by swamp forest adjacent to a small creek that defines the southern edge of the property, with the remainder in fields or pine woods. An entrance drive lined with oaks and pines, displaying the characteristics of a rural lane or farm road, parallels the north property line, turning near the water to reach the house. The adjacent property to the north has already been divided into the conventional pattern of farm fields along the state road and residential lots along the waterfront. The site can be best described in terms of three distinct open areas --or “outdoor rooms” -- bounded by the wet woods and the pine stands. The upper field, adjacent to the public road, enjoys views across neighboring farmland, and encompasses a small stand of oaks lining the existing drive. The central field, bordered on three sides by woods and on the fourth by the drive, is a comfortably e n-closed space focused inwardly on itself. And the waterfront area possesses a park-like quality with its tall pines, meadow grasses, and wildflowers framing outward views across the Sound.

The grouping of mature oak trees on the small rise near the road suggests that a farmhouse might once have been located on this property. Most significant historically, however, is the presence near the shore of a Native American archaeological site. Remains have been found dating back to the Woodland period (1000 B.C - 1000 A.D.), including shell middens and pottery. Remarkably intact pieces have been unearthed, suggesting that the site is largely undisturbed and could be of National Register significance. Sites of this kind are in extreme danger of being destroyed by earth-moving and excavation machinery during the “normal” course of development, or of being lost to coastal erosion. Like habitat areas, archaeological sites are threatened by fragmentation resulting from development. Subdivision of large farms into many private hands reduces the chance that evidence will ever be pieced together to form a coherent picture of past activities.

Following conventional development techniques, this important resource would clearly be endangered. By contrast, the conservation subdivision design process makes it possible to preserve not only the entire archaeological site, but also the property’s natural and scenic features -- such as the entrance drive, the formal line of oaks and pines, and the small fields that create the feeling of "outdoor rooms” -- all subtle elements of the property’s traditional landscape that collectively form its rural character, and none of which are afforded any protection by existing County regulations. Conservation subdivision design also helps protect water quality and wetland and upland ecosystems, since large areas of the site could easily be left undisturbed, with development shifted to the least sensitive and best suited areas. Under a conventional layout such as typified by the “Yield Plan”, it is likely that individual owners would gradually clear and fill much of the swamp forest vegetation occupying the back portions of their deep houselots, compromising the wildlife habitat and possibly lowering the water quality (through lawn runoff rich with fertilizers and weed-killing agents). In contrast to the methods used in laying out conventional plans, the process of designing conservation subdivisions begins by prioritizing the site features most worthy of protection and then fitting development areas around them.

## Design Phase

*Step One: Identifying Conservation Areas.*

The first step in this process is to delineate the Primary and Secondary Conservation areas noted in the site analysis. The Primary Conservation Area encompasses the wetlands along the creek where the water table is at or near the surface throughout the year (Figure 7.2.4). The native swamp forest in this part of the property consists of a canopy layer of bald cypress, water tupelo, red maple, American elm, loblolly pine, pond pine, sweetgum, tulip poplar, and several species of oak. The understory contains ironwood, American holly, sweetbay and red bay.

Shrubs and vines are quite dense, with fetterbush (Leucothoe racemosa and Lyonia lucida),highbush blueberry, Virginia sweetspire, and titi entwined with catbrier, Virginia creeper, muscadine, and trumpetvine. Several fern species are present including cinnamon fern and Virginia chainfern, while maidencane, pickerelweed and green arrow-arum inhabit the wettest places. Other species observed nearby were sugar hackberry, mulberry, inkberry, black cherry, yaupon, sassafras and loblolly bay.

These native plants provide an extensive palette which could be selectively used in landscaping developed areas so that they may blend more successfully into the natural landscape and extend the habitat for local wildlife. A mix of native species that approximates the layered structure of the natural forest offers a much richer and more productive landscape system than the typical pruned and mulched collection of exotic tropical species seen in so many coastal developments. This kind of mix would also be more resistant to drought and low temperatures, less vulnerable to insects and disease, and would require far less maintenance than would non-native plants and trees. In addition, it would blend in with the surrounding natural areas much more successfully than would standard suburban landscape treatments, capturing “the spirit of the place”. These characteristics offer clear advantages for developments with landscaped areas that must be maintained by homeowners’ associations.

The Secondary Conservation Areas are identified by delineating the other features of the site that are noteworthy for their historic or scenic values, or that contribute significantly to its rural character, such as the property’s “outdoor rooms” (open fields bounded by “walls” of trees). Among the Secondary Conservation Areas are the public viewshed from the state road (including the foreground meadow and most of the oaks and pines that line the entrance drive), parts of the inner field and the pines that frame its eastern edge, the views outward toward the Sound, the pine grove and meadow near the water and, most importantly, the Woodland-era archaeological site. This site has been determined to contain unusual flat-bottomed shell-tempered ceramic beakers and bowls in a variety of sizes and styles, according to the North Carolina Department of Cultural Resources.

Once these conservation areas have been mapped (see Figure 7.2.5), those parts of the site that are best suited for development can be identified as “Potential Development Areas” (see Figure 7.2.6) with house sites and streets located thereafter. Another criterion for Secondary Conservation Areas, on this particular property, should include soil conditions that are highly appropriate for individual or shared septic leaching fields, within several large common conservation meadows or neighborhood “greens”. These portions of the parcel should not be used for house sites or streets, and constitute another significant resource that should be deliberately “designed around”.

### *Step Two: Locating House Sites*

Although potential development areas readily emerge once the property's conservation elements have been prioritized, when locating the home sites care must be taken to maximize homeowners' views of the special site features. The waterfront area, typically divided into a few exclusive lots for the sole use of their owners, becomes instead a resource for the entire neighborhood to enjoy. When waterview lots are substituted for waterfront lots, the land along the shoreline can be conserved as a private park for use by all residents of the subdivision. Taking advantage of the county's Planned Residential Development (PRD) ordinance that allows lot sizes to be reduced to one-quarter acre (10,000 square feet), ten lots with direct views and easy access to the water can be created, three more than would be possible under the conventional Yield Plan. The value of the remaining lots is also increased by the presence of a neighborhood park along the water's edge (which could also accommodate individual or shared septic systems, except at the southern end where the archaeological remains are located). The archaeological site, once mapped, could be covered with a layer of turf and used as a softball field, which would not disturb any remaining prehistoric artifacts.

The other 25 homesites are situated around the edges of the two upper fields, so that their central areas may be managed as meadows or "village greens" for visual enjoyment, casual recreational use, and subsurface sewage disposal (Figure 7.2.7). Each of these housing groups possesses a slightly different character, providing residents with a stronger community atmosphere, a greater sense of place, and a real appreciation for the fields, woods, and shoreland that comprise their very special neighborhood. Sadly, basic elements such as these are missing in most conventional subdivisions where every street tends to look just like every other, and where most of the natural landscape features have been swept away by layouts insensitive to them. The interior lots in the conservation design are slightly larger than those on the waterfront, and are extended psychologically and visually by the adjacent open land in front and in back. As a result, residents should perceive a greater sense of space than they would in standard subdivisions where front windows stare blankly at garage doors across the street, and where rear decks often look out over one another.

### *Step Three: Designing Street Alignments and Trails*

Step Three involves laying out a street and pathway network to access the proposed homes and recreation areas (see Figure 7.2.8). The principal street follows the existing "country lane" (or drive) under the large oak trees. Care should be taken to minimize root damage during construction by directing heavy vehicle traffic and utility trenching outside the root zone. A stub connection to the adjoining property keeps the street from exceeding the maximum length allowed for cul-de-sacs. Pavement widths on the two short streets, which serve only five homes each, could be allowed to be as little as 12 feet because of their low traffic levels, with gravel shoulders provided to create 20 feet of vehicular-bearing surface. (Those shoulders could be surfaced with traditional materials such as clamshells, or could be covered with several inches of loam and be seeded with a tough but attractive groundcover such as white clover, to reduce dust and help retain the site's rural character.) Curbs and gutters should not be necessary at these overall building densities on such sandy soils, and casual footpaths of clamshell or beach gravel could be substituted for suburban walks of asphalt or concrete. Woodland trails could simply be cleared, slightly mounded, and mulched so they will remain dry, allowing residents to stroll about the open space while enjoying the property's natural features and outward views.

*Step Four: Drawing in the Lot Lines*

Finally, all that remains is to draw in the lot lines, making sure that each lot possesses at least 10,000 square feet, as required by the PRD ordinance (see Figure 7.2.9). Individual lots may vary in size according to the features of the site and market demands, thereby appealing to a broad spectrum of home buyers. Three “flag-lots” have been created at the eastern end of the upper green so that these homes can face this open space. (If they had been located at the opposite end of this green, they would have had less backyard privacy and would also have obstructed public views of this conservation area.) In other instances this creative lot shape has been used to reduce cul-de-sac length, thereby reducing future public street maintenance costs and the total amount of site disturbance. In areas where lots extend into the woodlands, it would be desirable to require that residents respect the existing forest edge, while allowing some additional plantings or selective cutting to occur. The goal is to blend the new development into the existing landscape rather than to impose a new geometry onto the traditional pattern.

In developments with lots of the size shown here (10,000 sq. ft.), it is also important that lot lines should be drawn so that each houselot will have fairly direct access to contiguous open space, where individual (or shared) off-lot septic drainage fields can be situated, within the open space, in locations earmarked for such use on the Final Plan.

This four step process maintains the original character of the landscape while accommodating a substantial change in land use, as illustrated in the third aerial perspective sketch (Figure 7.2.10) Development blends more gracefully into the surrounding landscape, and has less negative impact on the site’s cultural and natural resources, as compared with the conventional “checkerboard” approach. All this is accomplished while increasing real estate values, adding several special marketing advantages that typically produce faster sales, and that create a greater sense of community for the new residents who can also enjoy more of the rural landscape views that have attracted them to the area.

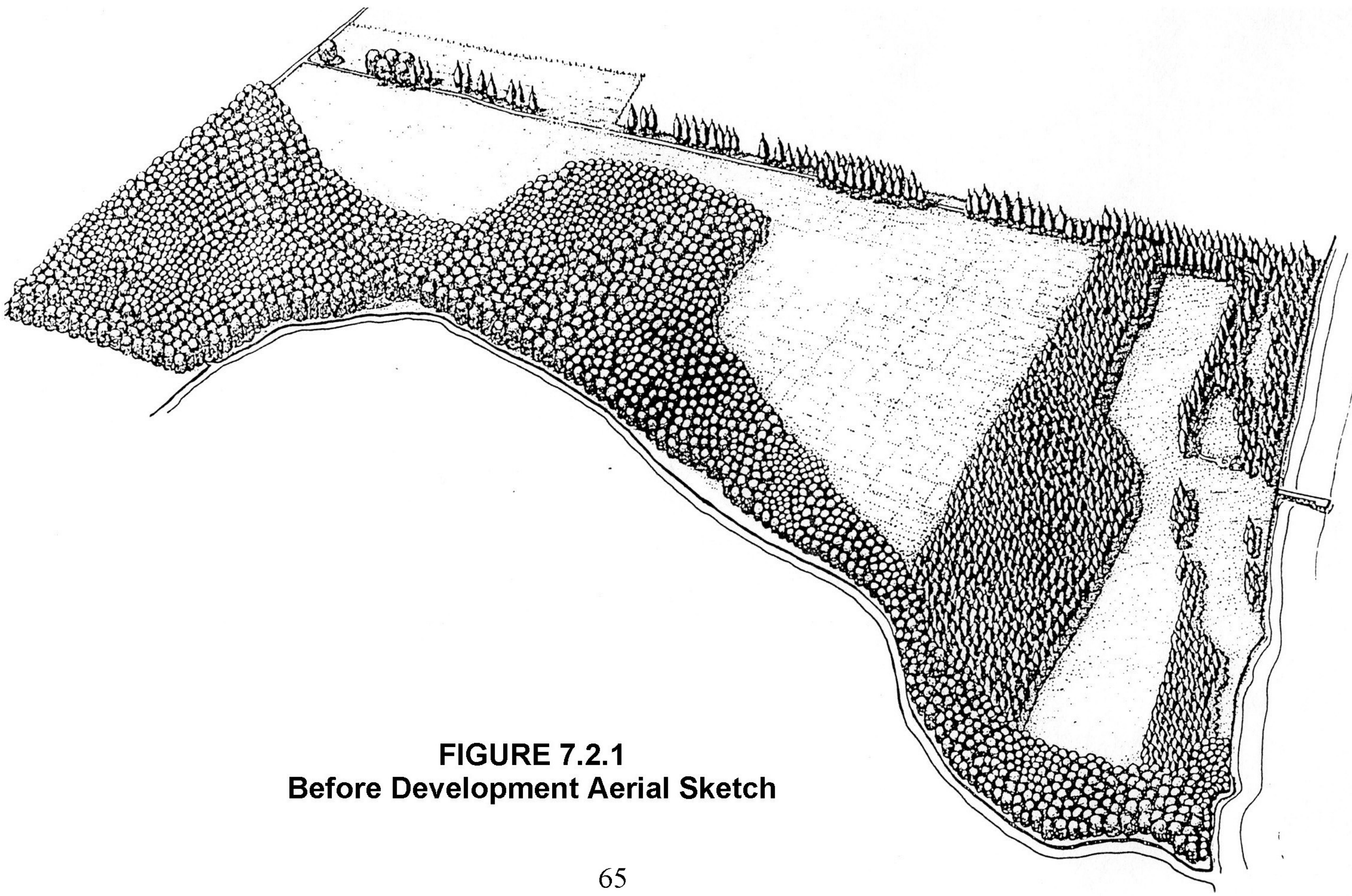

**FIGURE 7.2.1**
**Before Development Aerial Sketch**

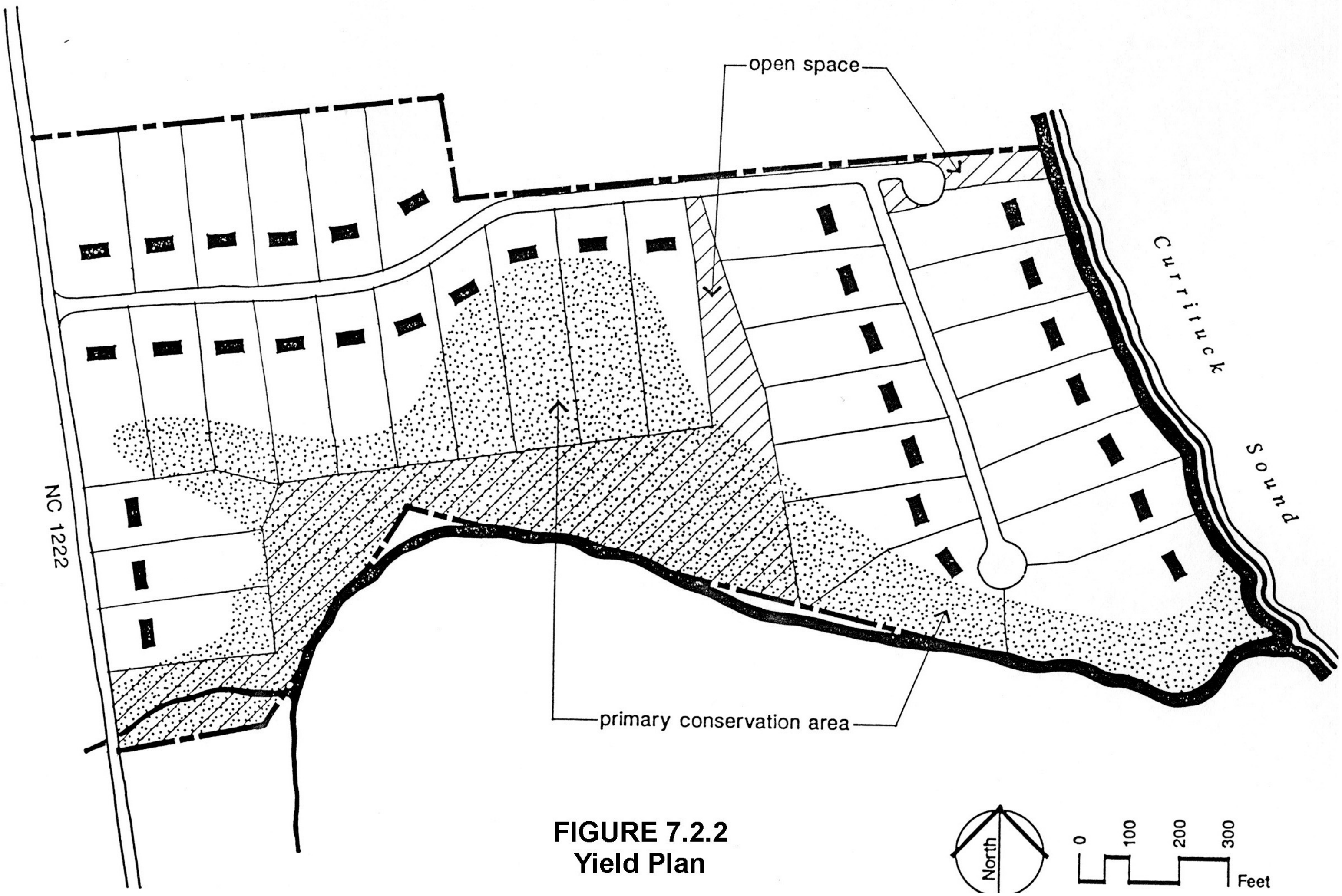


**FIGURE 7.2.2**
**Yield Plan**

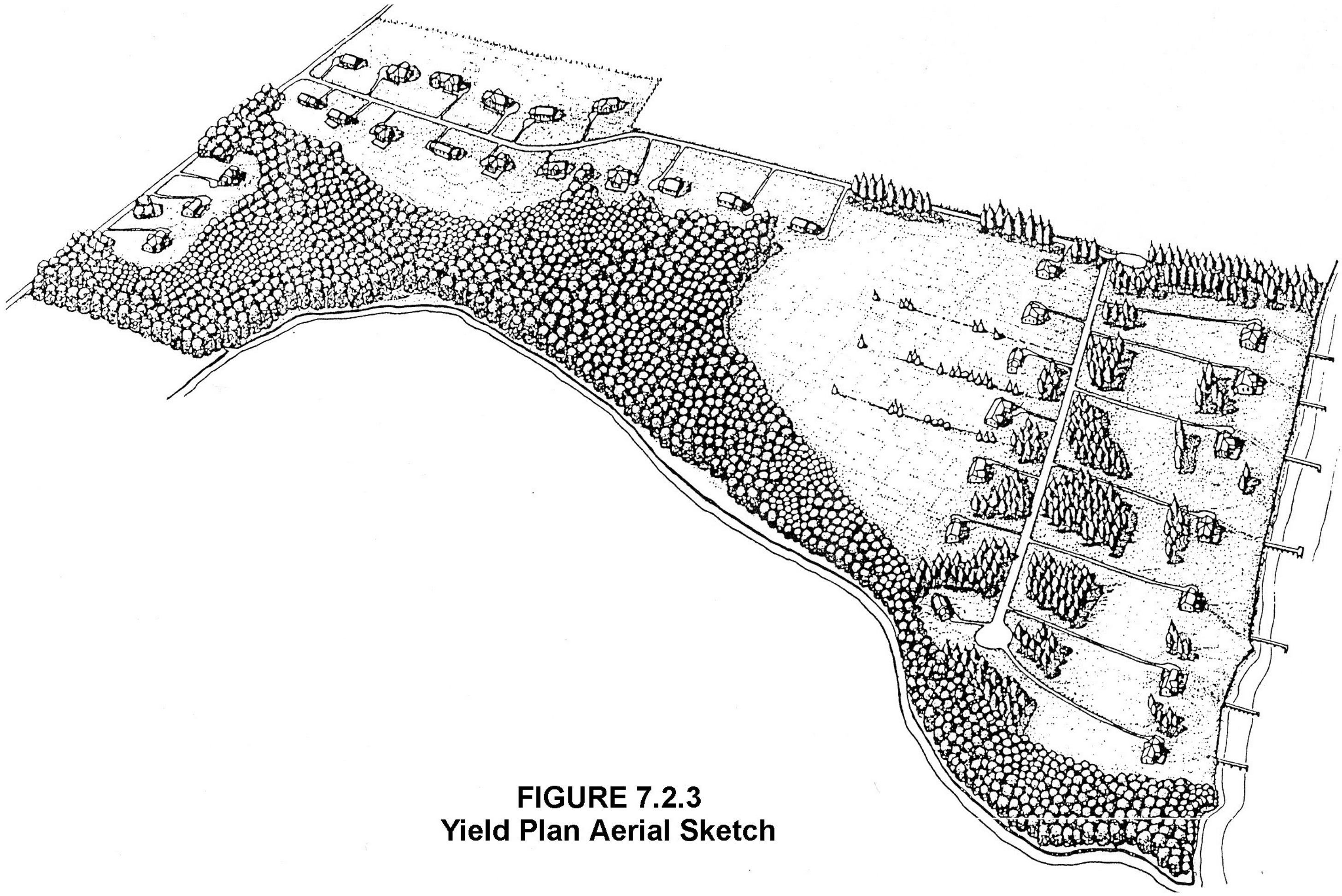

**FIGURE 7.2.3**
**Yield Plan Aerial Sketch**

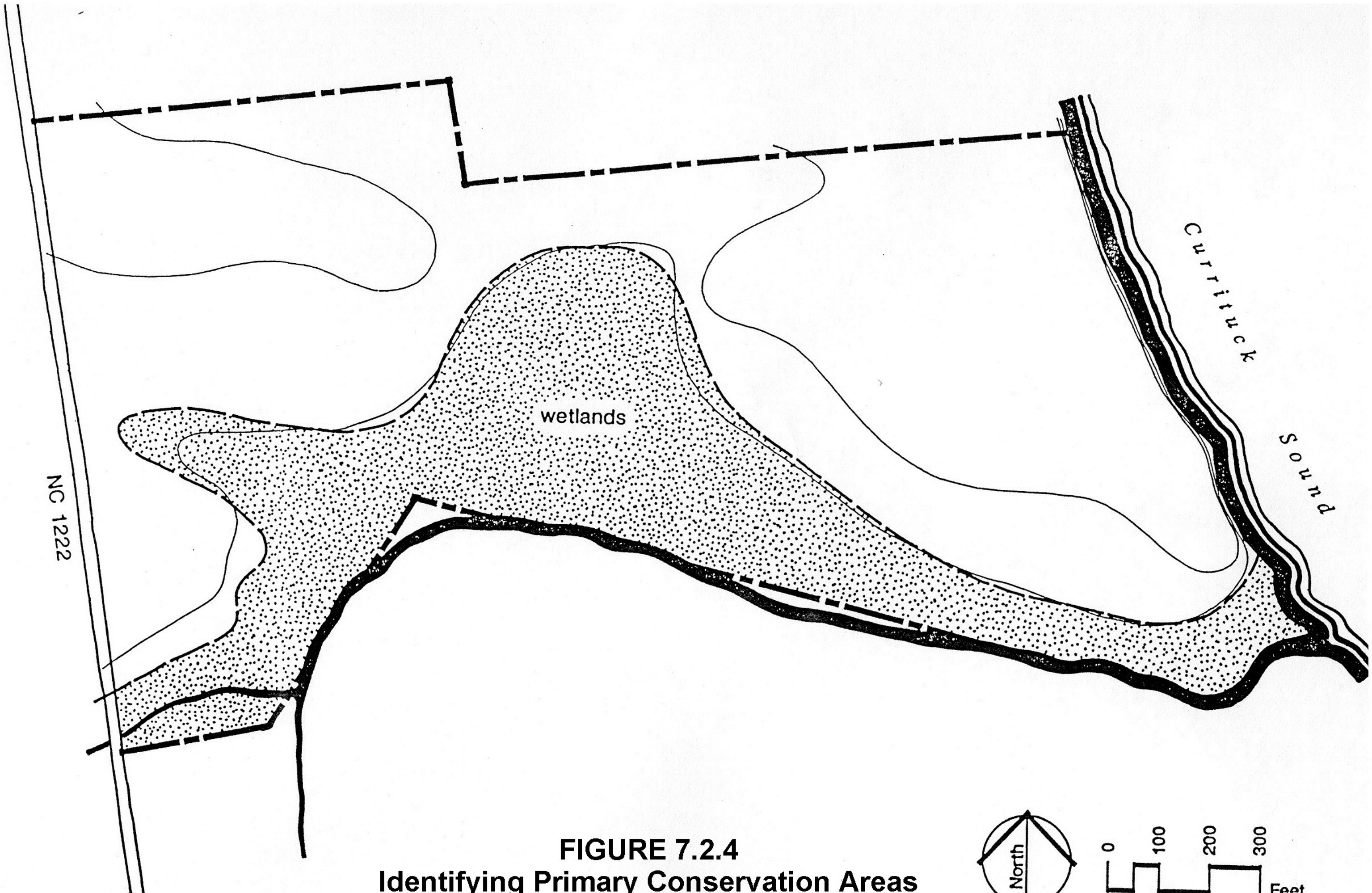


**FIGURE 7.2.4**
**Identifying Primary Conservation Areas**

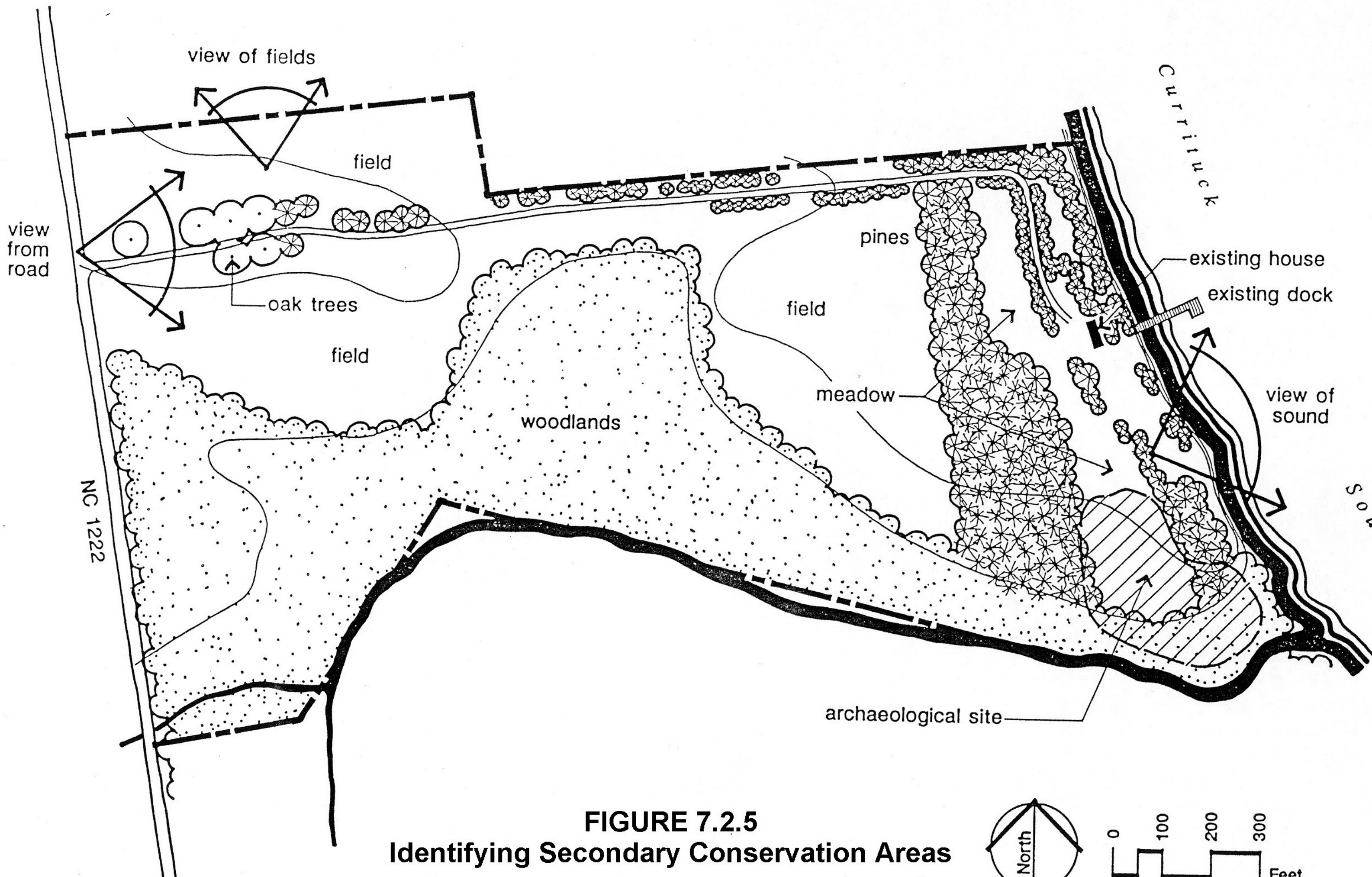


**FIGURE 7.2.5**
**Identifying Secondary Conservation Areas**

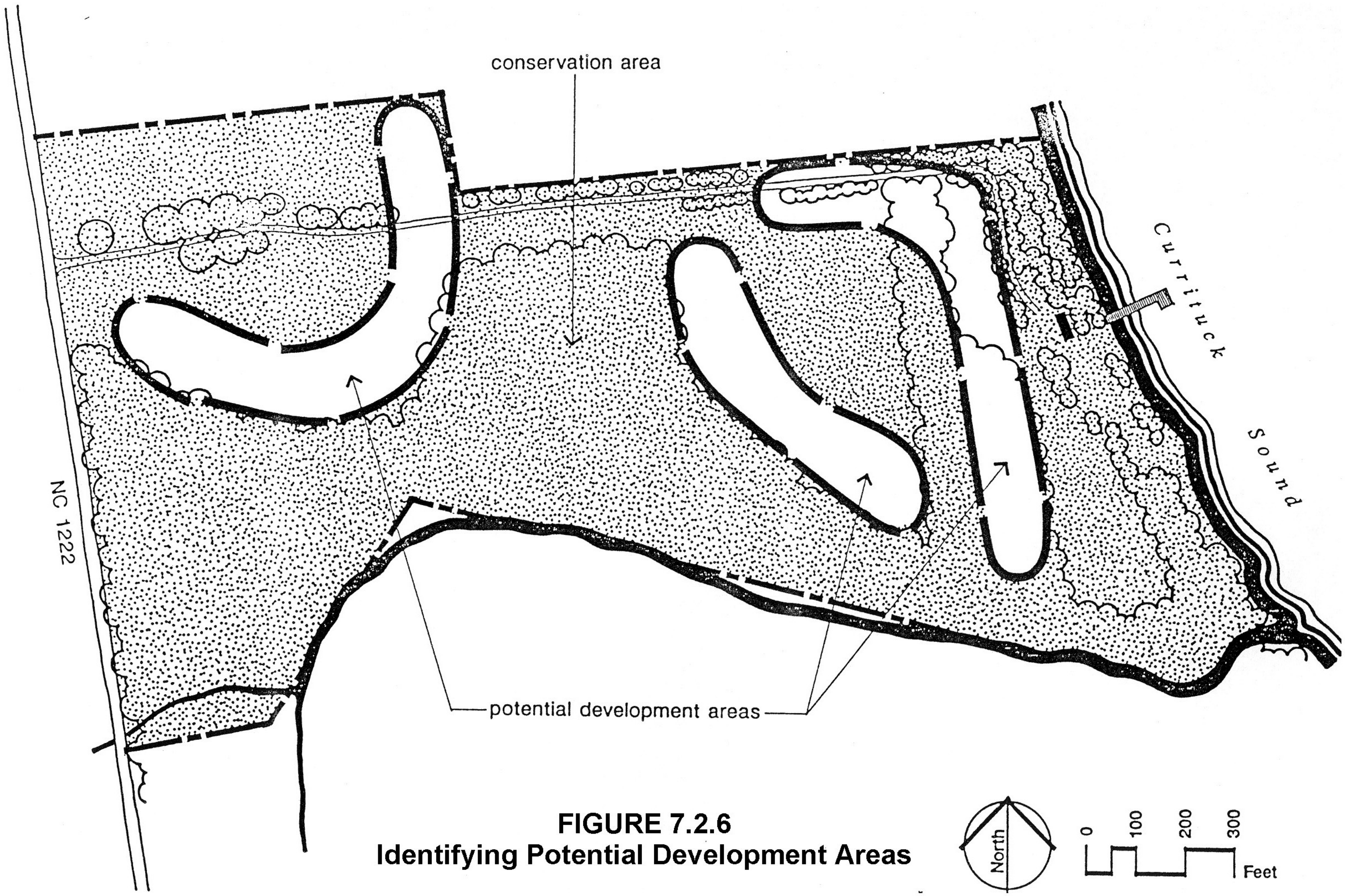


**FIGURE 7.2.6**
**Identifying Potential Development Areas**

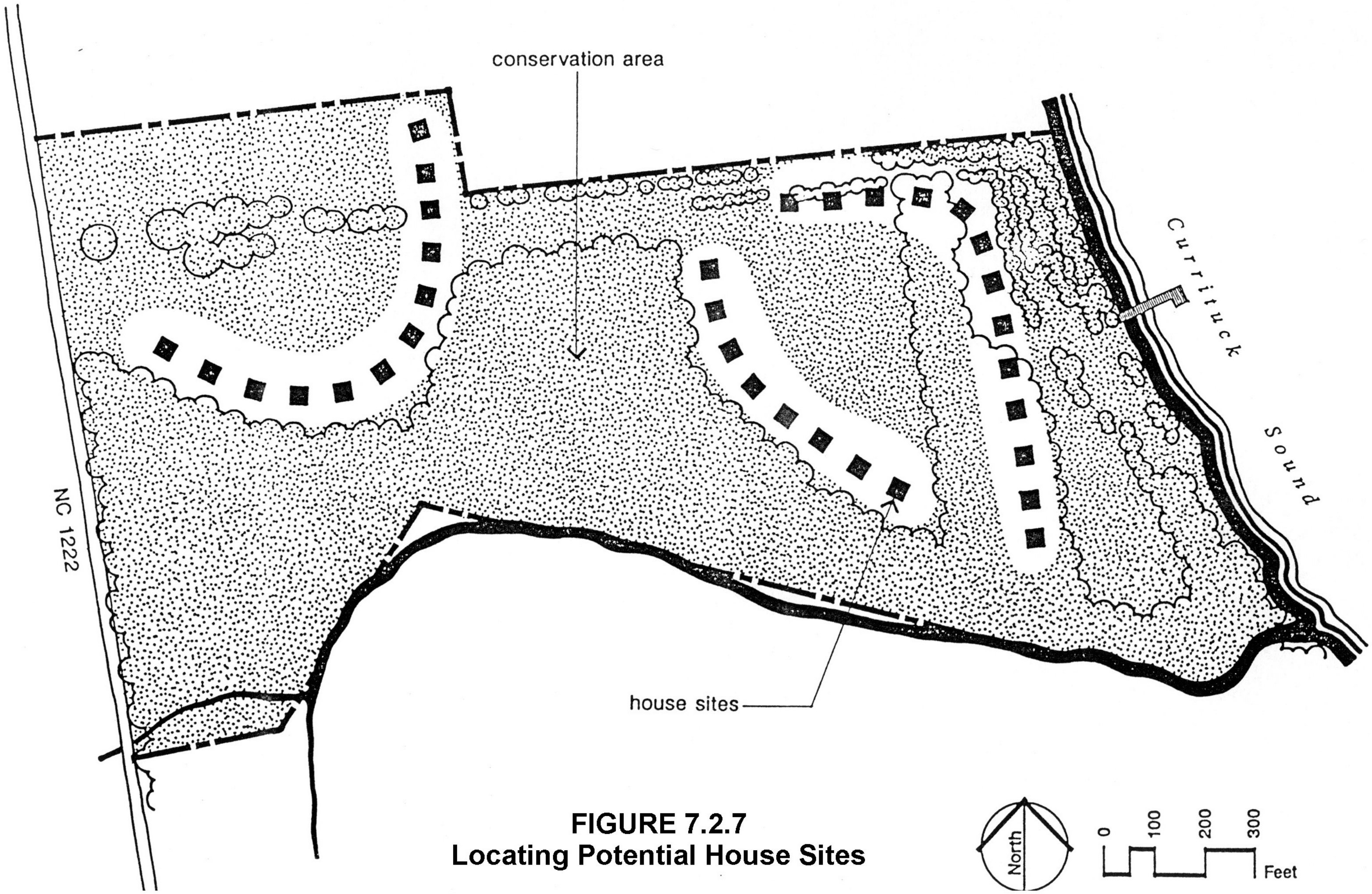


**FIGURE 7.2.7**
**Locating Potential House Sites**

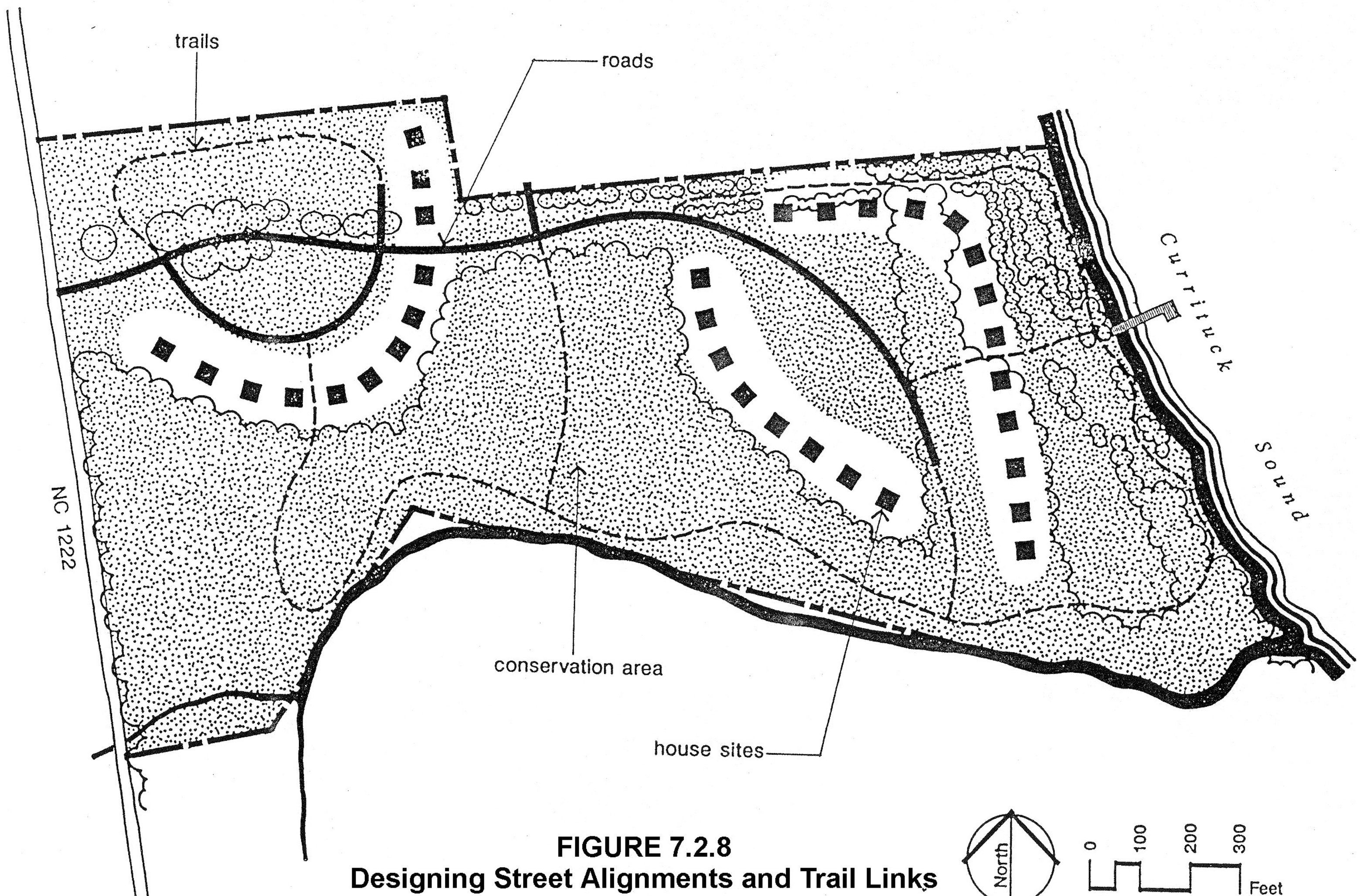


**FIGURE 7.2.8**
**Designing Street Alignments and Trail Links**

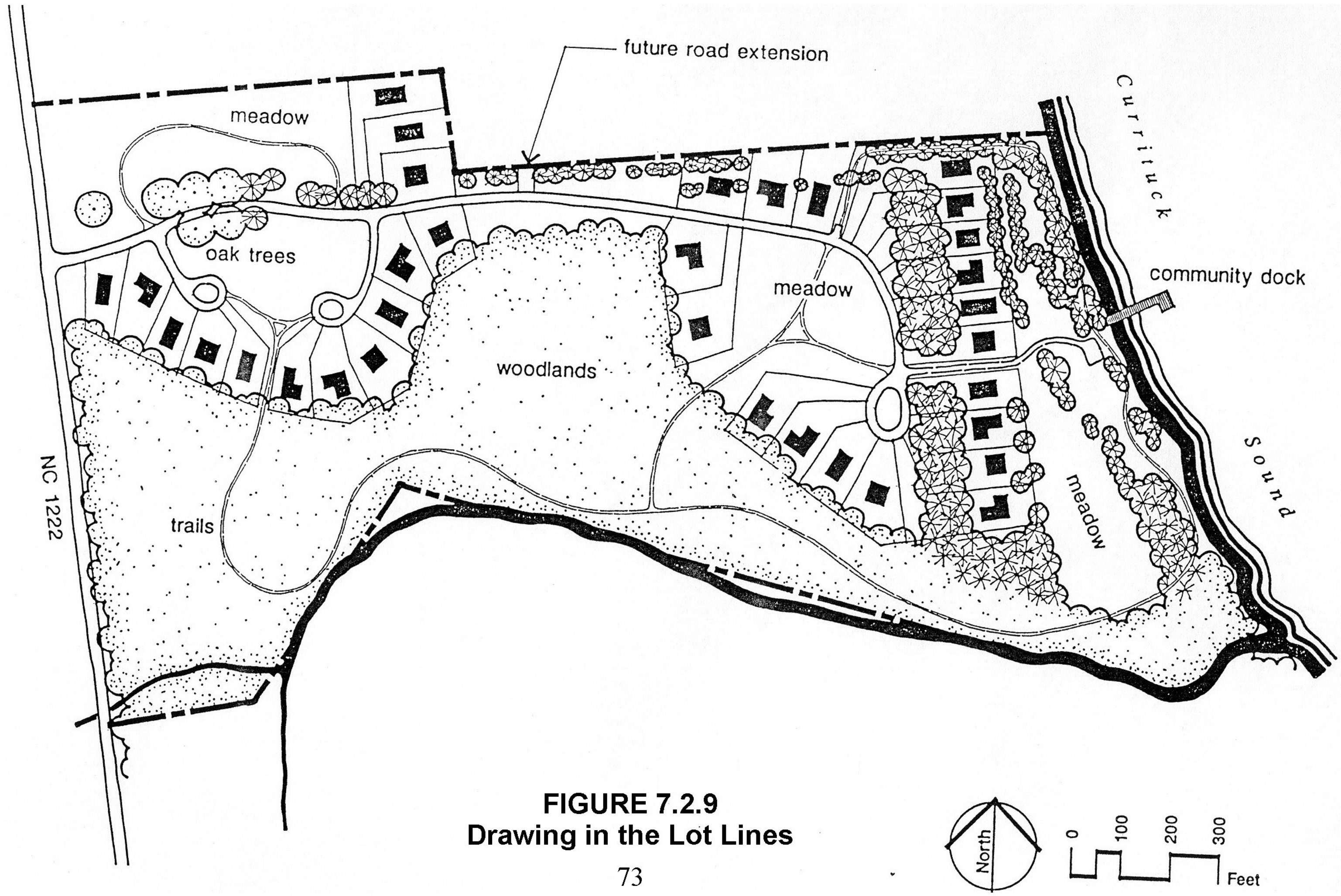


**FIGURE 7.2.9**
**Drawing in the Lot Lines**

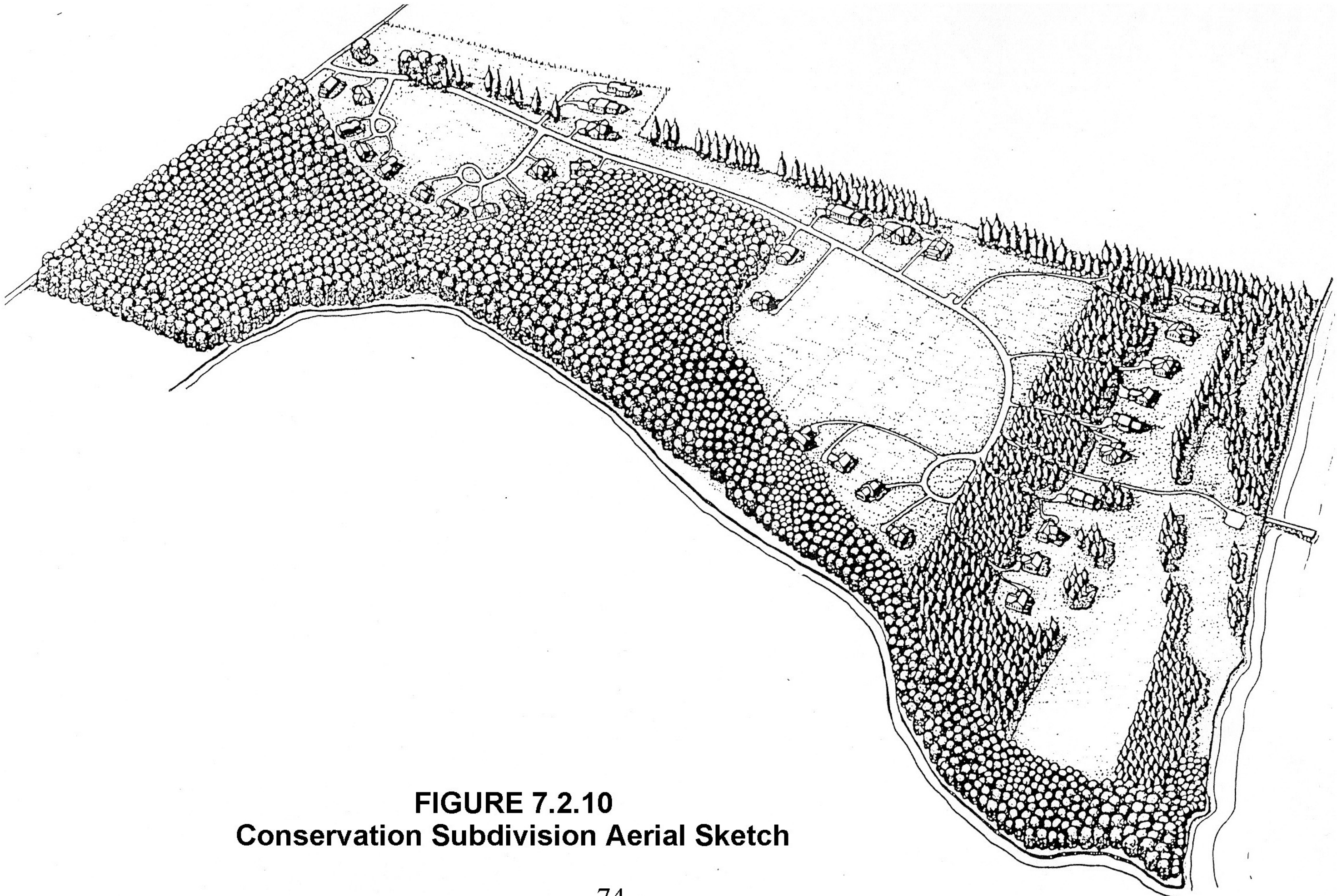

**FIGURE 7.2.10**
**Conservation Subdivision Aerial Sketch**

# APPENDIX 2

## Q3 Flood Data Users Guide

# Q3 FLOOD DATA USERS GUIDE

## Part 1 BACKGROUND

### History of the National Flood Insurance Program

In response to increasing losses from flood hazards nationwide, the Congress of the United States passed the National Flood Insurance Act of 1968 which established the National Flood Insurance Program (NFIP). The 1968 Act provided for the availability of flood insurance within communities that were willing to adopt floodplain management programs to mitigate future flood losses. The act also required the identification of all floodplain areas within the United States and the establishment of flood-risk zones within those areas. As a result of the 1972 Hurricane Agnes flooding along the East coast, the 1968 Act was expanded by the Flood Disaster Protection Act of 1973. The 1973 Act added the mandatory purchase requirement and increased the awareness of floodplain mapping needs throughout the country. The responsibility for administration of the NFIP falls with the Federal Insurance Administration of the Federal Emergency Management Agency (FEMA).

The risk data to identify floodplain areas, as required by the Act, are acquired through Flood Insurance Studies (FISs). FISs are hydrologic and hydraulic studies of flood risks developed by FEMA. Using the results of a FIS, FEMA prepares a Flood Insurance Rate Map (FIRM) that depicts the spatial extent of Special Flood Hazard Areas (SFHAs) and other thematic features related to flood risk assessment. SFHAs are areas subject to inundation by a flood having a one-percent or greater probability of being equaled or exceeded during any given year. This flood, which is referred to as the 1% annual chance flood (or base flood), is the national standard on which the floodplain management and insurance requirements of the NFIP are based.

FEMA publishes the FIRM and distributes it to a wide range of users: private citizens, community officials, insurance agents and brokers, lending institutions, and other Federal agencies. The FIRM is the basis for floodplain management, mitigation, and insurance activities of the NFIP. Uses of the FIRM for insurance activities include enforcement of the mandatory purchase requirement of the 1973 Act, which "requires the purchase of flood insurance by property owners who are being assisted by Federal programs or by Federally supervised, regulated, or insured agencies or institutions in the acquisition or improvement of land or facilities located or to be located in identified areas having special flood hazards" (Section 2(b)(4) of the 1973 Act). In addition to the identification of SFHAs, the risk zones shown on the FIRMs are the basis for the establishment of premium rates for flood coverage offered through the NFIP.

At present, FISs have been completed and FIRMs published for virtually all communities in the nation having flood risks. Flood risks have been assessed in approximately 20,400 communities nationwide. These studies, conducted at a cost of over $900 million, have resulted in the publication of over 80,000 individual FIRM panels. Typically, 6 to 8 million FIRMs are distributed to users each year by FEMA. Over 2.5 million flood insurance policies have been written through the NFIP, providing coverage against flood loss for over $200 billion in property nationwide.

In addition to initial FISs, FEMA is responsible for maintaining the FIRMs as communities grow, as new or better scientific and technical data concerning flood risks becomes available, and as some FISs become outdated by the construction of flood control projects or the urbanization of rural watersheds. Several thousand FIRMs need to be updated per year.

### Automation of NFIP Mapping

Developments in the fields of automated cartography and Geographic Information Systems (GIS) technology led FEMA to study the potential of automating NFIP mapping and engineering. After a series of technology assessment and pilot projects, FEMA concluded that existing technology made the automation of NFIP mapping and engineering feasible. In Fiscal Year 1992, FEMA implemented a ten-year automation program, beginning with the conversion of FIRMs to a digital format.

### Q3 Flood Data Product History

Starting with Hurricane Hugo in 1989, FEMA has attempted to support disaster relief operations with digital FIRMs. Disaster loan closings by the Small Business Administration (SBA), Temporary Housing Programs, and Individual Assistance and Family Grant Programs all require a flood hazard assessment. With automated flood map reading to support these assessments, significant time can be saved and map reading quality improved, thus resulting in faster disaster relief for victims.

More recently, increased funding for post-disaster mitigation activities has led to the extensive use of GIS and digital FIRMs for planning activities. Applications include selection of sites for relocation, prioritizing eligibility for home buyout programs, and identifying repeatedly damaged properties in SFHAs.

To support disaster recovery operations, FEMA has developed specifications for a digital product named the Q3 Flood Data. This product has the advantage of being far less costly in time and resources to produce than FEMA's other digital FIRM product, the Digital Flood Insurance Rate Map (DFIRM).

The Q3 Flood Data product is designed to serve FEMA's Response and Recovery activities as well as flood insurance policy marketing initiatives. This product is designed to allow rapid access to and distribution of digital FIRM data, and is compatible with all existing digital FIRM data already available and underway.

## Part 2 OVERVIEW OF Q3 FLOOD DATA

### Contents

The Q3 Flood Data are developed by scanning the existing hardcopy FIRM to create a raster product suitable for viewing or printing and vectorizing a thematic overlay of flood risks. Q3 Raster FIRM files contain all FIRM data in raster format, but only certain features are contained in the vector Q3 Flood Data files.

### Vector Files

The features contained in the vector Q3 Flood Data files include the following:

- 1% and 0.2% annual chance floodplain areas, including Zone V areas, certain floodway areas, and zone designations;

- political areas, including community identification number;
  eas, including panel number and suffix;
- 7.5-minute quadrangle areas; and
  mappable Letters of Map Change (LOMCs).

The vector Q3 Flood Data are contained in one single countywide file, including all incorporated and unincorporated areas of a county. The feature items and attributes are defined in detail in the *Q3 Flood Data Specifications* (Reference 1).

The means for linking other associated NFIP data to these files can be derived from the attributes contained within the files. For instance, the currently effective FIRM panel from FEMA's *Community Status Book* (Reference 2) or the Flood Map Status Information System (FMSIS) can be compared to the FIRM panel information in the Q3 Flood Data files to determine if the Q3 Flood Data files reflect the most current mapping.

The vector Q3 Flood Data files do NOT include the following:

- base map data (streets, etc.);
- base flood elevation lines and elevations;
- cross sections and letter identifiers;
- elevation reference marks and their elevations; and
- floodways if not shown on the FIRM.

### Raster files

neatlines for unprinted panels
- FIRM panel type attributes

In addition, the horizontal control of older data sets may have been consistent with that required for mapping at the scale of 1:100,000 instead of 1:24,000.

**Data Quality**

Edge-matching errors, overlaps and underlaps in coverage, and similar problems are not corrected during digitizing or scanning and vectorizing the Q3 Flood Data.

Although FEMA has established no independent quality control/quality assurance program for the Q3 Flood Data, the Q3 Flood Data files are distributed only after they have passed checking routines contained in FEMA's Q3QA Checking Software. The data are accompanied by documentation showing that the files have been evaluated and passed. FEMA has established a User Support mechanism through which any problems found with the data can be identified and channeled back to FEMA for resolution.

**Attribute Accuracy**

The attribute accuracy of the Q3 Flood Data vector files is tested by manual comparison of source FIRM with hardcopy plots and a symbolized display on an interactive computer graphic system. Selected attributes that cannot be visually verified are individually queried. In addition, FEMA's Q3QA Checking Software program is applied to the dataset to test the attributes against a master set of valid attributes and attribute combinations.

**Topology**

Polygon and line topology are present in Q3 Flood Data vector files. Certain node-area-line relationships are collected or generated to satisfy topological requirements, including the following:

- lines begin and end at nodes;
- lines connect to each other at nodes;
  extend through nodes;
- left and right areas are defined for each line segment and are consistent throughout the files; and
- the lines representing the limits of the file neatlines are free of gaps.

**Logical Consistency**

Tests of logical consistency are performed by ARC/INFO software modules. Check plots are made to test for closure of all internal polygons.

**Completeness**

Data completeness for Q3 Flood Data files reflect the content and completeness of the source FIRM. Features may have been eliminated or generalized on the FIRM due to scale and legibility constraints.

The flood risk data presented in the FIRM are developed only for communities participating in the NFIP for use in insurance rating and for floodplain management. Flood hazard areas are determined using the following sources:

- statistical analysis of records of river flow, storm tides, and rainfall;
- information obtained through consultation with the communities;
- floodplain topographic surveys; and
  rologic and hydraulic analyses.

Both detailed and approximate hydrologic and hydraulic analyses are employed. Generally, detailed analyses are used to generate flood risk data for developed or developing areas of communities. For undeveloped areas where little or no development is expected to occur, FEMA uses approximate analyses to generate flood risk data. Typically, only drainage areas that are greater than one square mile are studied.

**Comparison to Other FEMA Digital Data Products**

FEMA distributes digital FIRM data in two basic product levels. These are the DFIRM (including the hardcopy DFIRM and the DFIRM-DLG) and the Q3 Flood Data. These two products differ in their contents, quality, and intended use.

**Digital Flood Insurance Rate Map (DFIRM)**

The DFIRM is comprised of all digital data required to create the hardcopy FIRM. This includes base map information, graphics, text, shading, and other geographic and graphic data required to create the final hardcopy FIRM product to FEMA standards and specifications (see the *Standards for Digital Flood Insurance Rate Maps,* Reference 4). This product serves the purpose of map design and provides the database from which the Digital Line Graph (DLG) thematic product of the flood risks is extracted to create the DFIRM-DLG. This product is generally produced in a countywide format. DFIRMs are subjected to community review and approval and are, therefore, the official basis for implementing the regulations and requirements of the NFIP within the community. Specifications for digitizing DFIRMs are consistent with those required for mapping at a scale of 1:24,000, or larger.

With increasing frequency, highly detailed large scale digital mapping is becoming available. DFIRMs may utilize this data as a source (new engineering data collected using photogrammetric techniques) or as a base map. Communities whose digital base mapping files were utilized as the base map for the DFIRM will find that they may use the DFIRM-DLG files for all determination and enforcement regulations.

**Q3 Flood Data**

The Q3 Flood Data do not replace the existing hardcopy FIRM or, if one exists, DFIRM product. The product has been designed to support planning activities, some Community Rating System (CRS) activities, insurance marketing, and mortgage portfolio review. It does not provide base flood elevation information; thus, it has limited application for engineering analysis, particularly for site design or rating of flood insurance policies for properties located within SFHAs.

Q3 Flood Data are developed by scanning the existing hardcopy FIRM to create a raster product suitable for viewing or printing and vectorizing a thematic overlay of flood risks. Vector Q3 Flood Data files contain only certain features from the existing hardcopy FIRM.

Q3 Flood Data are not tied to a base map, are not used to produce a new version of the hardcopy FIRM, and are not subjected to community review. Q3 Flood Data are intended to provide users with automated flood risk data suitable for determining whether features are within or outside the SFHA.

The Q3 Flood Data product can be a valuable tool to assist in screening property addresses within a GIS to determine flood risks. However, as the geographic processing performed to develop the Q3 Flood Data may introduce differences with the source hardcopy FIRMs, users must apply considerable care and judgment in the application of this product. For instance, the Q3 Flood Data may be overlaid on highly detailed large scale community base mapping data, but, if parcel level determinations are made, they must be prefaced with information about the accuracy of the data from which they are derived.

**Part 3 USE POLICY**

**Standards of Care**

For the development of applications using the Q3 Flood Data, the user has the following responsibilities:

- to obtain and review the technical documentation of the Q3 Flood Data, with particular regard to the limitation of this product;

- to establish minimum mapping and accuracy standards required for the proposed application;

- to obtain digital base maps and ancillary data of appropriate scale, resolution, and accuracy to support the applications; and

- to determine whether Q3 Flood Data is based on the currently effective FIRM panel.

The quality, accuracy, and reasonableness of any applications developed using Q3 Flood Data are the sole responsibility of the end-user.

The Q3 Flood Data product is not suitable for engineering applications such as detailed site design and development plans, Letters of Map Change, or submittal of FIRM Map Revisions.

**Community Rating System**

For the purposes of the Community Rating System (CRS), Q3 Flood Data may be used in the following ways:

• for calculations of SFHA areas and similar applications that require geographic calculations and measures;

• for partial fulfillment of GIS provisions per the provisions of Section 440, "Flood Data Maintenance," as described in the *National Flood Insurance Program Community Rating System Coordinator's Manual* (Reference 5); and

• for development of "notification" lists of potentially flood-prone properties, per the provisions of Section 330; and

• for partial fulfillment of credits for the performance of flood determinations, when performed in conformance with guidelines for determination presented below.

**Flood Determinations**

The Q3 Flood Data can support flood determinations in a limited fashion, in conformance with the "Good Faith" standard, if used within the following guidelines:

• The end user has obtained a source of address or property location data and combined it with Q3 Flood Data in a manner that conforms to the Standards of Care outlined above.

• The end user has made no determinations as to the flood prone status of a property that is within 250 feet of an SFHA boundary. This requirement is due to the accuracy, resolution, and variations of the Q3 Flood Data relative to the source FIRMs.

• The end user has verified that the Q3 Flood Data FIRM panel and suffix conform to the panel and suffix of the currently effective FIRM.

• The end user has confirmed the availability of flood insurance in the community for which the determination is to be offered.

• The end user has confirmed the zone and BFE with the source FIRM or DFIRM for properties located within 250 feet of the SFHA boundary or within the SFHA.

**The "Good Faith Standard"**

The mandatory flood insurance purchase requirements of the 1973 National Flood Insurance Act apply only when a structure is located in an SFHA in a community that is participating in the NFIP. Such a structure must be insurable under the rules of the NFIP. Even though a portion of the land parcel upon which the structure is planned or built may be within an SFHA, the mandatory purchase requirement is triggered only if the structure itself is within an SFHA.

The compliance of lenders with the mandatory flood insurance purchase requirements of the 1973 Act is based on the "good faith standard." Determining whether a structure is located in an area of special flood hazard requires the examination of the location of the structure in relationship to the areas of special flood hazard as shown on the applicable FIRM. The good faith standard recognizes that despite FEMA's best efforts to make the FIRMs as useful as possible, the descriptions of SFHA areas, as depicted by some maps, may, in some instances, not be clear enough to permit lenders to decide with certainty and precision whether or not property that is the security for a loan or that is the subject of financial assistance is located in such an area. It is for this reason that FEMA has recommended a "good faith standard."

The good faith standard requires lenders to exercise "due diligence and good faith" in determining the location of a property that is the subject of a loan relative to areas of special flood hazards as shown on a FIRM. This guidance is further explained, with additional information on the 1973 Act, in the publication *Mandatory Purchase of Flood Insurance Guidelines* (Reference 6).

When determinations are being made by lenders, or firms or individuals retained by lenders to assist in these endeavors, collateral data in addition to the FIRM is frequently required. FIRMs do not include all roads within communities, nor do they depict address, property boundary, or structure location information. As a result, determinations frequently can be made only by using an ancillary source of data, such as a land parcel map, to determine the location of a property on the FIRM.

Digital address range data, land parcel, and structure information is available for many communities across the nation. Using these digital data and GIS technology, it is possible to make determinations relative to the 1973 Act and meet the good faith standard. However, the lenders must assure that due diligence and good faith are exercised in application of digital mapping systems to make determinations. Because of both the increased complexity and analytical capabilities of GIS, assuring compliance with the good faith standard may require additional effort relative to use of paper maps.

A prime concern is to assure that the accuracy of the digital base map and structure location data are appropriate for use with the chosen digital FIRM data set (DFIRM or Q3 Flood Data) to make determinations relative to the 1973 Act. The concern for accuracy of the ancillary data used with DFIRMs should increase in direct proportion to the relative closeness of the property under analysis to the SFHA boundary. Thus, lenders might not find it prudent to use digital data at the 1:100,000 scale as the primary source of information upon which to make a determination regarding a property located within 250 feet of an SFHA. Such caveats should be carefully considered when U.S. Bureau of the Census TIGER data are used as the source from which property determinations will be made.

In some instances, GIS technology will enable the use of large-scale land parcel, topographic, structure, and other information, with digital FIRM data to make determinations. GIS technology allows maps to be created at any user-specified scale. Enlargement of scales does allow for precise determinations to be made. However, precise measurements are not inherently accurate. Accuracy can only be assessed from an appraisal of the quality of source data.

SFHA boundary information conveyed by Q3 Flood Data files was developed to overlay USGS 7.5-minute topographic maps at a scale of 1:24,000. Thus, Q3 Flood Data cannot be assumed to have an accuracy of better than 40 feet. Due to other limitations, FIA recommends that determinations using GIS technology and Q3 Flood Data generally be made only when structures are located 250 or more feet outside an SFHA boundary. In cases where the structure is within 250 feet of the SFHA or inside the SFHA, data such as the BFE determined from a FIS flood profile and the surveyed lowest adjacent grade and/or lowest floor elevation should be used to make a determination.

Prudence may require that a more conservative margin than 250 feet be used to determine the need for ancillary data to support a GIS determination. Terrain variations, the nature of flood hazards in the area, and the quality of all digital data being used to make the determination should be considered when establishing the need for collecting survey and flood profile data.

(Http://www.fema.gov/MSC/ 1997)