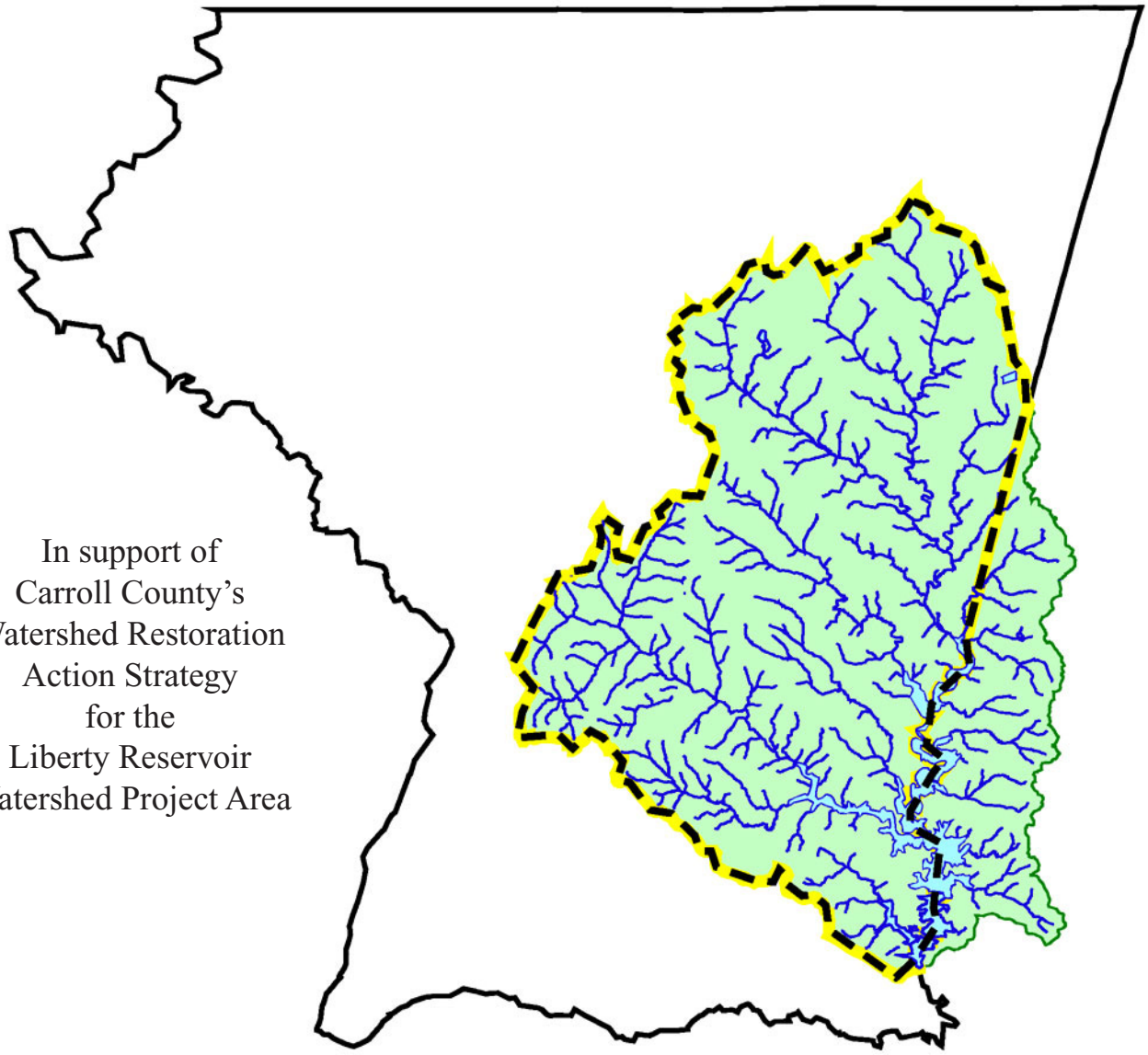
Liberty Reservoir
Watershed Characterization

September 2002



In support of
Carroll County's
Watershed Restoration
Action Strategy
for the
Liberty Reservoir
Watershed Project Area

Product of the
Maryland Department of Natural Resources
In partnership with Carroll County

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The Maryland Department of Natural Resources (DNR) seeks to preserve, protect and enhance the living resources of the state. Working in partnership with the citizens of Maryland, this worthwhile goal will become a reality. This publication provides information that will increase your understanding of how DNR strives to reach that goal through its many diverse programs.

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Liberty Reservoir Watershed Characterization
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For the Liberty Reservoir Watershed Characterization

Carroll County, Maryland is receiving Federal grant funding to prepare a Watershed Restoration Action Strategy (WRAS) for a project area in the Liberty Reservoir watershed. This Maryland 8-digit watershed ranked in the highest State priority for protection and restoration. The WRAS project area encompasses the Carroll County portion of the watershed covering 87,040 acres including about 2,137 acres of open water. The remaining 17,762 acres of the watershed are in Baltimore County, Maryland.

As part of WRAS project, the Maryland Dept. of Natural Resources (DNR) is providing technical assistance. For example, DNR is working with the County to prepare a Watershed Characterization which is a collection of available water quality related information and identification of issues that may be used as the County generates its Watershed Restoration Action Strategy.

Water Quality

Waters in the Liberty Reservoir watershed do not support all their designated uses which include public water supply, natural trout waters, recreational trout waters, water contact recreation and protection of aquatic life. The most wide-spread causes of these problems are excessive nutrients and suspended sediment. Other causes that occur in more limited areas are methylmercury in some fish species taken from the reservoir, fecal coliform bacteria in waterways near Finksburg and chromium and lead associated with naturally occurred mineral deposits of the Soldiers Delight area.

Baltimore City reported several significant water quality trends. Increasing concentrations of chloride in Liberty Reservoir were identified beginning 1992. Analysis suggests a relationship between increasing chloride and increasing miles of roadway and area of commercial land where salt is used to limit seasonal icy conditions. Dry weather total phosphorus concentrations are decreasing in some Liberty Reservoir subwatersheds. Using total phosphorus as one indicator of reservoir impairment, Liberty reservoir is the least impaired of the three Baltimore City reservoirs. Nitrate-nitrogen concentrations in Liberty Reservoir steadily increased from the 1980's through the mid-1990's, but appear to be leveling off since the mid-1990's.

Land Use / Land Cover

Carroll County's portion of the Liberty Reservoir watershed (the WRAS area) covers 83% of the entire watershed and the remaining 17% is in Baltimore County. Agriculture is the dominant land use (44.47%) in Carroll County and it is distributed across the WRAS area. Agricultural land is less pervasive in Baltimore County (33.01%). Nearly all agricultural easements and districts in the Liberty Reservoir watershed are almost entirely in Carroll County. Easements encompass 2,347 acres which is 5.4% of agricultural land. Another 4,186 acres are in agricultural districts which is an additional 9.7%. The largest concentrations of these protective zones are in the northern end of the

watershed. In the Carroll County portion of the Liberty Reservoir watershed, 1,277 agricultural best management practices have been implemented since 1980.

Forest accounts for 28.24% of Carroll County's WRAS area with large forest blocks concentrated around the Liberty Reservoir and along its Morgan Run tributary. Baltimore County's portion of the watershed 49.08% forested also with large forest blocks in the vicinity of the reservoir. In the Liberty Reservoir Watershed, natural resource lands identified as Green Infrastructure and/or forest interior are concentrated around the reservoir and along Morgan Run under ownership by Baltimore City and the Maryland Department of Natural Resources.

Developed land in Carroll County is mostly interspersed among the other land uses covering 27.23% of the WRAS area with concentrations near the communities of Westminster and Elderburg. A total of 167 stormwater management facilities serve about 6,280 acres of residential land in the Carroll County WRAS project area. About 17.74% of Baltimore County's portion of the Liberty Reservoir watershed is developed.

Living Resources and Habitat

One report of long term benthic macroinvertebrate monitoring (benthos or stream bugs) on the North Branch of the Potomac River upstream of the Liberty Reservoir found increasing diversity between 1978 and 1990. This reflected a limited improvement in water quality.

Assessments of benthos, fish and physical habitat were conducted by the Maryland Biological Stream Survey in the 1990s and 2000. Most sites were rated as good or fair for all three indices. The few sites that were ranked as poor or very poor appeared in limited areas of the watershed with several associated with developed areas. Native brook trout populations were found in several waterways: small streams around the Reservoir, the North Branch / East Branch of the Patapsco River, Morgan Run and Beaver Run. However, not all of these water bodies are designated as natural trout waters which would provide regulatory protection for this use.

Several areas of sensitive species are identified in the Liberty Reservoir watershed. They area concentrated at the north end of the watershed near the towns of Hampstead and Manchester and in the southeast corner of the watershed near Soldiers Delight.

Restoration Targeting Tools

A stream corridor assessments of Middle Run and Snowdens Run were completed in 2002. Another assessment for Western Run is projected for the end of the year. These efforts conducted by County and DNR personnel identified the status of stream buffers, stream bank erosion, etc. as a foundation for targeting and prioritizing restoration projects.

In 2002, DNR personnel also conducted water quality and biological assessments at selected road crossings of waterways in the watershed. Findings from this work will help identify relative nutrient loads at the subwatershed scale.

Computerized mapping was used to demonstrate opportunities for targeting protection and restoration projects including restoration of stream buffers, riparian forest and wetlands.

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INTRODUCTION

Purpose of the Characterization

The watershed characterization is the initial step of a three-step process to develop a watershed management plan for a portion of the Liberty Reservoir watershed (the watershed). An assessment of the information gathered combined with in-the-field stream monitoring during 2002 is the next step in the process. The assessment will identify, evaluate, and prioritize concerns/threats to water quality of Liberty Reservoir and the condition of its watershed. Based on this assessment, the third step in this process is to develop action strategies to target opportunities to improve water quality by restoration. This process will be completed by the end of 2002.

The characterization of Liberty Reservoir's watershed meets three objectives:

1. Summarize relevant information related to the watershed.
2. Describe the condition of the watershed from different perspectives (e.g., water quality, water supply, living resources, land use)
3. Identify sources for more information or analysis.

Watershed Selection

Carroll County, the City of Baltimore, and the state of Maryland all consider the Liberty Reservoir Watershed a high priority watershed in need of protection primarily because of its use as a drinking water supply for the City of Baltimore and surrounding counties. Map 1 WRAS Project Area shows the location of the watershed.

Carroll County is required to prioritize watersheds and identify areas of restoration due to its National Pollution Discharge Elimination System (NPDES) Permit. The county's Water Resource Planning Division assigned the highest priority to existing and near future surface drinking water supply reservoir watersheds including Liberty and Piney Run. Existing reservoirs not used by Carroll County citizens and planned reservoirs within Carroll received a lower priority. Other water supply uses such as groundwater received the next lowest priority. Finally, watersheds received the lowest priority that did not serve or planned to serve as water supplies.

In 1998, Maryland's Clean Water Action Plan, using a three-step process similar to the process mentioned above, identified watersheds across the state in need of protection and restoration. First, a Unified Watershed Assessment characterized the condition of Maryland's larger watersheds and, based on this condition, classified each into the following categories:

Category 1 - Watersheds not meeting clean water and other natural resource goals and therefore needing restoration

Category 2 - Watersheds currently meeting goals that need preventive action to sustain water quality and aquatic resources

Category 3 - Pristine or sensitive watersheds that need an extra level of protection

As a result, Liberty Reservoir's watershed was classified as both a category 1 and 3 watershed; consequently, it is viewed in need of both restoration and an extra level of protection. Second, watershed restoration priorities were assigned to each watershed. The Liberty Reservoir watershed received the highest priority for restoration and protection. Only 17 of the 138 larger watersheds (coded with 8-digits) in Maryland were ranked high priority for both restoration and protection. The last step in the Clean Water Action Plan is to develop action strategies that identify "the most important causes of water pollution and resources degradation, detail the actions that all parties need to take to solve those problems, and set milestones by which to measure progress."2 Again, this characterization is the first step to develop these action strategies for the watershed.

As the basis for the prioritization, indicators of water quality, landscape and living resources were developed for all watersheds in Maryland. These indicators are described in greater detail in separate sections in this watershed characterization.

As part of the State's commitment, the Maryland Department of Natural Resources (DNR) will providefunding and technical assistance to Counties willing to work cooperatively to devise and implement a Watershed Restoration Action Strategy (WRAS) for the impaired water bodies.1,2 Carroll County is one of five Counties participating in the second round of the WRAS grant program. Due to time and staffing constraints, Carroll County's Water Resource Planning Division (WRPD) selected three subwatersheds within the Liberty Reservoir watershed in Carroll County for creation of an action strategy. Together these subwatersheds comprise about ??% of the total area draining to Liberty Reservoir.

Liberty Reservoir Watershed
2000 Acreage Summary

County	Land	Water	Total
Carroll	84,903	2,137	87,040
Baltimore	16,549	1,213	17,762
Watershed Total	101,452	3,350	104,802

Location

The Liberty Reservoir watershed is located within the Pataspco River basin in the Piedmont Region of Maryland. This area is the focus of the Watershed Restoration Action Strategy and this Watershed Characterization. Map 1 WRAS Project Area shows the geographic location of the WRAS watershed in Maryland. As shown in Map 2 Streams and Sub-watersheds, DNR has divided the Liberty Reservoir watershed into 17 subwatersheds that can be used for tracking information within the watershed. Map 3 also shows the three subwatersheds selected for development of a WRAS: Middle Run (#1056), Snowdens Run, and the West Branch of the Patapsco River (#1051). A discussion of the rationale behind selecting these three subwatersheds follows in the water quality section of this report. About 83% of the Liberty Reservoir watershed is in Carroll County, Maryland and the remaining 17% of the watershed is in Baltimore County, Maryland.

Additional Characterization Components

The Watershed Characterization is intended to be a starting point. It is part of a framework for a more thorough assessment involving an array of additional inputs:

1. Stream Corridor Assessments will be conducted in the three subwatersheds only. They consist of physically walking the streams and cataloguing important stressors to the stream system such as channel erosion pipe outfalls, or presence of a stream buffer . This effort is part of the technical assistance coordinated by DNR and conducted by the Maryland Conservation Corps.
2. Synoptic water quality surveys will be conducted also in the three subwatersheds. Staff from DNR will collect biological (both aquatic insect and fish data) and chemical water quality data.
3. With the help of the WRAS partner agencies, targettechnical assistance.
4. Collect input from local stakeholders.

These additional components will be used in conjunction with the information provided here to further clarify and identify issues of concern and types of restoration.

Identifying Gaps in Information

It is important to identify gaps in available watershed knowledge and gauge the importance of these gaps. One method is to review available information in the context of four physical / biological assessment categories that have been successfully applied in other watershed restoration efforts. These are the four main categories that impact water supply protection and aquatic biota:

1. Water Quantity: storm flows and flooding events; baseflows reductions from dams, water withdrawals, and reduced infiltration
2. Water Quality: nutrient loadings, toxics, sediment, nuisance odors, algal scums
3. Habitat: physical structure, stream stability and biotic community (including the riparian zone)
4. Cumulative effects associated with habitat, water quantity and water quality.

Adaptive Management

In addition, the Watershed Characterization and the Watershed Restoration Action Strategy should be maintained as living documents within an active evolving restoration process. These documents will have to be updated periodically as new, more relevant information becomes available and as the watershed response is monitored and reassessed. This type of approach to watershed restoration and protection is often referred to as “adaptive management.”

WATER QUALITY

Water quality is in many respects the driving condition in the health of Maryland's streams. Historically, the emphasis has been on water chemistry such as nutrient, metals, temperature and pH. More recently, interest has focused on the biological conditions in streams and estuaries (e.g, condition of the aquatic insect and fish communities), while consideration of the physical parameters is even more recent. This developmental path reflects the ways streams have been monitored, the types of data gathered, and the regulatory approach taken.

Designated Uses

All waters of the State are assigned a "Designated Use" in regulation, COMAR 26.08.02.08, which is associated with a set of water quality criteria necessary to support that use. A simplified summary of the Designated Uses in the Liberty Reservoir watershed is listed below. Map 3 Designated Uses depicts the distribution of streams in each use category. (Consult COMAR or MDE for official regulatory information.) [3,5]

- Use I-P Water Contact Recreation, Protection of Aquatic Life, and Public Water Supply: All surface waters upstream of Liberty Dam that are not designated III-P or IV-P.
- Use III-P Natural Trout Waters And Public Water Supply: Norris Run, Cooks Branch, Keysers Run, Beaver Run, East Branch of the Patapsco River, Locust Run, Morgan Run, Snowdens Run and all their tributaries.
- Use IV-P Recreational Trout Waters And Public Water Supply: The mainstem of the North and West Branches of the Patapsco River above Liberty Reservoir and Cranberry Branch and all tributaries above MD Route 852 (Old Manchester Road)

Not Supporting Designated Use – 303(d) Listings

A statewide assessment of water quality is required under Section 303(d) of the Federal Clean Water Act. As part of the assessment, Maryland tracks waterways that do not support their designated use in a list of "impaired waters" and in a prioritized list of "Water Quality Limited Basin Segments" also known as the 303(d) priority list. Information considered in setting the 303(d) list priorities includes, but is not limited to, severity of the problem, threat to human health and high value resources, extent of understanding of problem causes and remedies.[5] These listings mean that pollution associated with the impairment listed are preventing full use of these water bodies based on State criteria. More complete information on the 303(d) list is available on MDE's Internet site www.mde.state.md.us/tmdl/. Also see What Causes Water Quality Impairment?

1. 1996 List

The current 303(d) list that was first adopted in 1996 and amended in 1998. The list included two listing for Liberty Reservoir as summarized in the table below. Each impairment identified in the 303(d) List is assigned a priority which is intended to help communicate the need for correcting the impairment relative to all impairments listed Statewide. Waterways with impairments having the greatest potential impacts to human health, high value resources, etc. are ranked numerically 1 through 25. All other impairments that are not ranked in the top 25 are ranked high, medium or low. In the table below, chromium and lead were given a high priority because of their potential to affect human health through the public water supply. However, these heavy metals are not currently viewed as an imminent risk to users of water from the Liberty Reservoir.

1996 303(d) List of Impaired Waters Including 1998 Additions
Liberty Reservoir Watershed Summary[4]

Name Stream or Watershed	Impairment	Sources	Priority
Liberty Reservoir	Chromium, Lead	Nonpoint and natural	19
Liberty Reservoir	Nutrients, Suspended Sediment, Chromium, Lead	Nonpoint and natural	low

2. Draft 2002 List

Some Liberty Reservoir watershed water bodies are identified as "impaired waters" by listings in the Draft Maryland's 2002 303(d) List summarized in the table below. Satisfactory completion of a public comment period and approval by US EPA is required before the list can be finalized later in 2002. Each water body listed in the table may require preparation of a TMDL to address the impairment.[4]

Draft 2002 303(d) List of Impaired Waters Liberty Reservoir Watershed Summary[4]			
Name Stream or Watershed	Impairment	Sources	Priority
N. Branch Patapsco River (Finksburg vicinity)	Fecal Coliform Bacteria	[not listed]	medium
Stream segments on Beaver Run, Middle Run, West Branch Patapsco River, North Branch Patapsco River, East Branch Patapsco River and several unnamed streams	Biological [due to poor fish or benthos biological index scores]	unknown	low
Liberty Reservoir Impoundment	Chromium	Nonpoint and natural	low
	Lead	Nonpoint and natural	low
	Methylmercury fish tissue	Atmospheric deposition	high
	Nutrients	Nonpoint and natural	low
	Suspended Sediment	Nonpoint and natural	low

What Causes Water Quality Impairment?

Biological. Within selected stream segments, populations of benthic macroinvertebrates and fish and their associated physical habitat have been assessed by the Maryland Biological Stream Program. Based on criteria developed for each physiographic/ecological zone in Maryland, each stream segment is rated as either good, fair, poor or very poor. Ratings of poor and very poor were listed as biological impairment for the first time in Maryland in the draft 2002 303(d) list of impaired waters.

Nutrients. In Maryland, most water bodies naturally have low levels of the nutrients nitrogen or phosphorus. These nutrients enter waterways from all types of land and from the atmosphere. Nutrient pollution or over-enrichment problems may arise from numerous sources. For example, residential land can be an important contributor of nutrients depending on fertilizer use, extent of lawn and the status of septic systems. Many farmers carefully manage nutrients using different approaches, so nutrients entering waterways from crop land varies greatly depending on management techniques. Typically, smaller amounts of nutrients reach surface waters from an acre of forest land than from an acre of other types of land. The atmosphere can contribute various forms of nitrogen arising from the burning of fossil fuels in power plants and from automobile exhaust.

Suspended Sediment. Most unpolluted streams and tidal waters naturally have limited amounts of sediment moving "suspended" in the water. Excessive amounts of suspended sediment in waterways are considered pollution because they can inhibit light penetration, prevent plant growth, smother fish eggs, clog fish gills, etc. Sediment in streams tends to arise from stream bed and bank erosion and from land that is poorly vegetated or disturbed. Suspended sediment pollution results fro exposed soil, construction sites and crop land. The amount of sediment contributed varies greatly site to site depending upon stream stability, hydrology, management controls and other factors.

Toxic Substances. A wide array of materials may be considered toxic substances because they exhibit poisonous or lethal effects or otherwise harm aquatic life. These materials are very diverse in their sources and effects. Sometimes toxic substances can occur naturally. However, toxic substances of concern for water quality restoration are those types that are the product of human activity. For regulatory purposes, the US Environmental Protection Agency maintains a list of substances that are considered to be toxic. Examples include heavy metals, polychlorinated biphenyls (PCBs), asbestos and many other materials.

Total Maximum Daily Loads

The Maryland Department of the Environment (MDE) uses the 303(d) priority list to help set State work schedules for various programs including establishment of Total Maximum Daily Loads (TMDLs). The intent of establishing one or more TMDLs for a water body is to estimate a pollutant load that the water body can assimilate and still meet water quality standards. Then a waste load allocation is generated to identify appropriate pollution reduction needs among current pollutant sources. For additional information, see MDE Internet site http://www.mde.state.md.us/tmdl .

MDE projects that the draft Liberty Reservoir TMDL for mercury in fish tissue will be available for public review in Autumn 2002 and that EPA approval of the final TMDL will be sought before the end 2002.[5] Scheduling for other TMDL work for the Liberty Reservoir watershed area is uncertain based on current work load projections.

Tributary Team Characterization

A Cheseapeake Bay Program Tributary Monitoring Station on the North Branch of the Patapsco River at Maryland Route 91 shown on Map 4 City of Baltimore Water Quality Monitoring Stations is a source of long term water quality data for the nontidal streams in the Liberty Reservoir watershed. While caution must be used when drawing conclusions based on findings from a single station, DNR Resource Assessment Service has analyzed this data. A summary of their findings appears in the table below. The status for each parameter in the table is a relative ranking at three levels: good, fair and poor. For example, the ranking of "good" means that this area of the Patapsco River ranking is good compared to comparable Chesapeake Bay nontidal tributaries.

As part of DNR's work of the Patapsco/Back Rivers Tributary Team, this relative water quality assessment for the North Branch of the Patapsco River is presented in DNR's Internet site http://www.dnr.state.md.us/bay/tribstrat/locator.html . [1]

North Branch Patapsco River at Maryland Route 91		
Parameter	**Status 1998 -2000 data**	**Trend 1985 through 2000**
Nitrogen: total	Poor	Degrading (20%)
Phosphorus: total	Good	Improving
Suspended Solids: total	Good	No Trend

Water Quality Indicators

The *Maryland Clean Water Action Plan* published in 1998 listed the water quality indicators for the Liberty Reservoir watershed described here.[2]

1. State 303(d) Impairment Number

The Liberty Reservoir Watershed appeared on the 303(d) for three impairments when the Unified Water Quality Assessment was completed. For this indicator, presence on the 303(d) list means that the watershed needs restoration.

2. Total Phosphorus Nontidal Index

In comparison to the other watersheds that drain to the Chesapeake Bay in Maryland, the Liberty Reservoir watershed was among those with a lower total phosphorus (TP) concentration based on data from one, long-term "core" nontidal stream monitoring station in the watershed. Watersheds in Maryland that had this data available were ranked on a 1(worst) to 10(best) scale to allow comparison of total phosphorus among them using the Tributary Team reporting methods for status/trends. The Liberty Reservoir watershed was ranked "10" for TP.

To create a benchmark for this indicator, the TP scores for the 8-digit watersheds draining to the Chesapeake Bay were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the lowest quartile (25% of the watersheds) "exceeded" the benchmark. The Liberty Reservoir watershed did not exceed this benchmark.

3. Total Nitrogen Nontidal Index

In comparison to the other watersheds that drain to the Chesapeake Bay in Maryland, the Liberty Reservoir watershed was among those with a high or excessive total nitrogen (TN) concentration based on data from one "core" nontidal stream monitoring station in the watershed. Watersheds in Maryland that had this data available were ranked on a 1(worst) to 10(best) scale to allow comparison of total nitrogen among them using the Tributary Team reporting methods for status/trends. The Liberty Reservoir watershed was ranked "2" for TN.

To create a benchmark for this indicator, the TN scores for the 8-digit watersheds draining to the Chesapeake Bay were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the lowest quartile (25% of the watersheds) "exceeded" the benchmark. The Liberty Reservoir watershed exceeded this benchmark because it was in the lowest quartile.

Water Quality Assessment

The City of Baltimore, Department of Public Works, Water Quality Section has the best available water chemistry data for the watershed. These monitoring stations are located at a down-stream point of six major subwatersheds near the reservoir pool. The subwatersheds sampled include Beaver Run, Bonds Run, Little Morgan Run, Middle Run, Morgan Run, and the North Branch of the Patapsco River. This data set includes wet and dry weather nutrient concentrations from all six of the subwatersheds listed. In addition, flow data are collected for three of the six subwatersheds (Beaver Run, Morgan Run, and the North Branch of the Patapsco River) making pollutant load estimates possible. Refer to Map 4 City of Baltimore Water Quality Monitoring Stations for the location of each of Baltimore City's water chemistry monitoring stations.

Additional water quality-related data is available via the Internet. Two recommended Web sites are www.dnr.state.md.us/irc/datasets.html , www.chesapeakebay.net/wquality.htm .

1. Subwatersheds Selected for Evaluation

Assessment of the entire Liberty Reservoir watershed was not possible due to limited water quality data and time and staff constraints. To make the best use of available resources, Carroll County Water Resources Planning Division (WRPD) selected three subwatersheds for evaluation: Middle Run, Snowdens Run, and the North Branch of the Patapso River. These subwatersheds were selected primarily based upon evaluation of the City of Baltimore's water quality data. Carroll County's WRPD used the City's nutrient concentration data from 1983 to 1999 to rank the subwatersheds using the total phosphorus and total suspended solids test results. This evaluation identified Middle Run and Bonds Run as the greatest contributors when divided by their contributing drainage areas. These watersheds were also selected because of their geographic distribution throughout the watershed and their level of development. For instance, Snowdens Run, the smallest of the three subwatersheds and located in the Eldersburg area, was added because it is the most densely developed subwatershed in the watershed within Carroll County. The North Branch of the Patapsco River subwatershed, the largest of the three subwatersheds, was added because it is the least densely developed subwatershed in the watershed within Carroll County.

2. Chloride

Results from City's most recent interim report completed in 2000 indicate several trends worth mentioning here. First, the most alarming water quality trend reported was a significant increase in chloride levels in Liberty Reservoir measured since 1992.[14] An increasing trend was also observed in conductivity readings; conductivity values serve as a suitable substitute when chloride values are absent.[14] Several relationships were explored to determine the most likely causes of this increasing trend. The strongest relationship occurred between increasing chloride values and the amount of commercial and industrial land use. Greater chloride results were observed with increasing amounts of commercial and industrial land uses. Typically, these land uses have very high percentages of paving known as impervious surfaces for parking and buildings. Another strong relationship was established between increasing chloride levels and increasing road density. A third trend observed

was the decreasing chloride levels with an increasing amount of agriculture land. This inverse relationship is expected given the lower amount of impervious surfaces typical of agriculture land use. One likely explanation for this trend is de-icing agents (i.e., road salts) used on roads and parking lots, which wash off of these surfaces during rain events into the adjacent stream system and are ultimately delivered to Liberty Reservoir.[14]

3. Total Phosphorus

Dry weather total phosphorus concentrations are decreasing at several locations throughout all three of the City's reservoirs (Liberty, Loch Raven, and Pretty Boy), although this downward trend in total phosphorus levels was not apparent for the Middle Run watershed.[14] Using total phosphorus as one indicator of reservoir impairment, Liberty reservoir is the least impaired of the three reservoirs.[14]

4. Nitrate-Nitrogen

Nitrate-nitrogen concentrations in Liberty steadily increased from the 1980's through the mid-1990's, but appear to be leveling off since the mid-1990's.[14]

Point Sources

Discharges from pipes or any discrete conveyances are called "point sources." Point sources may contribute pollution to surface water or to groundwater. For example, wastewater treatment discharges may contribute nutrients or microbes that consume oxygen (measured as Biochemical Oxygen Demand) reducingoxygen available for aquatic life. Industrial point sources may contribute various forms of pollution. Some understanding of point source discharges in a watershed targeted for restoration is useful in helping to prioritize potential restoration projects.

According to the 2000 Action Report for the Reservoir Watersheds, total phosphorus and nitrogen loads from wastewater treatment plants in the watershed declined substantially in the early 1980's and have leveled off since the 1990's.[14] "Downward trends in effluent phosphorus from wastewater treatment plants are important, not only because they have been reduced, but because most of the phosphorus from these point sources is in a dissolved form that contributes disproportionately to the eutrophication (nutrient enrichment process) of the reservoirs than particulate phosphorus. While phosphorus reductions from treatment plants are important, they should be considered in the context of of total phosphorus loads, both point and nonpoint, flowing into the reservoirs. For instance in the Loch Raven Reservoir, the watste water treatplant portion of the total phosphours load estimates were only 3% of the total load during a wet year and were 9% during a dry year." [14]

There are 31 permitted surface water discharges and 11 permitted groundwater discharges in Carroll County's portion of the Liberty Reservoir watershed according to the Maryland Department of the Environment (MDE) permit database as summarized in the following table. In Baltimore County, there are three permitted discharges. Map 5 MDE Permits shows the location of these facilities. Information on each permits is briefly summarized in four tables:

1. MDE Permits for Surface Water Discharge - Sewage Effluent or Industrial Effluent
2. MDE Permits for Surface Water Discharge - General Industrial Stormwater
3. MDE Permits for Surface Water Discharge - General Permits
4. MDE Permits for Groundwater Discharge

Characteristics of the these permitted discharges (volume, temperature, pollutants, etc.) are tracked by MDE through the permit system. Most of this information is accessible to the public and can be obtained from MDE.

MDE Permits for Surface Water Discharge - Industrial Effluent Liberty Reservoir Watershed (9/2001 data)			
	Facility Name	**MDE Permit / NPDES Permit**	**Receiving Stream / Location**
Industrial Effluent	Cranberry Water Treatment Plant	96DP3184 MD0067644	Old Manchester Rd., Westminster
	Freedom Dist. Water Treatment Plant	96DP3186 MD0067652	Oakland Road, Sykesville
	Congoleum Corp.	96DP0422 MD0001384	Emory Road, Finksburg
	AG/GFI Hampstead, Inc.	94DP0022 MD0001881	Hanover Pike, Hampstead
	City of Westminster Koontz Well	92DP1835 MD0058556	John Street, Westminster
	Camp Fretterd (Baltimore County)	00DP3078 MD0066982	Hanover Pike, Reisterstown
	Md National Guard Westminster Armory	96DP3188 MD0067679	Hahn Road, Westminster
	Tobacco Technology	92DP1947A MD0059307	Liberty Road, Eldersburg

MDE Permits for Surface Water Discharge - General Industrial Stormwater Liberty Reservoir Watershed (9/2001 data)		
Facility Name	**MDE Permit**	**Receiving Stream / Location**
Advanced Design Prod.	97SW3007	Industrial Park, Finksburg
BFI Waste Systems	97SW1219	Dede Road, Finksburg
Bullock's Meats, Inc.	97SW3001	Sykesville Road, Westminster
Condon's Auto Parts	97SW1452	Martin Drive, Westminster
Green Pallet Co., Inc.	97SW3003	Salem Bottom Road, Westminster
Hodges Landfill	97SW0664	Hodges Road, Eldersburg
Jones Auto & Salvage	97SW0954	E Nicodemus Road, Westminster
M&M Truck & Equipment	97SW1144	Baltimore Blvd, Finksburg
Marada Industries	97SW0731	Independence Way, Westminster
Maryland Paving	97SW0719	Industrial Park Dr., Finksburg
Miller Asphalt Products	97SW0115	Dede Road, Finksburg
Northern Municipal Landfill	97SW0660	Baltimore Blvd, Westminster
Omega Acquisition Corp	97SW3005A	South Carroll Street, Hampstead
Phoenix Systems, Inc.	97SW0385	Emory Road, Finksburg
SHA Westminster Shop	97SW1345	Wyndtryst Drive, Westminster
Thomas, Bennett & Hunter, Inc.	97SW0078	John Street, Westminster
Vogt's, Inc.	97SW1424	Old Westminster Pike, Finksburg

MDE Permits for Surface Water Discharge - General Permits Liberty Reservoir Watershed (9/2001 data)		
Facility Name	**MDE Permit / NPDES Permit**	**Receiving Stream / Location**
Bare, Inc. (terminal discharge)	99OGT2155 MDG342155	Sullivan Ave, Westminster
Carroll Independent Fuel (terminal discharge)	98OGT5965 MDG345965	Old Westminster Pike, Westminster
Tevis Oil, Inc. (terminal discharge)	98OGT4550 MDG344550	Hanover Pike, Hampstead
Tevis Oil, Inc. (terminal discharge)	99OGT4506 MDG344506	John Street, Westminster
Manchester Water Distribution System	00HT9507 MDG679507	York Street, Manchester
S&G Concrete	00MM2472 MDG492472	Industrial Park Dr, Finksburg

MDE Permits for Groundwater Discharge Liberty Reservoir Watershed (9/2001 data)			
	Facility Name	**MDE Permit / NPDES Permit**	**Location**
Sewage Effluent	River Downs Development	97DP3222	Lawndale Road, Finksburg
	Gerstell Academy	98DP3276	Old Westminster Pike, Finksburg
	Camp Fretterd (Baltimore County)	96DP3183	Hanover Pike, Reisterstown
	North Carroll Shopping Plaza	00DP3154	Hanover Pike, Hampstead
	Pearlstone Family Camp (Baltimore County)	99DP3305	Mt. Gilead Road, Reisterstown
	Todd Village Mobile Home Park	98DP3268	Old Westminster Pike, Finksburg
Industrial Effluent	Bare, Inc. (oil contamination remed.)	2002OGL215 MDG912155	Sullivan Ave., Westminster
	Heird Poultry Farm	92DP2964	S Houcksville Pike, Hampstead
	Herbert R. Shipley, Inc.	99DP2670	Adam Smith St, Sykesville
	Mine Safety Appliances	96DP2234	Poole Road, Westminster
	Bees Distributing Co.	95DP2477	Dede Road, Westminster

NonPoint Sources

Several water quality issues in the watershed are linked to non-point sources. Four of the most common pollutants typically associated with non-point sources are listed below.

1. Nutrients

Excessive nutrient loads (phosphorus and nitrogen) is a water quality concern. Most of the nutrient load appears to be coming from nonpoint sources because point sources of nitrogen in the watershed are small. The decreasing trends in total phosphorus concentrations both in the tributary streams of the watershed and within the reservoir itself detected by the City of Baltimoresuggest the effectiveness of the extensive adoption of no-till and conservation tillage agricultural practices in Carroll County.

2. Sediments

Liberty Reservoir is listed as an impaired for sediment [s3]in the draft 2002 303(d) list. In addition, the 2000 305(b) report notes that monitoring by the Maryland Biological Stream Survey (MBSS) indicated sediment related problems including siltation of the stream bead and stream bank instability affecting physical stream habitat for streams within the watershed.

3. Heavy Metals Chromium and Lead

Listings for chromium and lead in the 303(d) list relates generally to the remnants of former chromium mining in the Soldiers Delight area of Baltimore County near Liberty Reservoir.

Water Supply

It is widely accepted that effective watershed management that reduces nutrient and sediment inputs to the receiving streams that feed to a surface water supply reservoir greatly improves the water quality within the reservoir. Numerous watershed implementation measures or best management practices are available to limit the water quality impacts of land use activities. Nutrient and sediment reductions, for instance, can lead to reduced treatment costs at the water treatment plant and ultimately reduced water bills for the users.

Recently the City of Baltimore hired a consultant to complete a source water assessment.

1. Source Water Assessment for the City of Westminster Water Supply

The surface water portion of the water supply system for the City of Westminster is located within the Cranberry Branch Watershed. Stream flows from this small watershed drain to the West Branch of the Patapsco and eventually into Liberty Reservoir. Beginning in 2000, MDE conducted a source water assessment for the City of Westminster's water supply system. Because of historical water quality problems (e.g., elevated turbidity levels and odors) encountered at the treatment plant, a cooperative arrangement was initiated between City, county and state officials to identify potential sources of sediment and odors within the Cranberry Branch Watershed. Part of the source water assessment involved collecting water chemistry samples and conducting a stream corridor assessment for the Cranberry Watershed.

Most of the problems identified were either erosion sites along the stream banks or inadequate forested buffer to the stream within this watershed.[15] The estimated stream length effected by these impairments was 1.4 miles or about 35% of the total stream length. The large number of problems identified may account for the elevated total suspended solids and turbidity levels at the treatment plant.[15] Considering the distribution of livestock populations throughout the Cranberry Watershed combined with the lack of stream buffers, the pollution sources in the watershed is typical of non-point sources.[15] Refer to this document for more information.

2. Surface Water Permits

There are three permit holders that use surface waters for public water supply in the Liberty Reservoir watershed as summarized in the table below. Baltimore City and the Freedom District in Carroll County both draw water from Liberty Reservoir. The City of Westminster obtains water from both stream and reservoir surface water sources and dispersed groundwater sources.

Baltimore City owns Liberty Reservoir. The Reservoir is one of three large reservoirs in Baltimore City's water supply system that collectively serves over 1.4 million people in the City and several surrounding Counties. Management, monitoring and protection of this reservoir are a cooperative effort under the 1984 Reservoir Watershed Management Agreement and its subsequent updates and work plans.

Community Surface Water Supply Permits in the Liberty Reservoir Watershed [10]		
Permit Name	**Permit Number**	**Source**
Baltimore City	300002	Liberty Reservoir
Freedom District	60002	Liberty Reservoir
Westminster	60015	West Branch Patapsco Emergency Intake
		West Branch Patapsco WP Coffer Dam
		Cranberry Branch / Reservoir
		Cranberry Branch

3. Groundwater Permits

Surface water and groundwater in the Liberty Reservoir watershed is the source of all water used for agriculture and business and all potable water. In general, these water uses do not employ near-surface groundwater, which is subject to potential local pollution sources. Additionally, near surface groundwater is credited with carrying nutrients, particularly nitrogen, from land source to surface waters where nutrient over-enrichment is occurring.

All public water supply systems in the Liberty Reservoir watershed are listed in the table below and are shown on Map 6 Water Supply.

Community Groundwater Supply Permits in the Liberty Reservoir Watershed [10]		
Permit Name	**Permit Number**	**Source Formation**
Chapel Hill Nursing Center	BA1985G003	Ultramafic and Gabroic Rocks
Hampstead, Town of	CL1974G062	Up. Pelitic Schist Wissahickon
Hillandale Mobile Home Park	CL1970G001	Up. Pelitic Schist Wissahickon
Lakeview Village M.H.P.	CL1970G002	Wissahickon Formation
Manchester, Town of	CL1966G212	Up. Pelitic Schist Wissahickon
Reservoir Trailer Park	CL1978G085	Wissahickon Formation
Sullivan's Trailer Court	CL1959G017	Up. Pelitic Schist Wissahickon
Taylorsville Mobile Home Park	CL1966G017	Marburg Formation
Todd Village Mobile Home	CL1965G006	Up. Pelitic Schist Wissahickon
Westminster	CL1977G136, CL1977G436, CL1977G736	Sams Creek MetaBasalt, Wakefield Marble, Up. Pelitic Schist Wissahickon

LAND USE

Liberty Reservoir Watershed

Water quality in streams and reservoirs is directly affected by use of the land draining to those water bodies. Land condition also largely influences the kinds and quality of habitat on the land and in nearby aquatic environments. In recent years, improved understanding of the relationships between land use, water quality and habitat has suggested new ways protect and restore important natural resources. Within the WRAS project area, assessment of local land use, land cover and related land conditions can help provide a basis for prioritizing watershed management objectives and potential watershed projects.

Piedmont Geology

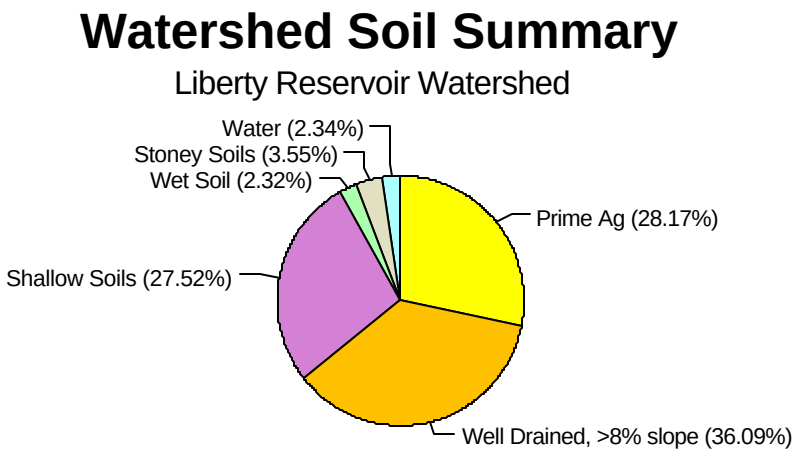
The Liberty Reservoir watershed is entirely in the Piedmont Province in Maryland. The watershed is characterized by rolling terrain varying from gentle slopes to some areas of steep slopes over 15% grade.

The geology that characterizes the bedrock that underlies the watershed is generally the Wissahickon Formation as shown in Map 7 Geology. The formation accounts for about 83% of the subsurface condition in the Liberty Reservoir watershed and is the most important geological condition in Carroll County's portion of the watershed.

Close to Liberty Reservoir, Lower Pelitic Schist has a significant presence (nearly 7% of the watershed). Two other geological formations, Ultramafic Rocks and Boulder Gneiss (each around 2% of the watershed) are locally important.

In the headwaters area of the Liberty Reservoir watershed, several other geologies are locally significant. Sams Creek Metabasalt accounts for nearly 4% of the watershed. Both Marburg Schist and Wakefield Marble account for less than half of one percent of the total watershed geology.

Soils



1. Natural Soil Groups

Soil conditions, like soil type and moisture conditions, greatly affect how land may be used and the potential for vegetation and habitat on the land. Soil conditions are one determining factor for water quality in streams and rivers. Local soil conditions vary greatly from site to site as published information in the Soil Surveys for Carroll County and Baltimore County show. This complicated information can be effectively categorized using Natural Soil Groups as summarized in the pie chart above to help identify useful generalizations about groups of soils.

Considering the distribution of soil groups in Map 8 Soils and the pie chart statistics above, several generalizations about the Liberty Reservoir watershed can be seen. Over one quarter of the watershed is prime agricultural land which tend to be widely dispersed across the watershed. Well drained soils over 8% slope cover slightly more than 1/3 of the watershed. Soils with less than 40 inches to bedrock are about 27% of the watershed. Wet soils tend to be limited to stream and headwater areas. Stoney soils are a small percentage of the watershed but they are scattered in the watershed. All the open water shown in the map are constructed impoundments that relatively recently submerged natural upland soils.

2. Soils and Watershed Planning

Local soil conditions can be a useful element in watershed planning and for targeting restoration projects. For example, soils with limitations related to wetness, slope, shallow depth or stoniness naturally inhibit active use for farming or development. By identifying these areas in Map 8 Soils with several following maps Map 12 Generalized 2000 Land Use / Land Cover; Map 13 Green Infrastructure; and Map 14 Forest Interior, it may be possible to identify general areas were marginal lands could be converted to natural vegetation or other low intensity uses. Once areas of interest are targeted and land owner interest is verified, additional detailed soil assessment is an essential step in identifying viable restoration project sites.

Landscape Indicators

In an effort to gauge the affects of land use on water quality, and to allow comparison between watersheds, DNR has developed a series of landscape indicators. These indicators can be used to portray landscape conditions on a watershed scale that tend to either support good water quality or degrade water quality.

Landscape conditions in the Liberty Reservoir watershed can be compared to similar watersheds using indicators published in the 1998 *Maryland Clean Water Action Plan*.[2] Based on these measurements, conditions in the Liberty Reservoir watershed compare well with similar watershed based on impervious surface, population density, historical wetland loss and unbuffered streams, however, soil erodibility is a potential water quality problem compared to similar watersheds in Maryland's Piedmont region.

1. Impervious Surface

On average across the entire Liberty Reservoir watershed, 6.3% of surface cover is impervious. This average imperviousness compares well with similar watersheds in Maryland.[2]

Roads, parking areas, and roof tops are collectively called impervious surfaces. Impervious surfaces prevents the natural seepage of rain through the soil and eventually into the groundwater. Watersheds with small amounts of impervious surfaces usually are associated with better water quality in streams than watersheds with greater amounts of impervious surfaces. Unlike natural surfaces, impervious surfaces concentrate stormwater runoff delivering storm flows more quickly to the nearest stream. There are many, well-documented, harmful effects of impervious surfaces on receiving stream systems. As the amount of impervious surfaces increases in a watershed, groundwater recharge decreases and stream flows become more exaggerated or "flashy." A reduction in stream flows occur between storm events and a significant increase occurs during storm events. This flow imbalance causes an excessive stream channel erosion and corresponding sediment deposition in the stream beds. This deposition results in loss of aquatic habitat.

Maryland's Stormwater Management Law, enacted in 1984, attempts to counteract the harmful effects of impervious surfaces on receiving stream systems created when land within a watershed develops. Storm water runoff is collected in storm water management (SWM) facilities and either slowly releases storm water to the stream or infiltrates it through the bottom recharging the groundwater. Map 9 Stormwater shows the distribution of SWM facilities within the watershed. A total of 167 facilities have been constructed within the watershed. Collectively they manage about 6,280 acres of residential land before discharging stormwater to the receiving streams within the watershed. This map also shows a lack of SWM facilities where older residential subdivision exists (e.g., the Middle Run watershed).

The Maryland Biological Stream Survey has related the percent of impervious surface in a watershed to the health of aquatic resources. For areas with less than 4% impervious cover, streams generally rate "Fair" to "Good" for both fish and instream invertebrates. Beyond about 12% impervious surface, streams generally rate "Poor" to "Fair" for both. Side-effects of impervious

surfaces become increasingly significant and negative as the percentage of impervious area increases. Examples of related problems include reduction of groundwater infiltration, increased soil and stream bank erosion, sedimentation, destabilization or loss of aquatic habitat, and "flashy" stream flows (reduced flow between storms and excessive flows associated with storms.)

The impervious surface estimate used for this indicator was generated for the 1998 Maryland Clean Water Action report. Each land use type in the 1994 Maryland State Planning land use data was assigned an estimated imperviousness taken from the TR-55 manual used by the former Soil Conservation Service.

To create a benchmark for comparing impervious area among Maryland watersheds, the percent of impervious area for 8-digit watersheds were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) "exceeded" the benchmark. The Liberty Reservoir watershed did not exceed this benchmark.

2. Population Density

The population density in the Liberty Reservoir watershed was 0.70 people per acre using pre-2000 Census data. This density compares well with similar Maryland watersheds.[2]

To create a benchmark for comparing population density among Maryland watersheds, the people per acre for 8-digit watersheds were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) "exceeded" the benchmark. The Liberty Reservoir watershed did not exceed this benchmark.

While population density may be beyond the scope of a WRAS, directing growth is a potential WRAS component. As human population increases, effects of human activity that tend to degrade, displace or eliminate natural habitat also tends to increase. Watersheds with higher populations, assuming other factors are equal, tend to exhibit greater impacts on waterways and habitat. However, growth can be directed in ways to reduce negative impacts.

3. Historical Wetland Loss

The historical loss of wetlands in the Liberty Reservoir watershed is estimated to be 3,987 acres which compares well with other similar Maryland watersheds.[2]

This interpretation is based on the assumption that the hydric soils were all, at one time, wetlands. Selective restoration of historic wetland areas can be an effective WRAS component. In most of Maryland's watersheds, extensive wetland areas have been converted to other uses by draining and filling. This conversion unavoidably reduces or eliminates the natural functions that wetlands provide. These functions include habitat and nursery areas for many aquatic organisms, flood attenuation, and uptake and redistribution of nutrients, etc. In general, watersheds exhibiting greater wetland loss tend to also exhibit greater loss of the beneficial functions that wetlands provide. Strategic replacement of wetlands can significantly improve natural function in local watershed areas.

To create a benchmark for comparing impervious area among Maryland watersheds, the historic wetland loss acreage for 8-digit watersheds were ranked highest to lowest and then divided

into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) “exceeded” the benchmark. The Liberty Reservoir watershed did not exceed the benchmark.

4. Unbuffered Streams

Approximately 43% of the streams in the Liberty Reservoir watershed were not buffered with trees. This finding is similar to other Maryland watersheds but could be improved.[2]

DNR recommends a forested stream buffer of 100 feet wide, i.e. natural vegetation 50 feet wide on either side of the stream, which is necessary to promote high quality, aquatic habitat and diverse aquatic populations. Stream buffer plantings are a valuable and relatively inexpensive method to improve stream conditions. In most of Maryland, trees are an important component to healthy, natural streams. They provide numerous essential habitat functions including: 1) filtration of surface and subsurface runoff, 2) flow attenuation, 3) shade to keep water temperatures down in summer and up in the winter, 4) leaf litter or "food" for aquatic organisms, 5) roots to stabilize stream banks, 6) vegetative cover for wildlife, etc. In general, reduction or loss of stream buffers degrades stream habitat while their replacement enhances stream habitat. For this indicator only "blue line streams" were included; intermittent streams were not considered.

This estimate of streams lacking forested buffer was generated for the 1998 Maryland Clean Water Action Plan by using Maryland Department of State Planning GIS data for streams and for 1994 land use.

To create a benchmark for comparing impervious area among Maryland watersheds, the percent of unbuffered streams for 8-digit watersheds were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) “exceeded” the benchmark. The Liberty Reservoir watershed did not exceed the benchmark.

5. Soil Erodibility

The average soil erodibilty of lands within 1000 feet of streams in the Liberty Reservoir watershed is 0.28 value/acre which suggests that control of soil erosion is particularly important here

Watersheds with more highly erodible soils are naturally more susceptible to surface erosion, sedimentation, stream bank erosion and other problems related to soil movement. These negative effects of soil erodibility on water quality can be minimized through careful management. The soil erodibility indicator accounts for natural soil conditions but not for management of the land; existing crop land management was not considered. Soil loss from farm land is addressed by techniques grouped together called best management practices (BMPs). BMPs like no-till, reduced till, cover crops, field strips, and others significantly reduce erosion and sediment movement.

This estimate of soil erodibility was generated through an analysis of GIS data that incorporated the soil erodibility factor (K), slope steepness, land area within 1000 feet of streams and cropland within that 1000 feet buffer based on 1994 Maryland Department of State Planning land use data.

To compare Maryland watersheds for this index, the benchmark of 0.275 value/acre was

used, i.e. less than 0.275 was considered relatively beneficial for water quality and 0.275 or greater was considered to be a likely factor for water quality problems.

Agricultural BMPs

Agricultural Best Management Practices (BMPs) are an effective watershed control measure and their use should be continued and expanded where possible. Since 1980, 1,277 BMPs have been implemented within Carroll County's portion of the Liberty Reservoir watershed. Map 10 Agricultural BMPs shows the distribution of these practices. This map also shows the distribution of agricultural districts, agricultural easements, and soil and water conservation plans throughout the watershed. The table below shows the number of soil and water conservation plans written for farms within the three subwatersheds that are receiving detailed evaluation for the WRAS.

Soil and Water Conservation Plan Count In Selected Subwatersheds	
Subwatershed	**Number of Plans**
Middle Run	13
Snowdens Run	2
West Branch of the Patapsco River	18

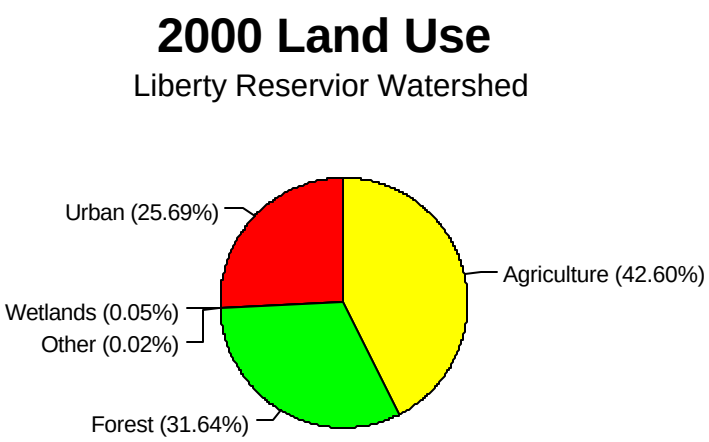
2000 Land Use / Land Cover

1. Carroll County Data Summary

The Carroll County Department of Planning recently completed its land use inventory for the entire county. Land use categories for the county's analysis are defined differently than the state's analysis; furthermore, those categories are defined in greater detail (i.e, developed land is split into different categories). Refer to Map 11 Detailed Land Use for Liberty WRAS Area for the distribution of land uses throughout the watershed. Some of the categories are self evident, but a few need clarification. For instance, the Mixed Use category means a mixture of both commercial and residential uses. The Public Use category means land open to the public not developed for residential use (e.g., schools, churches parks, gold courses, libraries). The Vacant category means unimproved land, which has the potential to be developed (e.g., abandoned buildings). The rest of the categories are defined as the Standard Land Use Categories within the Departments Community Comprehensive Plan Updates. From this map it is evident that a very small percentage of the watershed is currently used for commercial or industrial purposes. Note that this is not a zoning map, which shows the potential development for a planned area, but simply reflects the County's best estimate of existing land uses.

2. Maryland Data Summary

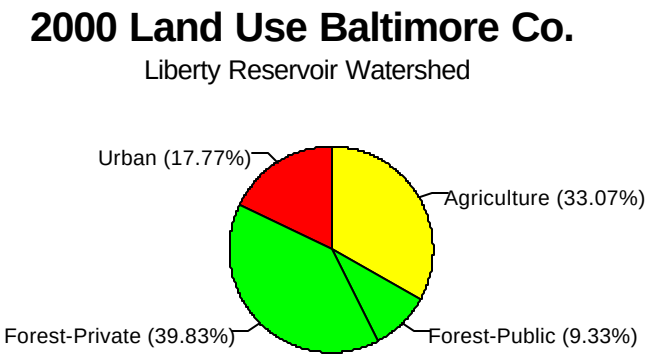
Based on Maryland Department of Planning data for the Year 2000, land use in the Liberty Reservoir watershed was mostly agriculture and forest. As the pie chart shows, it was just over 40% agriculture, nearly 33% forested and about 25% developed.



Map 12 Generalized 2000 Land Use / Land Cover shows forest land in the watershed trends to occur near the Reservoir and near streams. However, agricultural land and urban/developed land tends to be dispersed across the watershed. The table below summarizes land use statistics for the watershed.

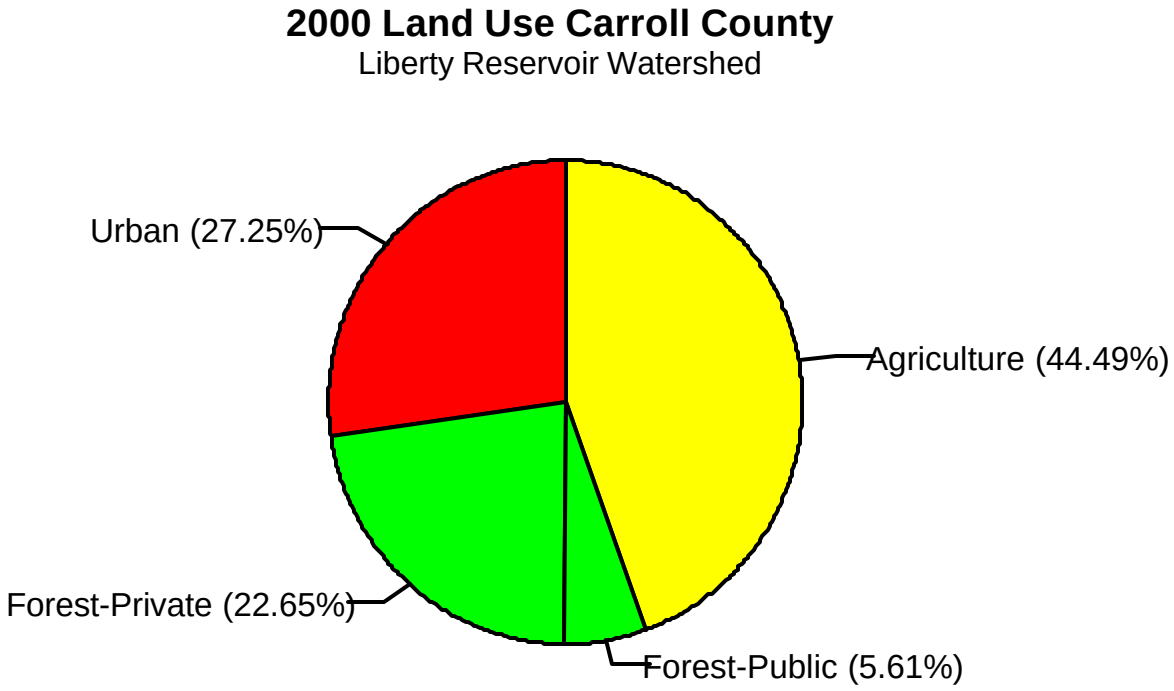
2000 Land Use / Land Cover Liberty Reservoir Watershed				
Category	**Description**	**Acres**		
		Carroll Co.	Balto. Co.	Watershed
Agriculture	Field, Pasture, Ag buildings	37,758	5,463	43,221
Forest	All woodlands and brush	23,979	8,123	32,102
Urban	All developed areas	23,123	2,935	26,058
Wetlands	Emergent wetlands	29	23	52
Other	Extractive and bare ground (not graphed)	14	5	19
Watershed Land Total (excluding open water)		**84,903**	**16,549**	**101,452**
Water (mostly Liberty Reservoir, not in pie chart)		2,137	1,213	3,350
Watershed Total Area		**87,040**	**17,762**	**104,802**

In the Liberty Reservoir watershed, Carroll County has roughly five times as much land as Baltimore County. It is important to keep this in mind when comparing land use/land cover in each County. To help show the difference in relative area, the pie chart for Carroll County on this page has roughly five times the area of the pie chart for Baltimore Co.



In Carroll County's portion of the watershed, agriculture accounts for a little less than one half of Carroll County's portion of the watershed. Urban and forest land each covers slightly more than one quarter of Carroll County's total acreage. About 20% of Carroll County's forest land in the watershed (4,760 acres) is publicly owned by either Baltimore City in the reservoir property or by DNR in the Morgan Run Natural Environment Area.

In Baltimore County's portion of the watershed, nearly half of the land is forested with about 19% (1,542 acres) in public ownershp by either Baltimore City in the reservoir property or by DNR in the Soldiers Delight Natural Environment Area. The remainder is about one third agriculture and slightly more than one sixth developed land.



Green Infrastructure

An additional way to interpret land use / land cover information is to identify "Green Infrastructure." In the GIS application developed by Maryland DNR and its partners, Green Infrastructure refers to areas of natural vegetation and habitat that have statewide or regional importance as defined by criteria developed by DNR. The criteria for identifying lands as Green Infrastructure is limited to considering natural resource attributes currently found on those lands. One example of the criteria is that interior forest and wetlands complexes must be at least 250 acres in size to be considered as part of Green Infrastructure. As a second example, sensitive species habitat that is located within areas of natural vegetation at least 100 acres in size is also counted as Green Infrastructure. Other potential attributes of Green Infrastructure lands, such as ownership or if the current natural conditions are protected in some way, are not criteria for Green Infrastructure but they may be considered independently.

Within the Green Infrastructure network, large blocks of natural areas are called hubs, and the existing or potential connections between them, called links or corridors. Together the hubs and corridors form the Green Infrastructure network which can be considered the backbone of the region's natural environment.[6]

Protection of Green Infrastructure lands may be addressed through various existing programs including Rural Legacy, Program Open Space, conservation easements and others. The 2001 Maryland General Assembly approved $35 million for the Green Print program which is targeted primarily to protecting Green Infrastructure areas. This funding category is administered by Program Open Space.

Map 13 Green Infrastructure shows several significant local characteristics of Green Infrastructure:

– Green Infrastructure in the Liberty Reservoir watershed is concentrated near Liberty Reservoir. The largest hub surrounding the reservoir includes Baltimore City's land ownership.
– Along Morgan Run and Joe Branch, the second Green Infrastructure hub connects to the Liberty Reservoir hub creating a relatively contiguous block of naturally vegetated land.
– Snowdens Run subwatershed includes a portion of the Green Infrastructure hub near Liberty Reservoir and a potential corridor along the stream that would link two hub areas. The corridor, shown on Map 13, was identified using a computer assessment of existing land cover.
– Most of the woodlands and wetland areas in the Liberty Reservoir watershed are less than 100 acres in size. Therefore, they are too small to meet the size criteria adopted as the minimum threshold for Green Infrastructure.

Large Forest Blocks / Forest Interior

Within large blocks of forest, habitat is available for species that are specialized for conditions with relatively little influence by species from open areas or humans. For example, forest interior dwelling birds require forest interior habitat for their survival and they can not tolerate much human presence. Map 14 Forest Interior shows blocks of contiguous forest that are at least 50 acres in size with at least 10 acres of forest interior (forest edge is at least 300 feet away) that may be important locally within the Liberty Reservoir watershed. This size threshold was chosen to help ensure that the forest interior is large enough to likely provide locally significant habitat for sensitive forest interior dwelling species. The assessment shown in Map 14 differs from the Green Infrastructure assessment which considered only large blocks of forest land cover at least 250 acres in size that are likely to have state or regional importance.

Forest interior covers about 16,000 acres (nearly 16%) of the land in the Liberty Reservoir watershed. Contributing to the total forest interior area is about 10,200 acres that are considered to be high quality habitat for forest interior dwelling birds (FIDS). The map shows that a high percentage of the forest interior in the watershed is owned by either Baltimore City around the reservoir or by DNR in the Morgan Run Natural Environment Area.

Protected Lands

As used in the context of watershed restoration, "protected land" includes any land with some form of long term limitation on conversion to urban / developed land use. This protection may be in various forms: public ownership for natural resource or recreational intent, private ownership where a third party acquired the development rights or otherwise acquired the right to limit use through the purchase of an easement, etc. The extent of protection varies greatly from one circumstance to the next.

Map 15 Protected Land and Smart Growth shows the location of protected lands in the Liberty Reservoir watershed and additional details are listed below.

1. Public Lands

– Baltimore City owns about 6,290 acres around the Liberty Reservoir within the Liberty Reservoir watershed. Of this land, 4,780 acres in Carroll County. (Additionally, Baltimore City owns additional Liberty Reservoir land downstream of the dam, which is outside of the watershed.) This land is managed primarily to provide a naturally vegetated buffer surrounding the reservoir. The property also provided for low intensity recreation like hunting and fishing.

– Carroll County has10 community parks in the watershed encompassing 244 acres. The largest of these parks is 40 acres.

– Baltimore County has one park area in the watershed covering 26 acres.

– DNR manages two areas in the watershed: the 1570-acre Morgan Run Natural Environment Area in Carroll County and a portion of the Soldiers Delight Area (1080 acres) in Baltimore County.

– No Federal land is identified in the Liberty Reservoir watershed.

2. Private Lands

– Conservation Easements on private land in Carroll County were not identified in DNR's database. In Baltimore County's portion of the watershed, the Maryland Environment Trust holds two perpetual easements covering nearly 180 acres.

– Agricultural Easements cover nearly 2200 acres in the watershed (all in Carroll County).

– Agricultural Districts encompass about 4010 acres that are not under agricultural easement in the watershed (nearly all in Carroll County).

– Through the development review process, two private conservation easements are required where applicable (e.g., Forest Conservation Easements and Water Resource Protection Easements). Forest Conservation easements are required when forest disturbance exceeds about an acre. Reforestation is required on an acre for acre basis, and when the development site has little or no forest at the time of development. When land is subdivided, Water Resource Protection Easements are required for all land within 100 feet of any stream channel.

Smart Growth

Within Maryland's Smart Growth program, there are two targeting programs that should be considered as potential watershed restoration projects are considered. In Priority Funding Areas, State funding for infrastructure may be available to support development and redevelopment. In Rural Legacy Areas, protection of land from future development through purchase of easements (or in fee simple) is promoted. Map 15 Protected Land and Smart Growth shows areas addressed by these programs in the Liberty Reservoir watershed and the summary below provides some details.

- Priority Funding Areas (PFAs) in the Carroll County cover the four largest developed areas in the Liberty Reservoir watershed: Eldersburg, Hampstead, Manchester and Westminster. About ten other small communities are also PFAs in Carroll County. Collectively, the PFA areas in Carroll County's portion of the watershed totals about 13,490 acres which is about 15% of the County's total acreage in the watershed.

- Priority Funding Area covering the Baltimore Metropolitan Area in Baltimore County extends into the Liberty Reservoir watershed in two small areas in the vicinity of Glyndon and Owings Mills. Collectively, the PFA areas in Baltimore County's portion of the watershed totals about 590 acres which is about 3% of the County's total acreage in the watershed.

- Currently, there is no Rural Legacy project in the Liberty Reservoir watershed. Carroll County's Little Pipe Creek Rural Legacy Area is in the Monocacy River watershed immediately west of Liberty Reservoir Watershed and the Westminster Priority Funding Area. Baltimore County's Piney Run Rural Legacy Areas is immediately east of the Liberty Reservoir Watershed in another part of the Patapsco River watershed.

- There have been two unsuccessful attempts to establish the Upper Patapsco Watershed Rural Legacy Area which would include part of the Liberty Reservoir watershed. This area is bounded on the east by Baltimore County (nearly adjacent to Baltimore County's Piney Run Rural Legacy Area), and surrounded by the Hampstead, Westminster, and Finksburg community planning areas. The 14,145 acre proposed Rural Legacy Area includes most of the watershed of the East Branch Patapsco River, part of the West Branch and comprises about 16% of the entire Liberty Reservoir watershed in Carroll County.

Wetlands

1. Wetland Categories

Wetlands are most abundant in the Coastal Plain due to the low topographic relief and high groundwater table characteristic of the region. Wetlands in the Liberty Reservoir watershed tend to occur adjacent to streams and the reservoir as shown in Map 16 Wetlands. The table on this page summarizes acreage for major wetland categories based on the DNR Wetlands Inventory.

Wetland Acreage Summary
Carroll County Portion Liberty Reservoir Watershed

Wetland Class		Acres
Lacustrine	unconsolidated bottom	1320
	unconsolidated shore	253
Palustrine	emergent	739
	forested	1,486
	semipermanently flooded	70
	scrub-shrub	373
	unconsolidated bottom	238
Riverine	all types	11
Total Wetlands	DNR Wetlands Inventory	4,490
National Wetlands Inventory	Carroll County Liberty Reservoir Watershed	2,760
	Baltimore County Liberty Reservoir Watershed	1,200

Note: No Wetlands of Special State Concern are in the Liberty Reservoir watershed. Also see the Sensitive Species Section.

Lacustrine wetlands are wetlands associated with lakes, ponds and freshwater impoundments. They cover more than 1500 acres in the watershed primarily because of Liberty Reservoir.

Palustrine forested wetlands are the most abundant and widely distributed palustrine wetland in the watershed covering nearly 1500 acres. These wetlands are found on floodplains along the freshwater tidal and nontidal portions of rivers and streams and in upland depressions. Emergent palustrine wetlands are the second most common wetland in the watershed.

The table includes National Wetlands Inventory data because the higher resolution DNR Wetlands Inventory data was not available for Baltimore County. However, the difference in data resolution is significant between these two sources. For Carroll County's portion of the Liberty Reservoir watershed, the DNR Inventory identifies nearly 4500 acres of wetlands while the National Inventory identifies less than 2800 acres.

Comparing Map 16 Wetlands to Map 12 Generalized 2000 Land Use / Land Cover, it can be seen that many of the wetlands in the wetland map are depicted as forest on the land use map. This difference is simply the result of two differing views of the landscape. For example, wooded nontidal wetlands can be viewed as "wetlands" from a habitat / regulatory perspective and they can be viewed as "forest" from a land use perspective.

In the Liberty Reservoir watershed, differing perspectives on counting wetlands are significant for watershed management. From a land use perspective, only ten acres of wetlands are identified by the Maryland Department of Planning. From a habitat / regulatory perspective, many more wetland

areas can be identified. In the Carroll County portion of the Liberty Reservoir wetlands, the National Wetlands Inventory identified about 2,760 acres of wetlands. For the same watershed area, the thorough DNR Wetlands Inventory identified at least 4,490 acres of nontidal wetlands

2. Tracking Wetlands

Oversight of activities affecting wetlands involves several regulatory jurisdictions. The Maryland Dept. of the Environment (MDE) is the lead agency for the State and cooperates with DNR, the Army Corps of Engineers and other Federal and local agencies. As part of its responsibility, MDE tracks State permitting and the net gain or loss of wetlands over time.

As the table Tracking Nontidal Wetland Change By Watershed on the next page shows, the State regulatory program has measured a small net increase of wetland acreage in the Liberty Reservoir watershed over the past 10 years.

Floodplains

Floodplains and associated riparian areas are naturally important areas for habitat and hydrologic functioning of streams. Map 17 Floodplains shows that the most 100-year floodplain in the Liberty Reservoir watershed are adjacent to Liberty Reservoir and major streams tributary to the Reservoir. Using the information on the map, a comparison of general floodplain location and location of roads and land use in the watershed, it appears that more identified floodplains are on naturally vegetated land or agricultural land. However, some roads, numerous road crossings and some community areas may have risk of flood damage.

Tracking Nontidal Wetland Change By Watershed For The Patapsco River Basin In Acres 1/1/1991 through 12/31/2001 [7]						
Watershed	**Basin Code**	**Permanent Impacts**	**Permittee Mitigation**	**Programmatic Gains**	**Other Gains**	**Net**
Liberty Reservoir	02130907	-2.55	2.67	0	0	0.11
South Br. Patapsco R.	20130908	-1.91	1.33	3.00	0	2.42
Lower N. Br Patapsco R.	02130906	-17.20	22.23	0	0.21	5.24
Gwynns Falls	02130905	-4.96	5.75	0	0.50	1.30
Jones Falls	02130904	-2.73	4.19	0	0.25	1.70
Balto. Harbor	02130903	-9.85	7.91	8.50	0	6.56
Bodkin Cr.	02130902	-0.03	0	0	0	-0.03
Back River	02130901	-5.78	3.58	0	0.03	-2.17
TOTAL Patapsco River Basin	021309	-45.01	47.65	11.50	0.99	15.13

Notes: Acreage presented for each watershed does not identify County and is not normalized. Regulatory tracking for authorized nontidal wetland losses began in 1991. Comprehensive tracking of voluntary wetland gains began in 1998.

LIVING RESOURCES AND HABITAT

Overview

Living resources, including all the animals, plants and other organisms that call the land and waters of the Liberty Reservoir watershed home, are being affected by human activity. The information summarized here suggests that some of the significant stresses on living resources in the watershed are manipulation of habitat, excessive movement of sediment and excessive availability of nutrients.

The Living Resource information summarized here should be considered a partial representation because numerous areas of potential interest or concern could not be included due to lack of information, time, etc. For example, information on many forms of aquatic life, woodland communities, terrestrial habitats, etc. should be considered as watershed restoration decisions are being made. Therefore, it is recommended that stakeholders in the watershed identify important living resource issues or priorities so that additional effort can be focused where it is most needed. New information should be added or referenced as it becomes available.

Living Resource Indicators

Aquatic organisms are sensitive, in varying degrees, to changes in water quality and aquatic habitat. This association offers two perspectives that are important for watershed restoration. First, improvements for living resources offer potential goals, objectives and opportunities to gauge progress in watershed restoration. Second, the status of selected species can be used as to gauge local conditions for water quality, habitat, etc. This second perspective is the basis for using living resources as an "indicator."

The *Maryland Clean Water Action Plan* published in 1998 listed the following living resource indicators for the Liberty Reservoir Watershed.[2] Several of these indicators rely on index rankings generated from a limited number of sampling sites which were then generalized to represent entire watersheds. Considering this limitation on field data, it may be beneficial to conduct additional assessments to provide a more complete understanding of local conditions as part of the WRAS.

1. Benthic Index of Nontidal Biotic Integrity

Streams in the Liberty Reservoir watershed are generally in fair/good condition on average based on assessment of benthic macroinvertebrate communities (stream bugs). For this index, Liberty Reservoir streams scored an average of 6.89 on a scale of 1 (worst) to 10 (best). For this index, an average score for an 8-digit watershed less than 6.0 means that restoration is needed and a score of 8.0 or greater means that protection is recommended. To generate this index, each stream site that is assessed is compared to reference conditions that were established for comparable streams that are minimally impacted. Nontidal rivers (streams seventh order and larger) are not incorporated into this index. Also see Why Look at Benthos in Streams?

2. Fish Index of Nontidal Biotic Integrity

Based on assessment of fish communities, streams in the Liberty Reservoir watershed are generally in good condition on average. In this index, protection is recommended for Liberty Reservoir streams based on their average score of 8.87 on a scale of 1 (worst) to 10 (best). For this index, an average score for an 8-digit watershed less than 6.0 means that restoration is needed and a score of 8.0 or greater means that protection is recommended. In each stream site where fish are surveyed, the makeup of the overall fish population is measured in nine distinct ways such as the number of native species, number of benthic fish species, percent of individuals that are "tolerant" species, etc. These nine scores are then integrated to generate an index ranking for the survey site. To generate the index for the watershed, the scores for all the stream sites assessed within the 8-digit watershed are averaged together.

3. Nontidal In-Stream Habitat Index

Based on habitat conditions in nontidal streams in the Liberty Reservoir watershed, conditions are generally fair on average. In this index, Liberty Reservoir streams scored an average of 6.47 on a scale of 1 (worst) to 10 (best). This index allows comparison of streams based on habitat for fish and benthic organisms as measured by in-stream and riparian conditions. For each stream site that was assessed, visual field observations are used to score the site for substrate type, habitat features, bank conditions, riparian vegetation width, remoteness, aesthetic value, etc. For each site, the individual scores are integrated to generate a single score for each stream site. The index score reported for each stream site is a relative score to the maximum attainable score for comparable streams. The watershed index is created by averaging the scores for all the sites that were assessed in the watershed.

Benthic Macroinvertebrates [8, 9]

Assessments of "bugs" (benthic macroinvertebrates or benthos) living in streams in streams that flow into the Liberty Reservoir have been conducted at various times in recent years. The intent of this assessment is to gauge water quality and habitat conditions by interpreting these in-stream populations. See the text box Why Look At Benthos In Streams for more details.

Findings reported here represent sites where stream segments of over 200 feet were assessed by the Maryland Biological Stream Survey. Conditions in the same stream can vary significantly upstream or downstream, however, the MBSS employs a random site selection design to allow for general assessments for the entire watershed (provided enough sites have been sampled).

1. One Long Term Station Shows Improvement Trend

Assessment of benthos at one long-term stream site provides some insight into changing conditions over time for this station only in the Liberty Reservoir watershed. The "core" long-term monitoring station NPA0165, is located at the Route 91 bridge over the East Branch of the Patapsco River as shown on Map 18 Benthic Index. Based on eleven years of information collected between

1978 and 1992, there was an increase in the kinds of bugs found in the stream. No other macroinvertebrate trends appeared during that period. Field notes taken by State field personnel recorded a problem with filamentous algae on the rocks and gravel in the late 1970s and early 1980s. In the late 1980s, the algae disappeared and a river weed (Podostemon sp.), which is sensitive to pollution appeared. Taken together, these findings reflect a slight improvement in water quality between 1978 and 1992.[12] These improvements may be explained by the shift in agricultural practices from conventional till to reduced till that occurred in Carroll County during this period. Sampling by the Maryland Biological Stream Survey (MBSS) of two nearby sites in the North Branch Patapsco River in 1995 and 1996 rated the area as "fair" on the Benthic Index.

2. MBSS Monitoring in the 1990s and 2000

The Maryland Biological Stream Survey (MBSS) assessed 58 monitoring sites in the Liberty Reservoir watershed as shown on Map 18 Benthic Index between 1995 and the 2000. The map also shows an additional 52 monitoring sites sampled by citizen volunteers cooperating with MBSS in the Stream Waders Program.17 Additional MBSS assessments will be conducted in the watershed in 2003.

A corresponding narrative rating is associated with each IBI score generated from examining the numbers and kinds of aquaitic insects present in the stream sample. A "good" rating means that a stream is comparable with those streams identified by MBSS that are minimally impacted (reference streams). A "fair" rating means that a stream is somewhat degraded compared to the reference streams. "Poor" and "Very Poor" ratings correspond to degraded and severely degraded streams degraded respectively compared to the reference streams.

According to Stranko, et al, 2001, a large number of sampling sites (53%) were associated with minimally degraded conditions for fish or benthos indicating that human influences to the stream biota are likely to be minimal.[17]

Only two sites were rated as Poor for fish (3%), and 16 sites were rated Poor for benthos (28%).[17] The only site rated as "very poor" is located near Westminster that may reflect the impacts of stormwater runoff. Sites rated as "poor" are usually associated with both developed and agricultural areas. More detailed findings for each site is available via the Internet.[13]

Why Look at Benthos in Streams?

Benthos are sometimes called "stream bugs" though that name overly simplifies the diverse membership of this group. Unimpaired natural streams may support a great diversity of species ranging from bacteria and algae to invertebrates like crayfish and insects to fish, reptiles and mammals. Benthic macro-invertebrates, collectively called benthos, are an important component of a stream's ecosystem. This group includes mayflies, caddisflies, crayfish, etc. that inhabit the stream bottom, its sediments, organic debris and live on plant life (macrophytes) within the stream.

The food web in streams relies significantly on benthos. Benthos are often the most abundant source of food for fish and other small animals. Many benthic macroinvertebrates live on decomposing leaves and other organic materials in the stream. By this activity, these organisms are significant processors of organic materials in the stream. Benthos often provide the primary means that nutrients from organic debris are transformed to other biologically usable forms. These nutrients become available again and are transported downstream where other organisms use them.

Benthos are a valuable tool for stream evaluation. This group of species has been extensively evaluated for use in water quality assessment, in evaluating biological conditions of streams and in gauging influences on streams by surrounding lands. Benthos serve as good indicators of water resource integrity because they are fairly sedentary in nature and their diversity offers numerous ways to interpret conditions. They have different sensitivities to changing conditions. They have a wide range of functions in the stream. They use different life cycle strategies for survival.

Fish

1. Assessments by MBSS

The majority of stream segments assessed in the Liberty Reservoir watershed were rated as "good" or "fair" by the Maryland Biological Stream Survey (MBSS) in the middle 1990s and the Year 2000. Map 19 Fish In Nontidal Streams shows the sampling site locations. In general, a rating of good means that a diverse range of fish species were found at the site. Relatively few sites were rated as "poor" and none were "very poor". Also see detailed findings on the Internet.[13] Sites where brook trout were identified are highlighted on the map because these native fish only in high quality, cool water.

2. Fish Consumption Advisory

In late 2001, MDE issued revised fish consumption advisories. Based on fish tissue analyzed in 2000, the public is advised to limit consumption of several fish species from Liberty Reservoir because of potentially unhealthy levels of contaminates. The fish consumption advisories are especially important for children and women of child-bearing age who are or may become pregnant or are nursing. It is important to realize that mercury originates from atmospheric deposition from outside of the watershed; the watershed is not a source of this metal. In this index, Liberty Reservoir streams scored an average of 8.87 on a scale of 1 (worst) to 10 (best). Additional information is available at http://www.mde.state.md.us/fishadvisory/index.html

Liberty Reservoir Watershed - 2001 Advisory On Fish Consumption
Recommended Maximum Allowable Meals Per Month

Species	Area	General Population 8oz meal	Women 6oz meal	Children 3oz. meal	Contaminant
Black Crappie	Liberty Reservoir	8	4	4	PCBs, Pesticides
Common Carp	Liberty Res.	4	2	2	
Smallmouth & Largemouth Bass, Pickerel, Northern Pike, Walleye	Lakes and Impoundments	4	4	4	Methyl-mercury
	Rivers and Streams	no advisory	8	8	
Bluegill	Lakes and Impoundments	8	8	8	

Physical Habitat In Nontidal Streams

Overall, the habitat conditions in Liberty Reservoir watershed streams tend to be good or fair based on the available assessments by the Maryland Biological Stream Survey (MBSS) conducted in the middle 1990s and the Year 2000. As shown on Map 20 Physical Habitat Index, only one site in the watershed, near the rural community of Warfieldsburg, was rated as very poor. Five other sites were rated as poor. More detailed findings for each site is available via the Internet.[13]

According to Stranko, et al, 2001, "The relatively small amount of urbanization and abundance of physical habitat structure in most of the stream in this watershed were also indicative of minimal degradation." [17] The most common types of stream degradation encountered were stream bank erosion and insufficient, vegetated, riparian buffers.[17]

As also shown in Map 20, MBSS also found that most of the subwatersheds in the Liberty Reservoir watershed drain toward areas of stream habitat that was in good condition as the time of their field investigations. Watershed management in these areas will likely affect the viability of these habitat areas over time.[17]

Using the information in Maps 18, 19 and 20, it is possible to make general preliminary interpretations about local conditions in streams where sufficient information is available. For example, the maps show that Morgan Run has generally good physical habitat and fisheries populations that include brown trout. The presence of nature brown trout populations demonstrate that water in the local stream segment is high quality and cool year-round. The Morgan Run Natural Environment Area that encompasses some of these habitat areas may provide management that will protect existing good conditions.

In comparison to Morgan Run, the East Branch of the Patapsco River also tends to have good physical habitat and fisheries populations including brown trout. Both waterways have benthic populations that are generally rated as fair.

Sensitive Species

Sensitive species are most widely known in the form of Federally-listed Endangered or Threatened animals such as the bald eagle. In addition to these charismatic rare animals, both US EPA and Maryland DNR work through their respective Federal and State programs to protect numerous endangered, threatened, or rare species of plants and animals and the habitats that support those species.

For the purposes of watershed restoration, it is valuable to account for known locations of habitat for these species. These places are often indicators, and sometimes important constituents, of the network of natural areas or "green infrastructure" that are the foundation for many essential natural watershed processes. Protecting these species and/or promoting expansion of their habitats can be an effective foundation for a watershed restoration program.

DNR's Wildlife and Heritage Division uses three designations for areas providing habitat for sensitive species. These designations are described in the text box Maryland's Sensitive Species Protection Areas. As shown in Map 21 Sensitive Species, one of the three sensitive species designations are found in the Liberty Reservoir watershed. The purpose of these designations is to help protect sensitive species and their habitat through the review of applications for State permits or approvals, and review of projects that involve State funds. For the types of projects potentially described above, DNR makes recommendations and/or requirements to protect sensitive species and their habitat.

These categories do not place requirements on any activities that do not require a permit/approval or do not involve State funds. However, there are State and Federal restrictions that address "takings" of protected species that apply more broadly. In addition, many counties have incorporated safeguards for these areas into their project and permit review processes. In all instances, property owners are encouraged to seek advice on protecting the sensitive species / habitat within their ownership. More details and guidance can be requested from DNR Natural Heritage Division staff.

Sensitive Species Protection Areas In the Liberty Reservoir Watershed

Sensitive Species Project Review Area (SSPRA)

In Carroll County's portion of the Liberty Reservoir watershed, there at least three SSPRAs. In Baltimore County's portion of the watershed, there are at least two SSPRAs. Each SSPRA contains one or more sensitive species habitats. However, the entire SSPRA is not considered sensitive habitat. The SSPRA is an envelope identified for review purposes to help ensure that applications for permit or approval in or near sensitive areas receive adequate attention and safeguards for the sensitive species / habitat they contain. Also see Map 21 Sensitive Species.

Natural Heritage Area (NHA)

No NHAs are located in the Liberty Reservoir watershed. NHAs are rare ecological communities that encompass sensitive species habitat. They are designated in State regulation COMAR 08.03.08.10. For any proposed project that requires a State permit or approval that may affect an NHA, recommendations and/or requirements are placed in the permit or approval that are specifically aimed at protecting the NHA. To help ensure that proposed projects that may affect an NHA are adequately reviewed, an SSPRA is always designated to encompass each NHA and the area surrounding it.

Wetlands of Special State Concern (WSSC)

No WSSCs are located in the Liberty Reservoir watershed. WSSC wetlands are associated with one or more sensitive species habitats that are in or near the wetland. For any proposed project that requires a wetland permit, these selected wetlands have additional regulatory requirements beyond the permitting requirements that generally apply to wetlands. To help ensure that proposed projects that may affect a WSSC are adequately reviewed, an SSPRA is always designated to encompass each WSSC and the area surrounding it. For a listing of designated WSSC sites, see COMAR 26.23.06.01 at www.dsd.state.md.us

RESTORATION TARGETING TOOLS

2002 Stream Corridor Assessment

Using the Stream Corridor Assessment Methodology (SCAM) developed and applied by the DNR Watershed Restoration Division, valuable information can be compiled to assist in targeting restoration activities. This information will compliment existing watershed-related information and may explain cause and effect relationships between what is occurring in the watershed and how those activities are impacting the stream systems. Trained teams from the Maryland Conservation Corps will walk along streams to identify and document potential problems and restoration opportunities such as the items listed below: DNR will provide a report for County use.

Stream Corridor Assessment Data Collection Categories	
Pipe Outfalls	Fish Blockages
Pond Sites	Exposed Pipes
Tree Blockages	Unusual Conditions
Inadequate Buffers	Trash Dumping
Erosion	In or Near Stream Construction

The subwatersheds selected by Carroll County for assessment include Middle Run, Snowdens Run, and the West Branch of the Patapsco River. Stream corridor assessements were completed in summer 2002 for Middle and Snowdens Run watersheds. The assessment for the West Branch will be completed in October, 2002.

2002 Synoptic Survey and Benthic Community Assessment

Based on 2002 sampling in the Liberty Reservoir watershed, DNR staff will report on water quality in nontidal streams to supplement knowledge of local conditions. Based on parameters listed below, the survey findings will help identify problem areas and relative conditions among local streams. It will also help rank subwatersheds by their nutrient load contributions to the reservoir.

For the same 2002 sampling sites, DNR staff will also report on benthic organism populations in nontidal streams as a gauge of water quality and habitat conditions. DNR's report of 2002 findings will include assessment of water quality, benthic organism populations and the potential relationships that may be drawn from the 2002 data.

Synopic Survey Data Collection Parameters	
Dissolved Oxygen	Nutrients (nitrogen and phosphorus)
pH	Conductivity

Agricultural Conservation Programs

Carroll County has one of the highest levels of conservation participation in the state. Farmers in the county willingly implement management systems that address nutrient runoff and infiltration, erosion and sediment control, and animal waste utilization. The Carroll Soil Conservation District, one of the WRAS partners, works with farmers and landowners in the development of Soil Conservation and Water Quality plans that recommend best management practices that will prevent nutrient and sediment impact on surface and ground water. Some of the conservation practices installed were grassed waterways, riparian herbaceous and riparian forested buffers, conservation cover, cover crops, shallow water wildlife areas and grade stabilization structures. The Maryland Agricultural Cost-Share program (MACS), the Conservation Reserve Program (CRP and CREP) and the Environmental Quality Incentive Program (EQIP) are some of the state and federal programs promoted and administered by the Carroll SCD and NRCS. [28]

Farmers in the watershed who are already using good management practices that benefit water quality could provide examples to promote adoption of similar practices by other farmers. Also see the Agricultural BMPs section for a summary of existing BMPs in the Liberty Reservoir watershed.

Fish Blockage Removal

Many fish species need to move from one stream segment to the next in order to maintain healthy resilient populations. Blockages in streams can inhibit or prevent many fish species from moving up stream to otherwise viable habitat.

To help prioritize stream blockages for mitigation or removal, the DNR Fish Passage Program maintains a database of significant blockages to fish movement. A summary of blockages listed in the database for the Liberty Reservoir watershed appears in the table below and Map 19 Fish In Nontidal Streams. The listings in this database should be considered as supporting information for initiating a thorough Stream Corridor Assessment. Based on experience in other watersheds, it is likely that an assessment would identify additional potential fish blockage problems.

Some blockages to fish movement may be structural components of stream gauging weirs, farm ponds, drainage ditches, etc. If a blockage is found to be in this category, circumstances like requirements for drainage control function and public or land owner needs are considered in determining the potential for a restoration project.

Fish Blockages / Removal Opportunities in the Liberty Reservoir Watershed			
Station	**County**	**Stream**	**Name / Location**
PA004	Carroll	Cranberry Branch West Branch Patapsco	Gauging Weir, Gahle Road
PA27	Carroll	North Branch Patapsco River	Gauging Weir, unnamed road in Cedarhurst
PA028	Carroll	North Branch Patapsco River	100 yards upstream of unnamed road in Cedarhurst

Stream Buffer Restoration

1. Benefits and General Recommendations

Natural vegetation in stream riparian zones act as stream buffers that can provide numerous valuable environmental benefits:

– Reducing surface runoff
– Preventing erosion and sediment movement
– Using nutrients for vegetative growth and moderating nutrient entry into the stream
– Moderating temperature, particularly reducing warm season water temperature
– Providing organic material (decomposing leaves) that are the foundation of natural food webs in stream systems
– Providing overhead and in-stream cover and habitat
– Promoting high quality aquatic habitat and diverse populations of aquatic species.

2. Using GIS

Identifying the areas that need buffer restoration and prioritizing them for action can be a time-consuming expensive project. Fortunately, use of a computerized Geographic Information System (GIS) to manipulate remote sensing data can help save limited time and funds. To assist in this technical endeavor, DNR Watershed Management and Analysis Division is offering assistance, including GIS work, to help target restoration of naturally vegetated stream buffers, wetlands and other watershed management projects that may be identified locally. With these tools, information generated by a Stream Corridor Assessment and additional on-the-ground verification or "ground truthing," local government may more efficiently and confidently consider stream buffer restoration as part of a local Watershed Restoration Action Strategy.

Several scenarios are presented here to help consider potential areas for stream buffer and wetland restoration. These scenarios can be used alone or in combination as models for targeting potential restoration sites for field verification. These maps are intended to demonstrate a methodology that can be used to locate sites having a high probability of optimizing certain ecological benefits of stream buffers. The resolution of the data used to generate these maps is not sufficient for an accurate site assessment, but can be used to identify potential candidate sites for more detailed investigation. The streams presented in the maps are perennial (blue line) streams as generally shown on US Geological Survey Quadrangle Maps. Intermittent streams were not considered in the stream buffer scenario maps.

3. Headwater Stream Buffers

Headwater streams are the smallest and most numerous in Maryland watersheds and unlike larger streams (they intercept all of the surface runoff within the watersheds that they drain. Also, these streams at the "top" of the watershed are the type and size that are most effected by development. In addition, for many watersheds, headwater streams drain the majority of the land within the entire watershed; therefore, stream buffers restored along headwater streams tend to have greater potential to intercept nutrients and sediments than stream buffers placed elsewhere. The

nutrient removal function of headwater streams buffers with their associated springheads provides water supply benefits. In targeting stream buffer restoration projects, giving higher priority to headwater streams is one approach to optimizing nutrient and sediment retention.

Restoring headwater stream buffers can also provide habitat benefits that can extend downstream of the project area. Forested headwater streams provide important organic material, like decomposing leaves, that "feed" the stream's food web. They also introduce woody debris which enhances in-stream physical habitat. The potential for riparian forest buffers to significantly influence stream temperature is greatest in headwater regions. These factors, in addition to positive water quality effects, are key to improving aquatic habitat.

4. Land Use and Stream Buffers

One factor that affects the ability of stream buffers to intercept nonpoint source pollutants is adjacent land use. Nutrient and sediment loads from different land uses can vary significantly. The loading rates shown in the table here were calculated for the Lower Potomac River Tributary Basin from the model of the Chesapeake Bay Watershed Model.

Annual Nonpoint Source Pollution Load Rates By Land Use Chesapeake Bay Watershed Model (2000)

Land Use	Nitrogen (lbs/ac)	Phosphorus (lbs/ac)	Sediment (tons/ac)
Crop land	17.11	1.21	0.74
Urban	7.5	0.7	0.09
Pasture	8.40	1.15	0.30
Forest	1.42	0.00	0.03

In general, restoration of stream buffers has been an agricultural Best Management Practice (BMP), with less applicability in urban areas. By identifying land uses in riparian areas with inadequate stream buffers, like crop land adjacent to streams, the potential to reduce nutrient and sediment loads can be improved. To assist in finding areas with crop land adjacent to streams, the same land use data shown in Map 12 Generalized 2000 Land Use / Land Cover can be filtered using GIS. The new scenario shown in the Land Use Scenario for Stream Buffer Restoration focuses on the land use within 150 feet of a stream as shown in Map 22A and Map 22B. This view, supplemented with the land use pollution loading rates, suggests potential buffer restoration opportunities that could minimize nutrient and sediment loads. (Note: DNR is encouraging stream buffers 150 feet wide on each side of the stream, which is significantly greater than minimum buffer requirement, to enhance nutrient and habitat benefits beyond minimum buffer requirements.)

5. Nutrient Uptake from Hydric Soils in Stream Buffers

In general, the nutrient nitrogen moves from the land into streams in surface water runoff and in groundwater. In watersheds like the Liberty Reservoir watershed, a significant percentage of nitrogen enters streams in groundwater. Stream buffers can be used to capture nitrogen moving in groundwater if buffer restoration projects have several key attributes:
– Plant with roots deep enough to intercept groundwater as it moves toward the stream
– Plants with high nitrogen uptake capability, and
– Targeting buffer restoration projects to maximize groundwater interception by buffer plants.

Hydric soils in stream riparian areas can be used as one factor to help select stream buffer restoration sites. Siting buffer restoration on hydric soils would offer several benefits:
– Plant roots are more likely to be in contact with groundwater for longer periods of time
– Hydric soils tend to be marginal for many agricultural and urban land uses
– Natural vegetation in wet areas often offers greater potential for habitat.

Map 23 Stream Buffer Hydric Soil On Open Land Scenario identifies lands adjacent to streams that are composed of hydric soil and also have insufficient stream buffers in the Liberty Reservoir watershed. An important next step in using this information is verification of field conditions. Care must be taken during field validation to evaluate any hydrologic modification of these soils, like subsurface drains, which would serve to decrease potential benefits.

6. Optimizing Water Quality Benefits by Combining Priorities

Strategic targeting of stream buffer restoration projects may promote many different potential benefits. To maximize multiple benefits, site selection and project design need to incorporate numerous factors. For example, finding a site with a mix of attributes like those in the following list could result in the greatest control of nonpoint source pollution and enhancement to living resources:

– land owner willingness / incentives
– marginal land use in the riparian zone
– headwater stream
– hydric soils
– selecting appropriate woody/grass species
– adjacent to existing wetlands / habitat

Additionally, selecting restoration projects that are likely to produce measurable success is an important consideration in prioritizing projects for implementation. In the early stages of a watershed restoration program, measurable water quality improvement can be one of the strongest ways to demonstrate project success.

In general, targeting restoration projects to one or a few selected tributaries or small watersheds will tend to offer the greatest probability of producing measurable water quality improvement. By selecting small areas like a small first order stream for restoration, there is greater likelihood that water quality problems arise locally and that they can be corrected by limited investment in carefully selected local restoration projects.

Wetland Restoration

Wetlands serve important environmental functions such as erosion control, habitat and nursery areas for many organisms and nutrient uptake/recycling. However, most watersheds in Maryland have significantly fewer wetland acres today than in the past. This loss due to draining, filling, etc. has led to habitat loss and negative water quality impacts in streams and in the Chesapeake Bay. Reversing this historic trend is an important goal of wetland restoration. One approach to identifying candidate wetland restoration sites involves using GIS to identify open land and "historic" wetland areas based on the presence of hydric soils.

For the Liberty Reservoir watershed, Map 24 Hydric Soils Near Wetlands shows where nonwetland hydric soils are near wetlands identified in the DNR wetland GIS data. These areas are more likely to offer conditions for wetland restoration than upland sites that do not have hydric soil. The steps used to generate the map are listed below and findings are summarized in the table below:

– Data used: Hydric soils (Natural Soil Groups), existing wetlands (DNR Wetlands covering Carroll County, NWI wetlands covering Baltimore County), land use (Md. Dept. of Planning 2000).
– Identify candidate hydric soil areas based on land use. Hydric soils on open land including farm fields, bare ground, etc. Hydric soils underlying natural vegetation and developed lands were excluded but opportunities on developed lands could be considered in other scenarios.
– Explore hydric soils based on public land ownership and proximity to existing wetlands.

Open Lands on Hydric Soil Near Wetlands In Selected Subwatersheds
Morgan Run - About 17 acres total with 5 acres within 100 feet of existing wetlands. Some of these opportunities may be on the Morgan Run NEA and the remainder are on adjacent private lands
Little Morgan Run #1 - About 9 acres total with 2 acres within 100 feet of existing wetlands.
Little Morgan Run #2 - About 135 acres total with 44 acres within 100 feet of existing wetlands.
Middle Run - About 170 acres total with 64 acres within 100 feet of existing wetlands.

CURRENT AND HISTORICAL RESTORATION PROJECTS

Overview

There are numerous projects and programs that have the potential to contribute to successful development and implementation of a Watershed Restoration Action Strategy (WRAS). The listing included here suggests opportunities for cooperation and coordination that can improve the likelihood of success for the WRAS. This listing is not all-inclusive. It is recommended that this list be augmented as new information becomes available and that follow-up should continue to promote the WRAS process with these and other projects and programs.

319(h)-Funded Projects

Within the watershed, Carroll County has participated in three 319-funded projects. The first two involved stream channel restoration efforts along Linton Road and adjacent to the Hodges Landfill. The third project, a much larger effort, examined watershed restoration opportunities within the Longwell Branch Watershed in the City of Westminster. A number of projects were completed including the creation of several stormwater management facilities for previously developed land, improvements to an older stormwater management pond, and another stream channel restoration. Currently, MBSS is assisting the county with post-implementation monitoring to see what improvements have occurred with respect to the stream channel restoration and how quickly the improvements are detected.

Other Projects

Currently, the two stormwater management dry ponds at Liberty High School in Eldersburg are being reconstructed to provide much greater water quality benefits. A large amount of stream channel erosion has occurred in the past and the improvements will greatly reduce the stream flows to the receiving stream.

POTENTIAL BENCHMARKS FOR WRAS GOAL SETTING

Several programs designed to manage water quality and/or living resources have existing or proposed goals that are relevant to setting goals for the Liberty Reservoir Watershed Restoration Action Strategy (WRAS). The goals from these other programs tend to overlap and run parallel to potential interests for developing WRAS goals. Therefore, to assist in WRAS development, selected goals from other programs are included here as points of reference.

Chesapeake 2000 Agreement

The Chesapeake 2000 Agreement (C2K) includes several significant commitments pertaining to local watershed management planning and implementation. The goal in the C2K Agreement that is directly related to the development of watershed management plans and action strategies is "By 2010, work with local governments, community watershed groups and watershed organizations to develop and implement locally supported watershed management plans in two-thirds of the Bay watershed covered by this Agreement. These plans would address the protection, conservation and restoration of stream corridors, riparian buffers and wetlands for the purposes of improving habitat and water quality, with the collateral benefits for optimizing flow and water supply."

Four common elements of watershed management planning were adopted by the Chesapeake Bay Program member jurisdictions to be applied Bay-wide. Those elements support the WRAS components which were also identified as common Bay-wide criteria for watershed management planning. The four approved C2K Agreement watershed planning elements are as follows:

1. Does the plan "address the protection, conservation and restoration of stream corridors, riparian forest buffers and wetlands?" Each watershed management plan needs to be based on site-specific assessments of natural resources within the watershed. At a minimum, the assessment will evaluate the condition of stream corridors, riparian buffers and wetlands within the watershed.

2. Does the plan reflect the goals and objectives of "improving habitat and water quality?" The plan should reflect the issues that the stakeholders feel are important, and, at a minimum, exhibit a benefit to habitat and water quality within the watershed.
   The goals should be based on priority issues identified by the watershed assessment.

3. Chesapeake 2000 Watershed Commitments (CWiC) Criteria #3-- Does the plan identify implementation mechanisms?
   Capacity to implement the plan will be demonstrated by identifying:
   - What are the specific management actions?
   - What are the resources necessary for implementation?
   - Who will implement the plan?
   - When will the actions be implemented?

The implementation mechanisms should also incorporate a periodic re-evaluation to ensure the plan is "living" and flexible to the changes in the watershed.

4. Does the plan have demonstrated local support? Every effort should be made to demonstrate a diversity of local support. At a minimum, local governments, community groups and watershed organizations should be encouraged to participate in developing and implementing the watershed management plan.

Goals from the *Clean Water Action Plan* [2]:

– Clean Water Goals - Maryland watersheds should meet water quality standards, including numerical criteria as well as narrative standards and designated uses.

– Watersheds should achieve healthy conditions as indicated by natural resource indicators related to the condition of the water itself (e.g. water chemistry), aquatic living resources and physical habitat, as well as landscape factors (e.g. buffered streams and wetland restoration).

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GLOSSARY

303(d)	A section of the federal Clean Water Act requiring the states to report which waters of the state are considered impaired for the uses for which they have been designated, and the reasons for the impairment. Waters included in the "303(d) list" are candidates for having TMDLs developed for them.
319	A section of the federal Clean Water Act dealing with non-point sources of pollution. The number is often used alone as either a noun or an adjective to refer to some aspect of that section of the law, such as grants.
8-digit watershed	Maryland has divided the state into 138 watersheds, each comprising an average of about 75 square miles, that are known as 8-digit watersheds because there are 8 numbers in the identification number each has been given. These nest into the 21 larger 6-digit watersheds in Maryland which are also called Tributary Basins or River Basins. Within the Chesapeake Bay drainage, 8-digit watersheds also nest into 10 Tributary Team Basins.
Anadromous fish	Fish that live most of their lives in salt water but migrate upstream into fresh water to spawn.
Benthic	Living on the bottom of a body of water.
CBIG	Chesapeake Bay Implementation Grant Program, a DNR-administered program that awards grants from the Chesapeake Bay Program to reduce and prevent pollution and to improve the living resources in the Chesapeake Bay.
CBNERR	The Chesapeake Bay National Estuarine Research Reserve in a federal, state and local partnership to protect valuable estuarine habitats for research, monitoring and education. The Maryland Reserve has three components: Jug Bay on the Patuxent River in Anne Arundel and Prince Georges' Counties, Otter Point Creek in Harford County and Monie Bay in Somerset County.
CCWS	Chesapeake and Coastal Watershed Service, the unit in DNR that works with local governments and other interested parties to develop restoration strategies and projects.

COMAR	Code Of Maryland Regulations (Maryland State regulations)
CREP	Conservation Reserve Enhancement Program, a program of MDA. CREP is a federal/state and private partnership which reimburses farmers at above normal rental rates for establishing riparian forest or grass buffers, planting permanent cover on sensitive agricultural lands and restoring wetlands for the health of the Chesapeake Bay.
CRP	Conservation Reserve Program, a program of Farm Service Agency in cooperation with local Soil Conservation Districts. CRP encourages farmers to take highly erodible and other environmentally-sensitive farm land out of production for ten to fifteen years.
CWAP	Clean Water Action Plan, promulgated by EPA in 1998. It mandates a statewide assessment of watershed conditions and provides for development of Watershed Restoration Action Strategies (WRASs) for priority watersheds deemed in need of restoration
CWiC	Chesapeake 2000 Agreement watershed commitments. CWiC is a shorthand phrase used in the Chesapeake Bay Program.
CZARA	The Coastal Zone Reauthorization Amendments of 1990, intended to address coastal non-point source pollution. Section 6217 of CZARA established that each state with an approved Coastal Zone Management program must develop and submit a Coastal Non-Point Source program for joint EPA/NOAA approval in order to "develop and implement management measures for NPS pollution to restore and protect coastal waters".
CZMA	Coastal Zone Management Act of 1972, establishing a program for states and territories to voluntarily develop comprehensive programs to protect and manage coastal resources (including the Great Lakes). Federal funding is available to states with approved programs.
Conservation Easement	A legal document recorded in the local land records office that specifies conditions and/or restrictions on the use of and title to a parcel of land. Conservation easements run with the title of the land and typically restrict development and protect natural attributes of the parcel. Easements may stay in effect for a specified period of time, or they may run into perpetuity.

DNR	Department of Natural Resources (Maryland State)
EPA	Environmental Protection Agency (United States)
Fish blockage	An impediment, usually man-made, to the migration of fish in a stream, such as a dam or weir, or a culvert or other structure in the stream
GIS	Geographic Information System, a computerized method of capturing, storing, analyzing, manipulating and presenting geographical data.
MBSS	Maryland Biological Stream Survey, a program in DNR that samples small streams throughout the state to assess the condition of their living resources.
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MET	Maryland Environmental Trust, an organization that holds conservation easements on private lands and assists local land trusts to do similar land protection work.
MGS	Maryland Geological Survey, a division in DNR.
NHA	Natural Heritage Area, a particular type of DNR land holding, designated in COMAR.
NOAA	National Oceanic and Atmospheric Administration, an agency of the US Department of Commerce that, among other things, supports the Coastal Zone Management program, a source of funding for some local environmental activities, including restoration work.
NPS	Non-Point Source, pollution that originates in the landscape that is not collected and discharged through an identifiable outlet.
NRCS	Natural Resources Conservation Service, formerly the Soil Conservation Service, an agency of the US Department of Agriculture that, through local Soil Conservation Districts, provides technical

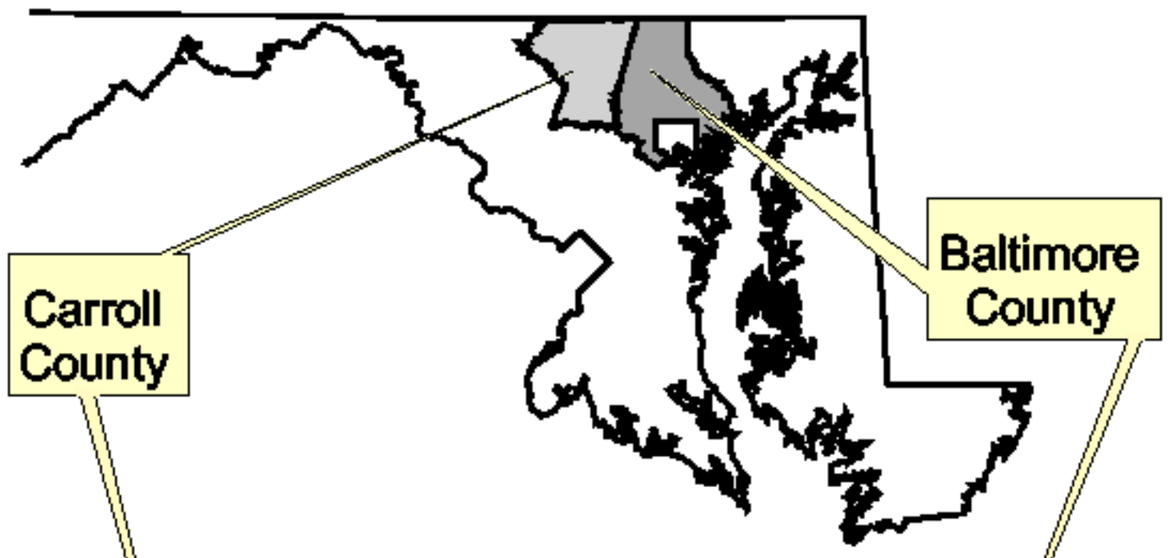
	assistance to help farmers develop conservation systems suited to their land. NRCS participates as a partner in other community-based resource protection and restoration efforts.
PDA	Public Drainage Association
Palustrine Wetlands	Fresh water wetlands, including bogs, marshes and shallow ponds.
RAS	Resource Assessment Service, a unit of DNR that carries out a range of monitoring and assessment activities affecting the aquatic environment.
Riparian Area	1. Land adjacent to a stream. 2. Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e. a zone of influence). Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes, and estuarine-marine shorelines. (National Research Council, *Riparian Areas: Functions and Strategies for Management*. Executive Summary page 3. 2002)
SAV	Submerged Aquatic Vegetation, important shallow-water sea grasses that serve as a source of food and shelter for many species of fin- and shell-fish.
SCA[M]	Stream Corridor Assessment is an activity carried out by CCWS in support of WRAS development and other management needs, in which trained personnel walk up stream channels noting important physical features and possible sources of problems.
SCD	Soil Conservation District is a county-based, self-governing body whose purpose is to provide technical assistance and advice to farmers and landowners on the installation of soil conservation practices and the management of farmland to prevent erosion.
SSPRA	Sensitive Species Protection Review Area, an imprecisely defined area in which DNR has identified the occurrence of rare, threatened and/or endangered species of plants or animals, or of other important

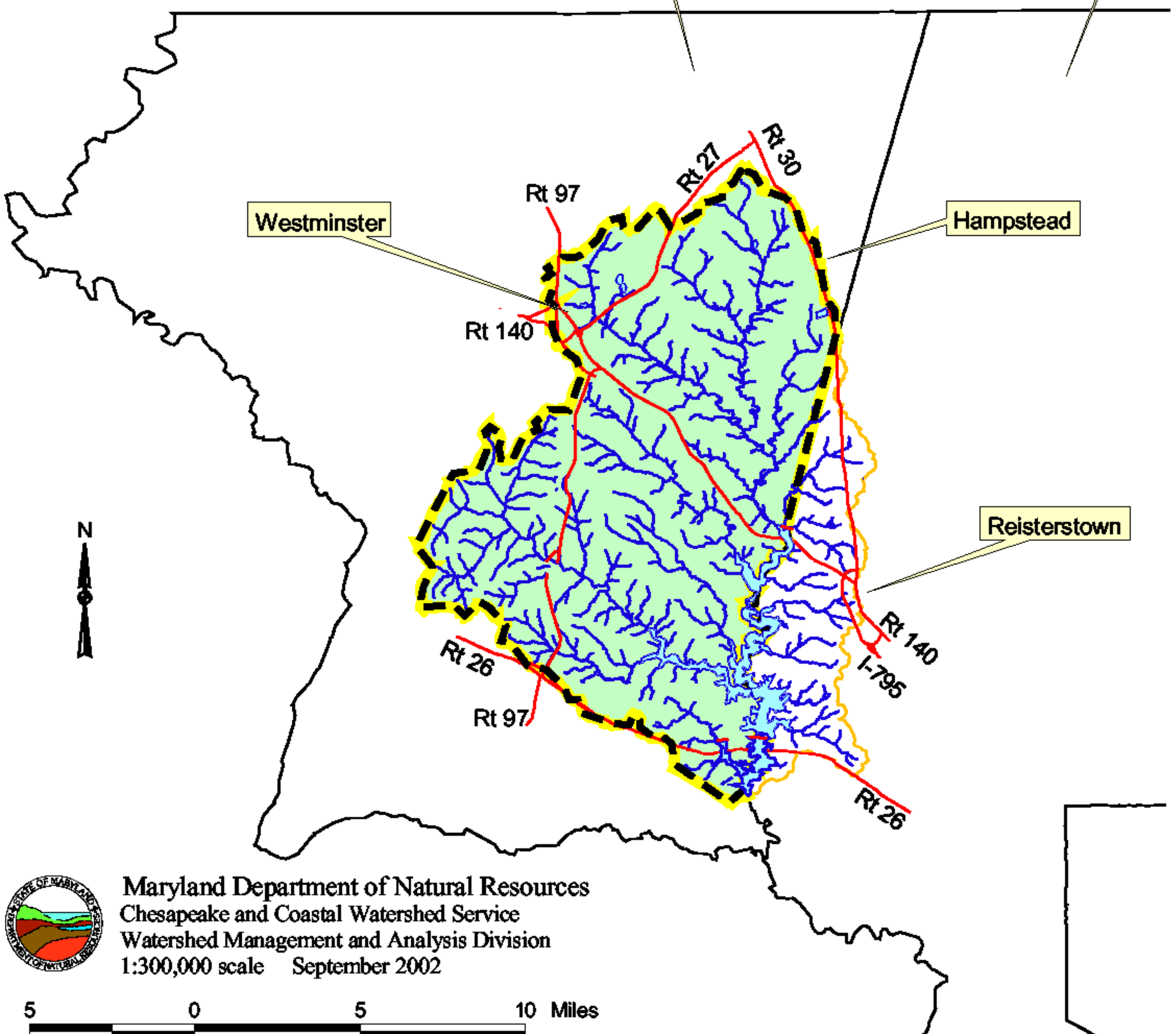
	natural resources such as rookeries and waterfowl staging areas.
Synoptic survey	A short term sampling of water quality and analysis of those samples to measure selected water quality parameters. A synoptic survey as performed by DNR in support of watershed planning may be expanded to include additional types of assessment like benthic macroinvertibrate sampling or physical habitat assessment.
TMDL	Total Maximum Daily Load, a determination by MDE of the upper limit of one or more pollutants that can be added to a particular body of water beyond which water quality would be deemed impaired.
Tributary Teams	Geographically-focused groups, appointed by the Governor, oriented to each of the 10 major Chesapeake Bay tributary basins found in Maryland. The teams focus on policy, legislation, hands-on implementation of projects, and public education. Each basin has a plan, or Tributary Strategy.
USFWS	United States Fish and Wildlife Service, an agency of the Department of Interior.
USGS	United States Geological Survey
Water Quality Standard	Surface water quality standards consist of two parts: (a) designated uses of each water body; and (b) water quality criteria necessary to support the designated uses. Designated uses of for all surface waters in Maryland (like shell fish harvesting or public water supply) are defined in regulation. Water quality criteria may be qualitative (like "no objectionable odors") or quantitative (toxic limitations or dissolved oxygen requirements).
Watershed	All the land that drains to an identified body of water or point on a stream.
WRAS	Watershed Restoration Action Strategy, a document outlining the condition of a designated watershed, identifying problems and commiting to solutions of prioritized problems.
WSSC	Wetland of Special State Concern, a designation by MDE in COMAR.

Map 1 WRAS Project Area
Liberty Reservoir Watershed
Carroll and Baltimore Counties, Maryland

Key

- WRAS Project Area
- Liberty Reservoir watershed, including watershed area inside and outside the WRAS project area
- County boundaries
- Water, streams and shoreline
- Highways

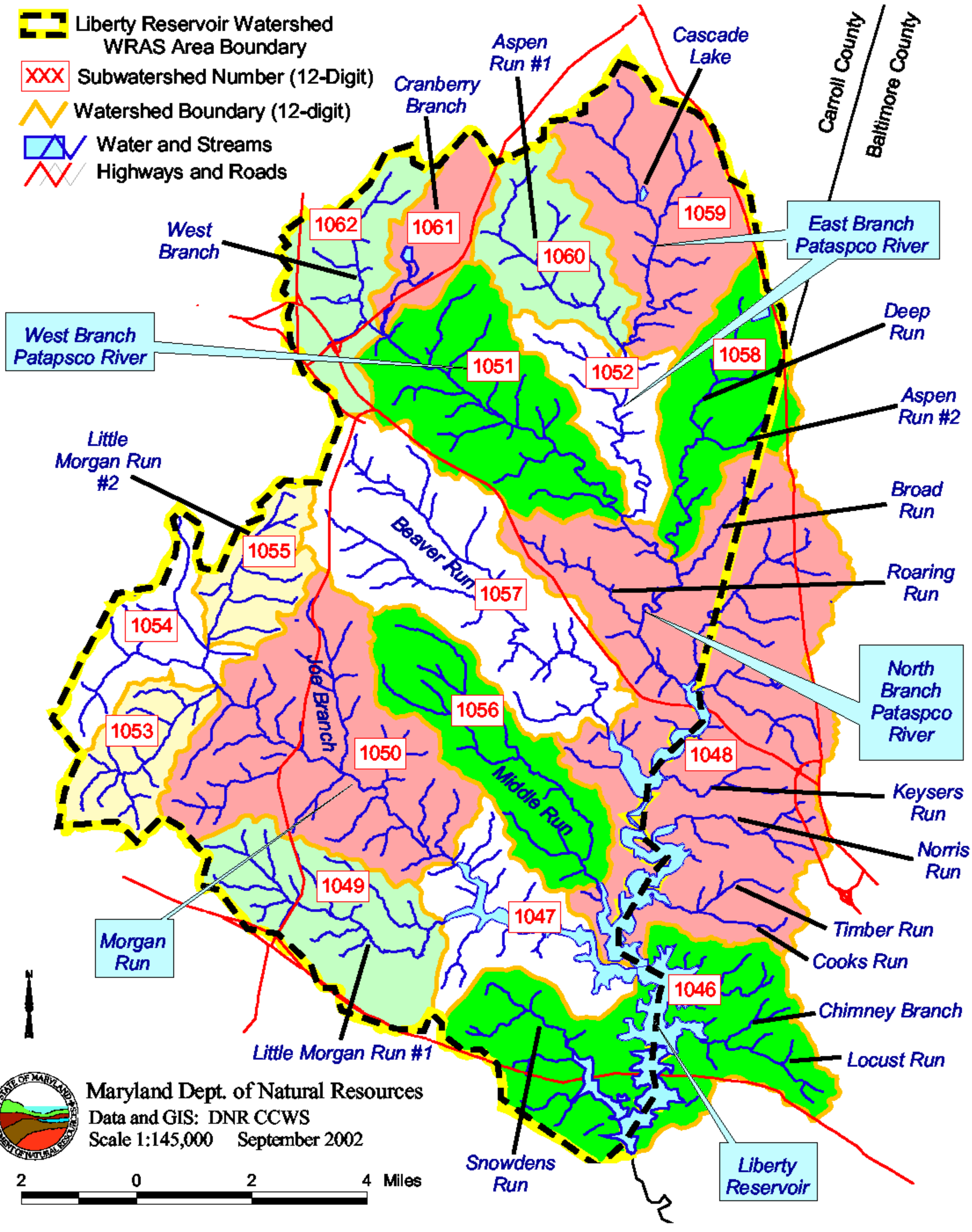




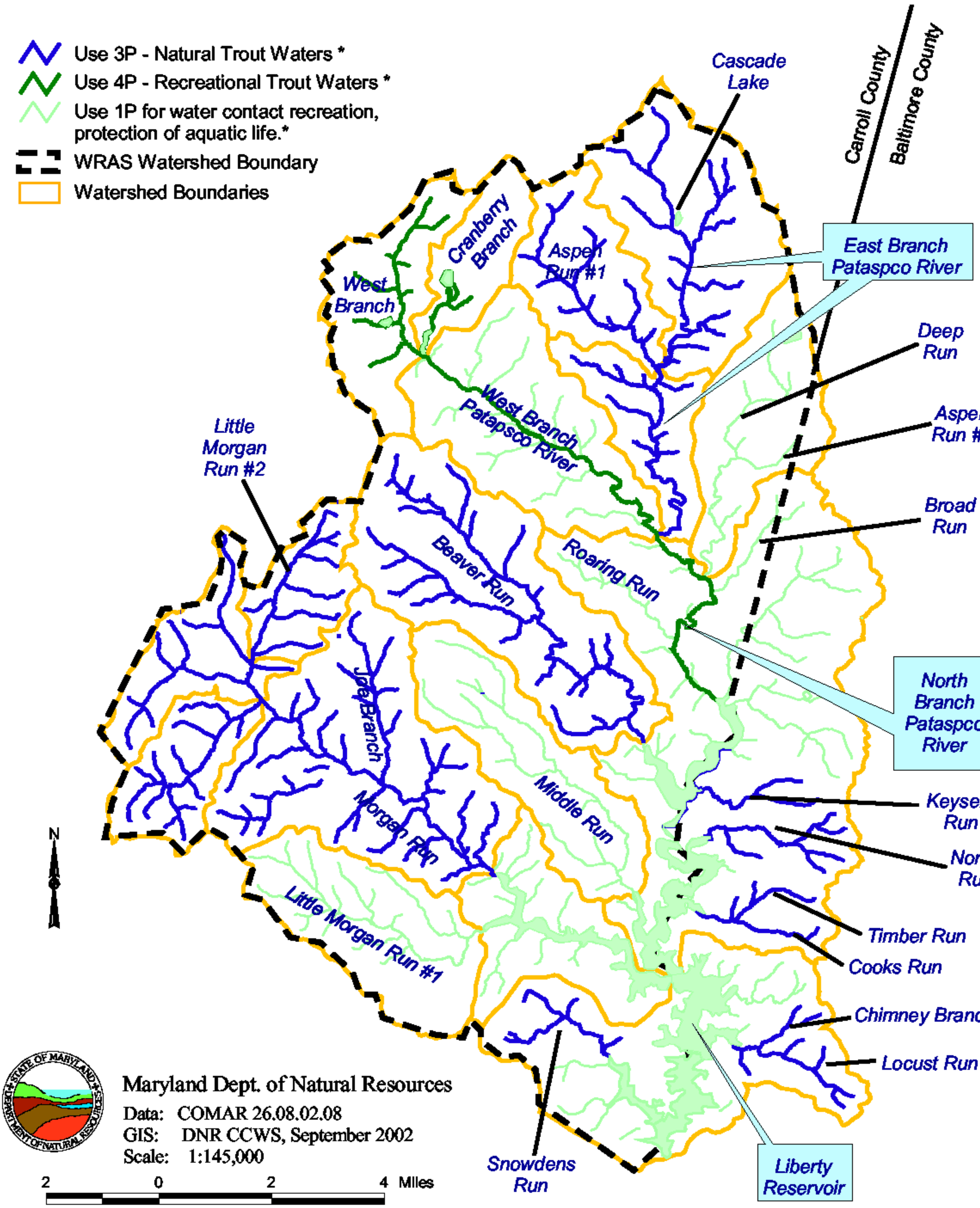
Maryland Department of Natural Resources
Chesapeake and Coastal Watershed Service
Watershed Management and Analysis Division
1:300,000 scale September 2002

5 0 5 10 Miles

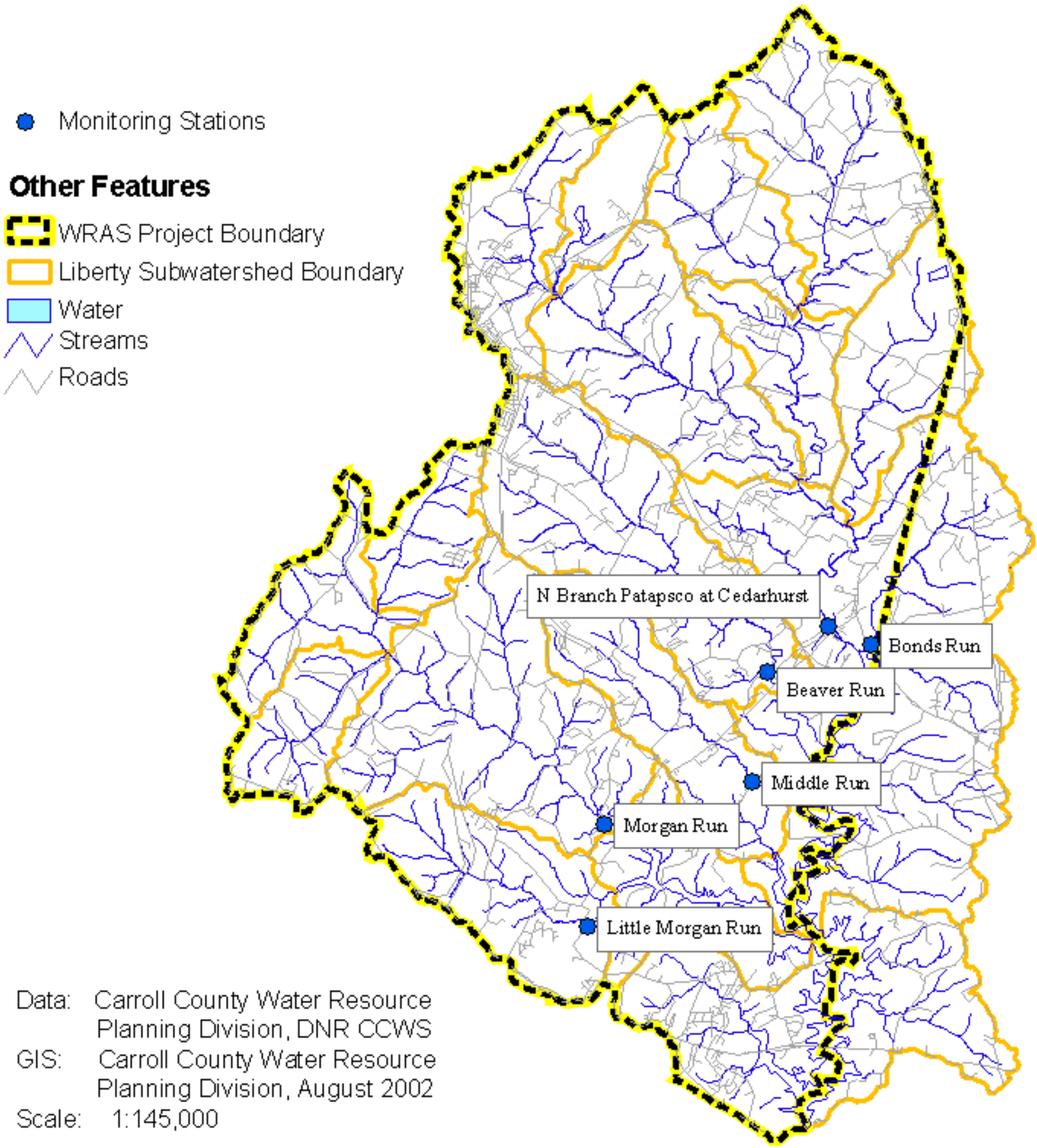
Map 2 Streams and Subwatersheds
Liberty Reservoir Watershed 02130907



Map 3 Designated Uses
Liberty Reservoir Watershed



Map 4 City of Baltimore Water Quality Monitoring Stations Liberty Reservoir Watershed



Data: Carroll County Water Resource Planning Division, DNR CCWS

GIS: Carroll County Water Resource Planning Division, August 2002

Scale: 1:145,000

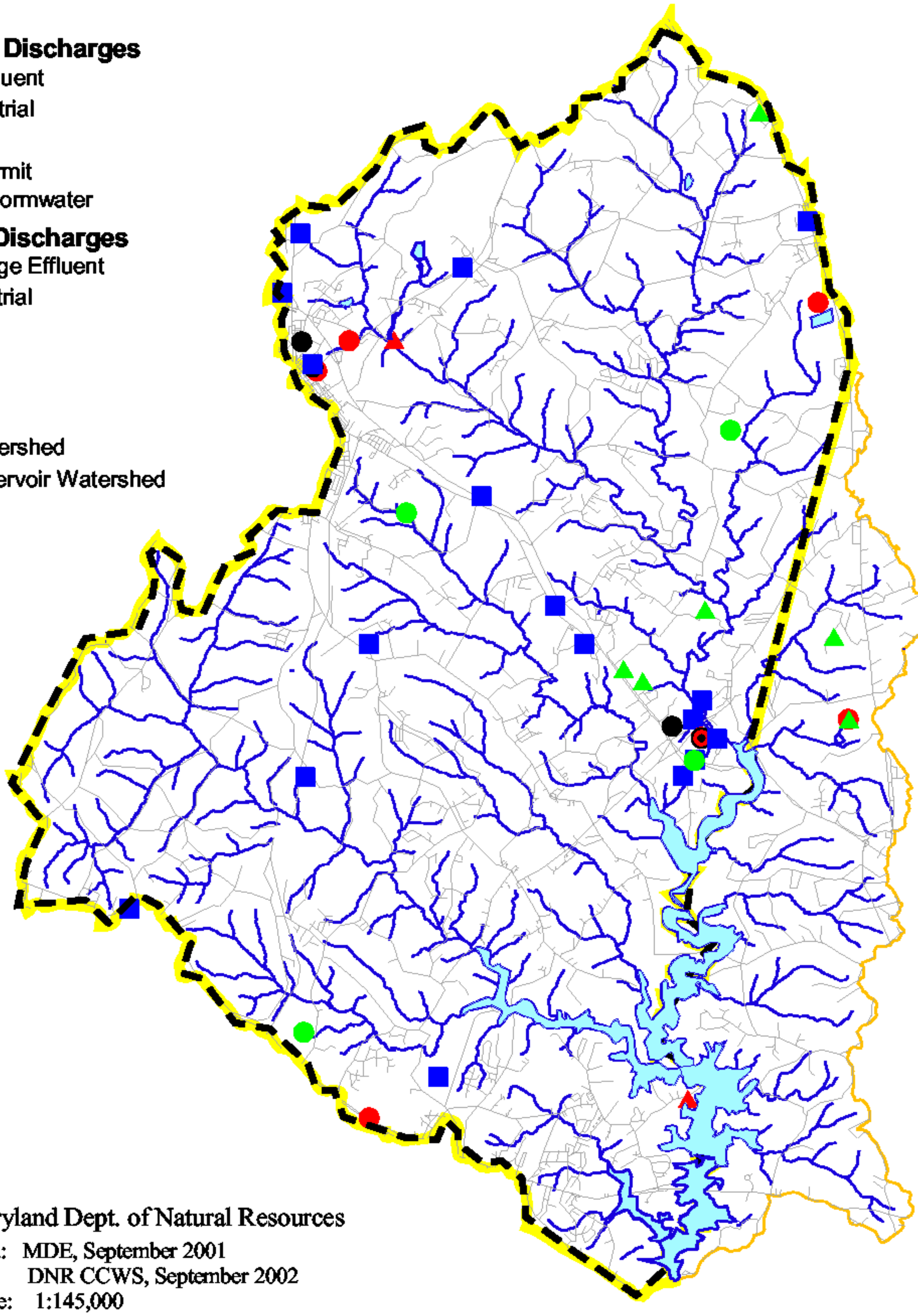
2 0 2 4 Miles

Map 5 MDE Permits
Liberty Reservoir Watershed

Surface Water Discharges
- Sewage Effluent
- Major Industrial
- Industrial
- General Permit
- Industrial Stormwater

Groundwater Discharges
- GW - Sewage Effluent
- GW - Industrial

- Streams
- Roads
- Water
- WRAS Watershed
- Liberty Reservoir Watershed



Maryland Dept. of Natural Resources
Data: MDE, September 2001
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 6 Water Supply
Liberty Reservoir Watershed

Surface Water
- Baltimore City
- Freedom District
- Westminster

Groundwater
- Chapel Hill Nursing Center
- Hampstead
- Manchester
- Westminster
- Mobile Home Community
  - 1- Hillandale
  - 2- Lakeview Village
  - 3- Reservoir
  - 4- Sullivan's
  - 5- Taylorville
  - 6- Todd Village
- Well Head Protection Area
- WRAS Project Area
- Watershed Boundary (12-digit)
- Streams
- Highways

Manchester
Hampstead
Westminster
④
⑯
③
⑤
②
Liberty Reservoir

N

Maryland Dept. of Natural Resources
Data: MDE Water Supply Division, March 2002
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 7 Geology
Liberty Reservoir Watershed

Geological Formation
Ranked By Area (Greatest Area First)

- Wissahickon Formation
- Lower Pelitic Schist
- Sams Creek Metabasalt
- Ultramafic Rocks
- Boulder Gneiss
- Marburg Schist
- Wakefield Marble
- Baltimore Gabbro Complex
- Ijamsville Formation

Other Features

- WRAS Project Boundary
- 02130907_12digit.shp
- Water
- Streams
- Highway
- Roads

N

Maryland Dept. of Natural Resources
Data: DNR Maryland Geological Survey
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 8 Soils by Natural Soil Group
Liberty Reservoir Watershed

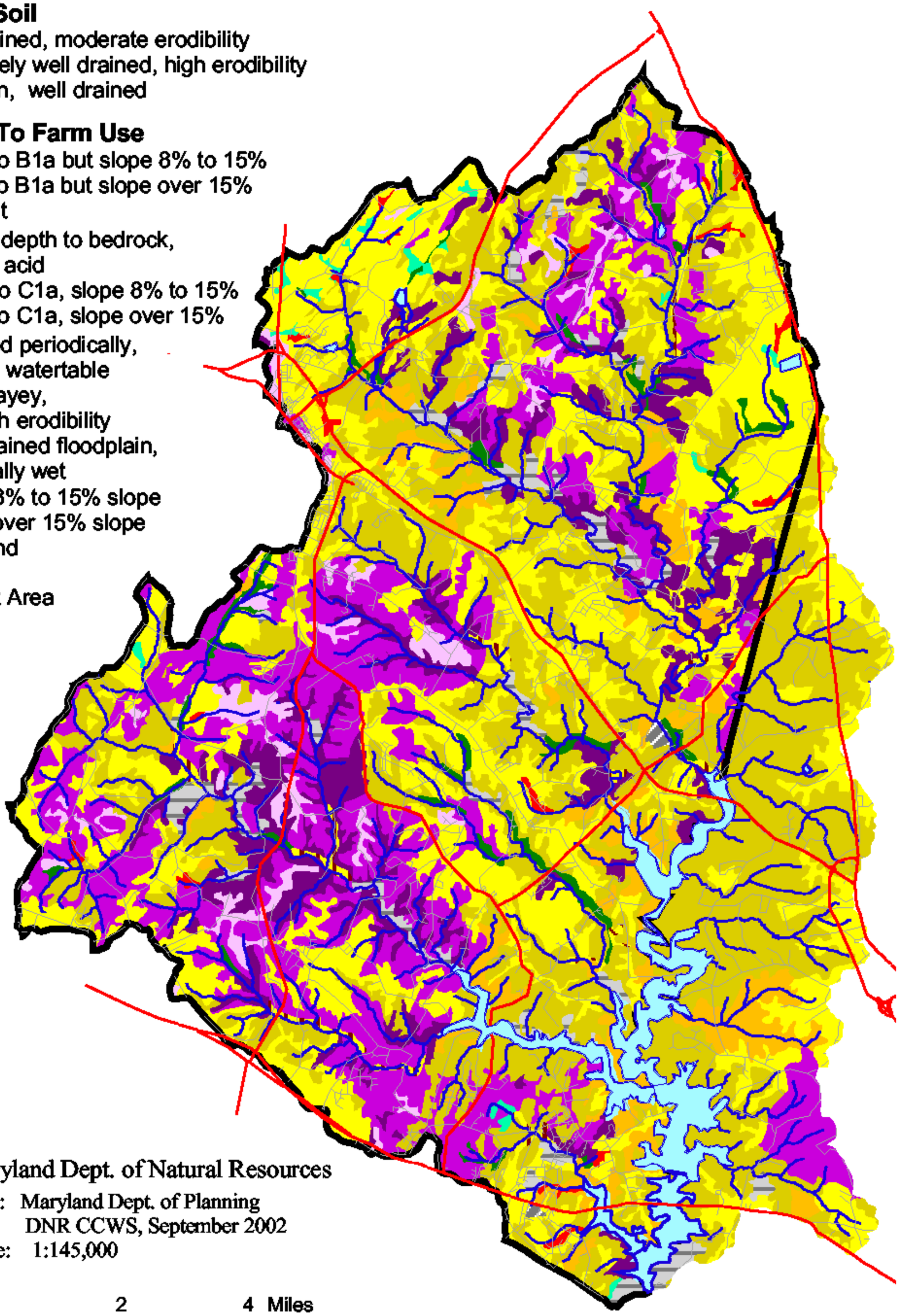
Prime Farmland Soil

- B1a - Well drained, moderate erodibility
- E3a - Moderately well drained, high erodibility
- G1 - Floodplain, well drained

Soil Less Suited To Farm Use

- B1b - Similar to B1a but slope 8% to 15%
- B1c - Similar to B1a but slope over 15%
- BP - Borrow pit
- C1a - Shallow depth to bedrock, strongly acid
- C1b - Similar to C1a, slope 8% to 15%
- C1c - Similar to C1a, slope over 15%
- E2a - Saturated periodically, perched watertable
- F3 - Hydric, clayey, very high erodibility
- G2 - Poorly drained floodplain, seasonally wet
- H1b - Stoney 8% to 15% slope
- H1c - Stoney over 15% slope
- Ma - Made Land

- WRAS Project Area
- Water
- Streams
- Highways
- Roads

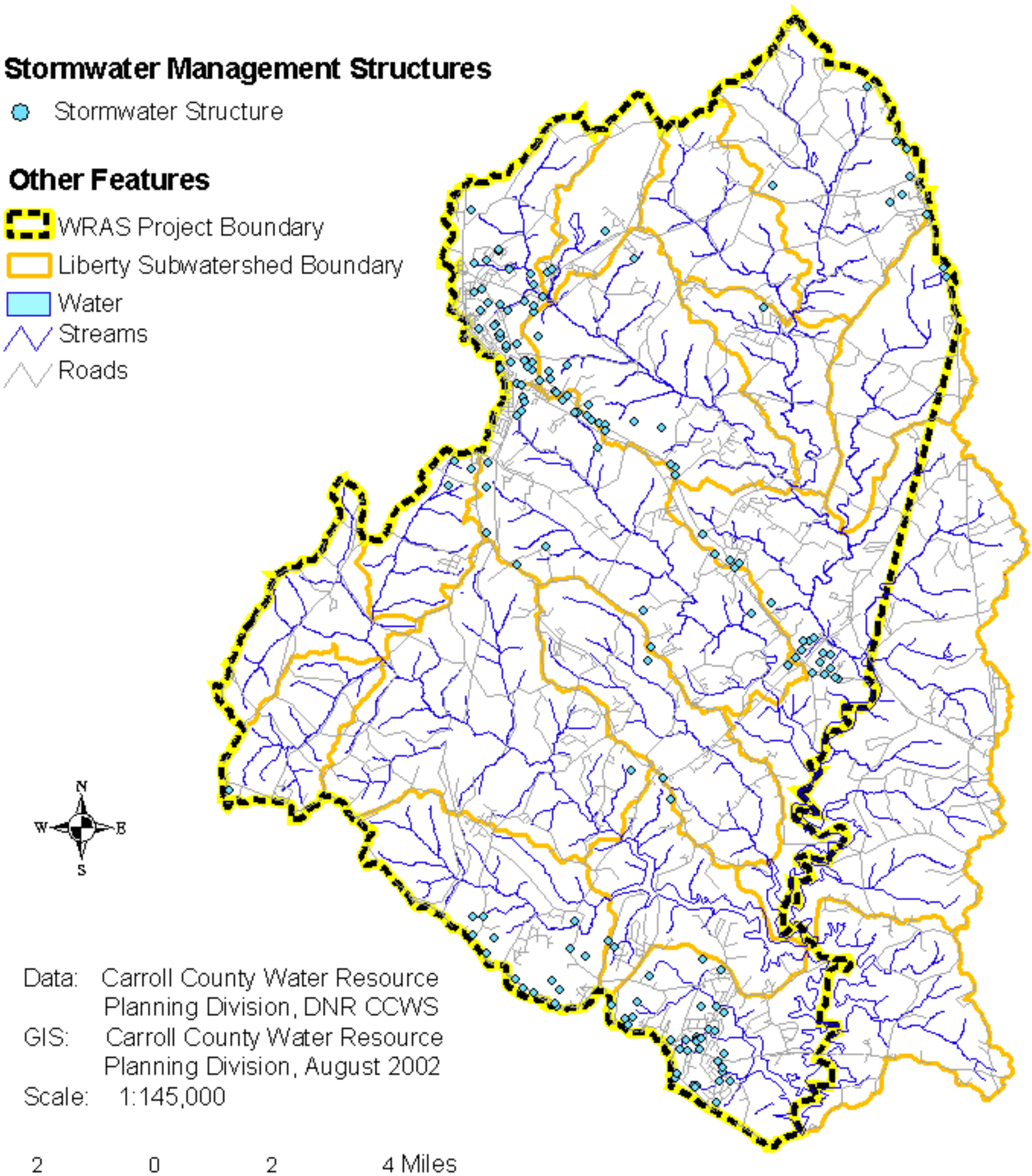


Maryland Dept. of Natural Resources

Data: Maryland Dept. of Planning
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 9 Stormwater Management Structures
Liberty Reservoir Watershed



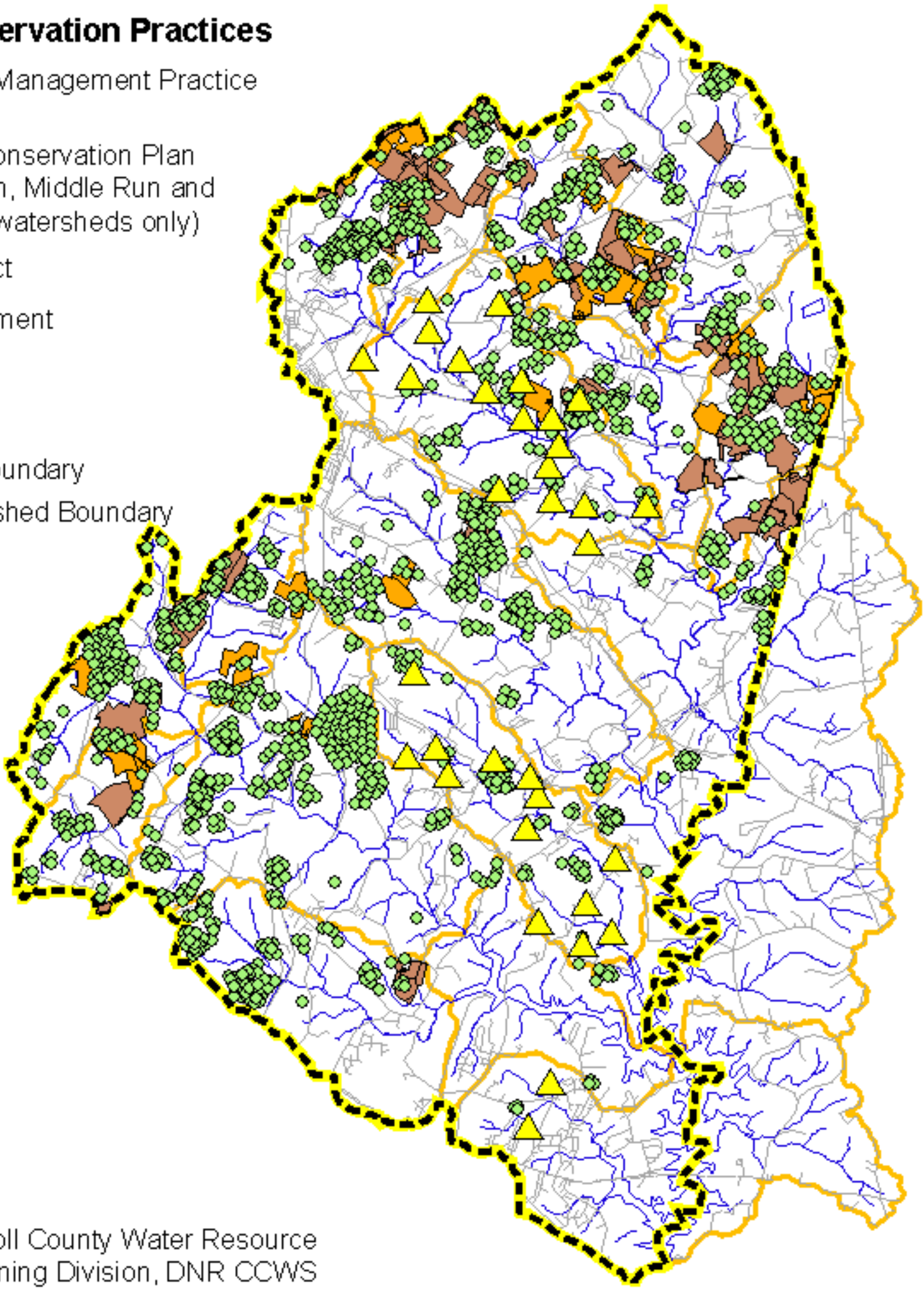
Map 10 Agricultural Conservation Efforts
Liberty Reservoir Watershed

Agricultural Conservation Practices

- Agricultural Best Management Practice (BMP)
- Soil and Water Conservation Plan (in Snowdens Run, Middle Run and West Branch subwatersheds only)
- Agricultural District
- Agricultural Easement

Other Features

- WRAS Project Boundary
- Liberty Subwatershed Boundary
- Water
- Streams
- Roads



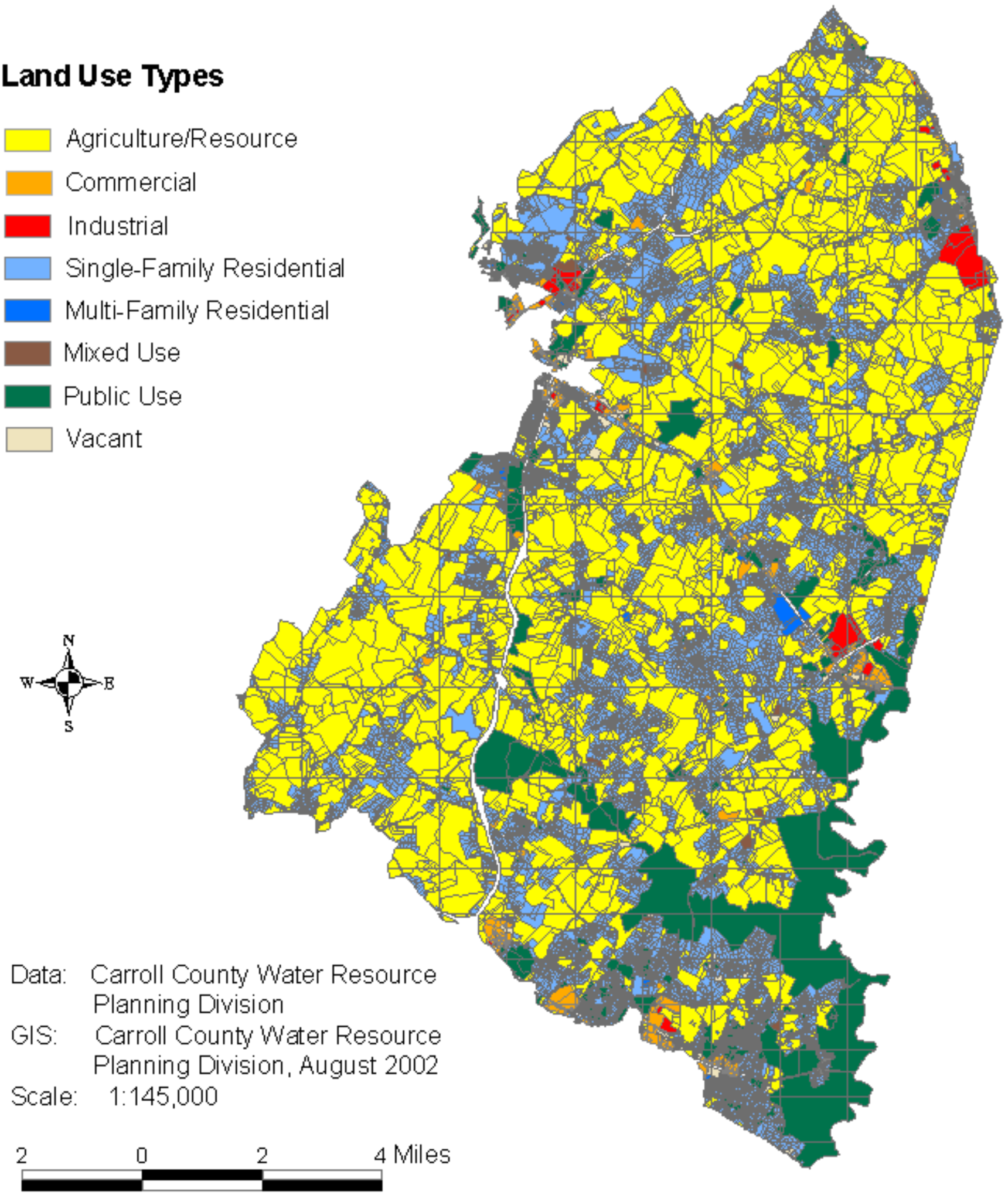
Data: Carroll County Water Resource Planning Division, DNR CCWS

GIS: Carroll County Water Resource Planning Division, August 2002

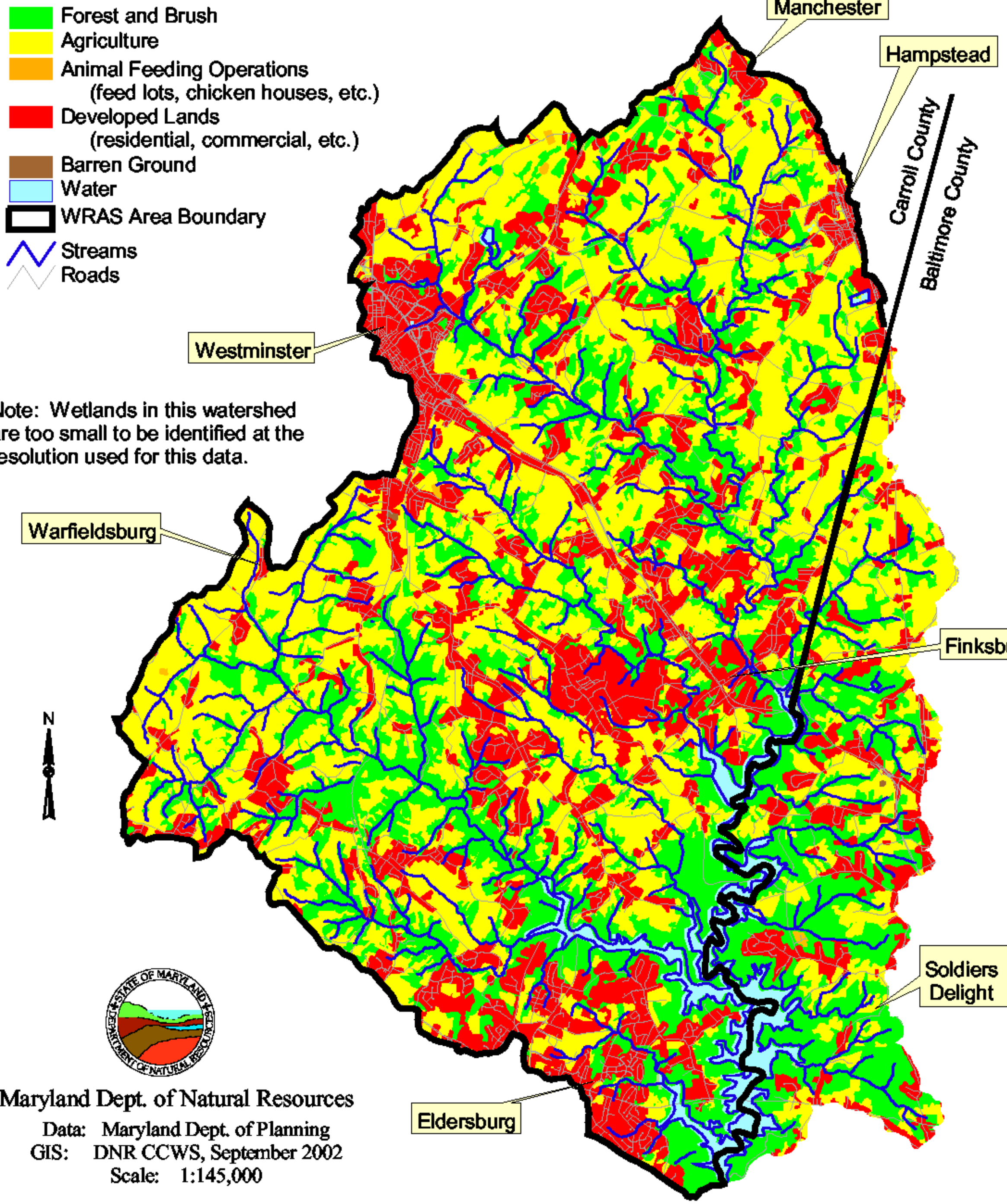
Scale: 1:145,000

2 0 2 4 Miles

Map 11 Detailed Land Use
Liberty WRAS Area



Map 12 Generalized 2000 Land Use / Land Cover
Liberty Reservoir Watershed



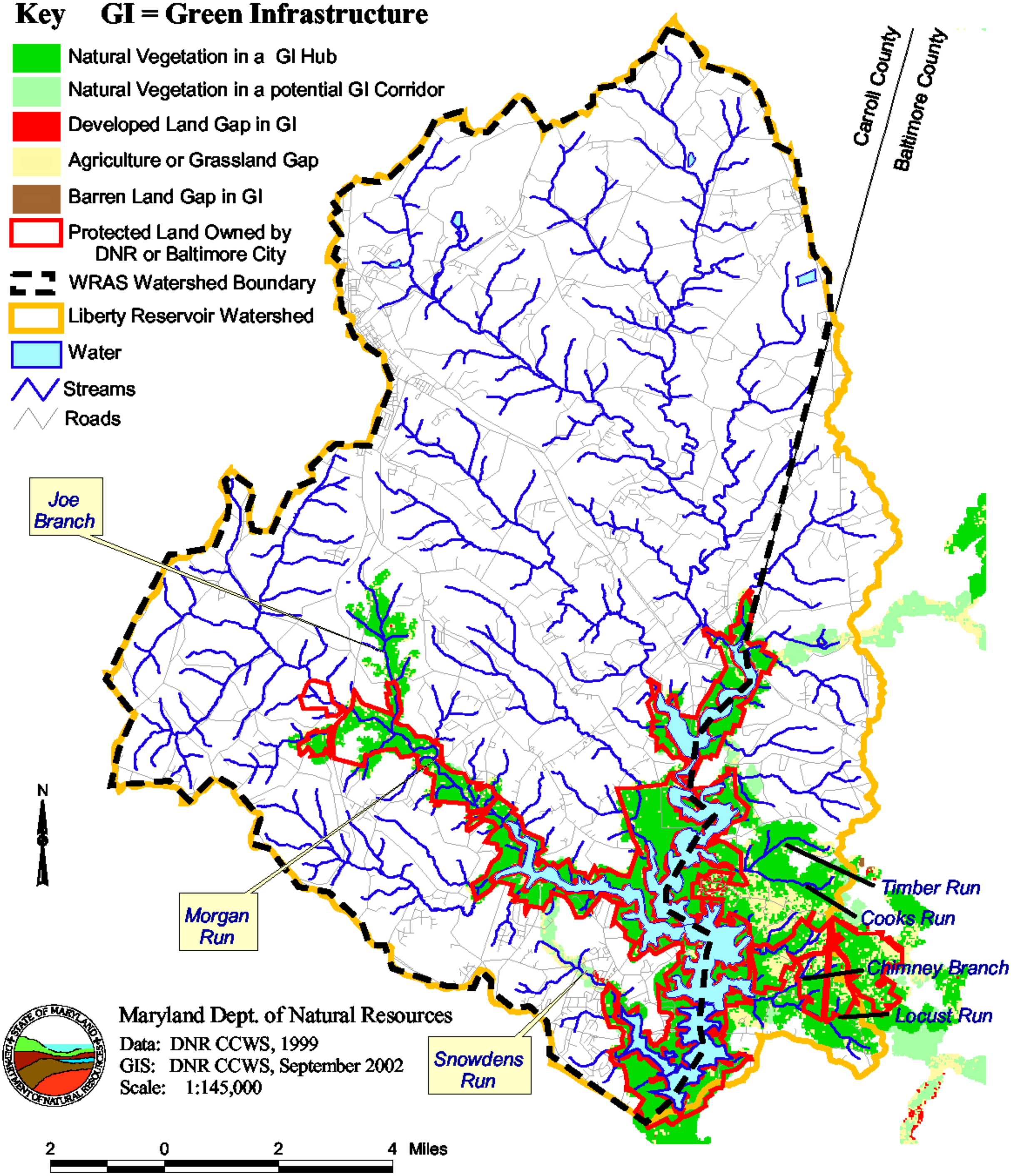
Note: Wetlands in this watershed are too small to be identified at the resolution used for this data.

Maryland Dept. of Natural Resources

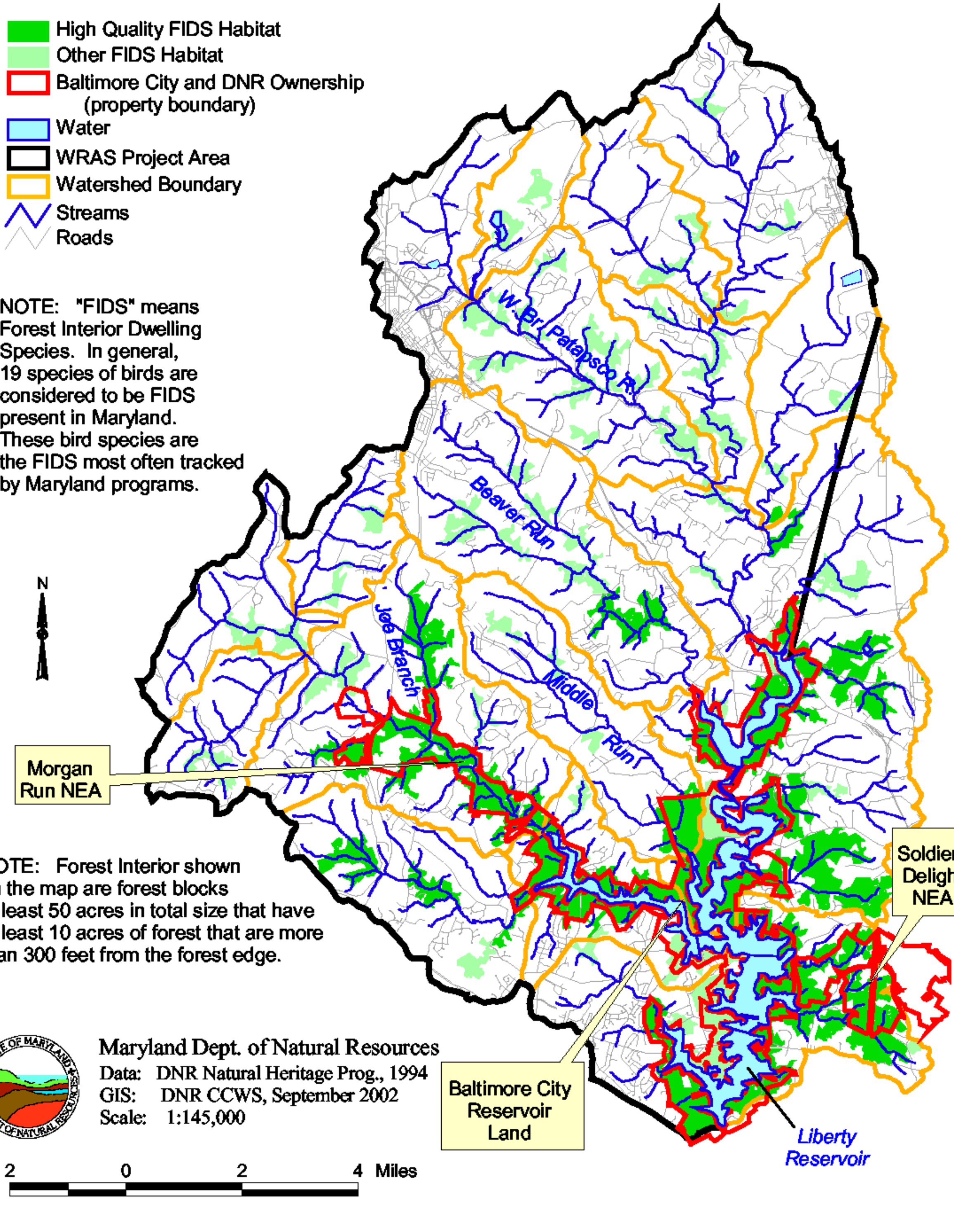
Data: Maryland Dept. of Planning
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 13 Green Infrastructure
Liberty Reservoir Watershed



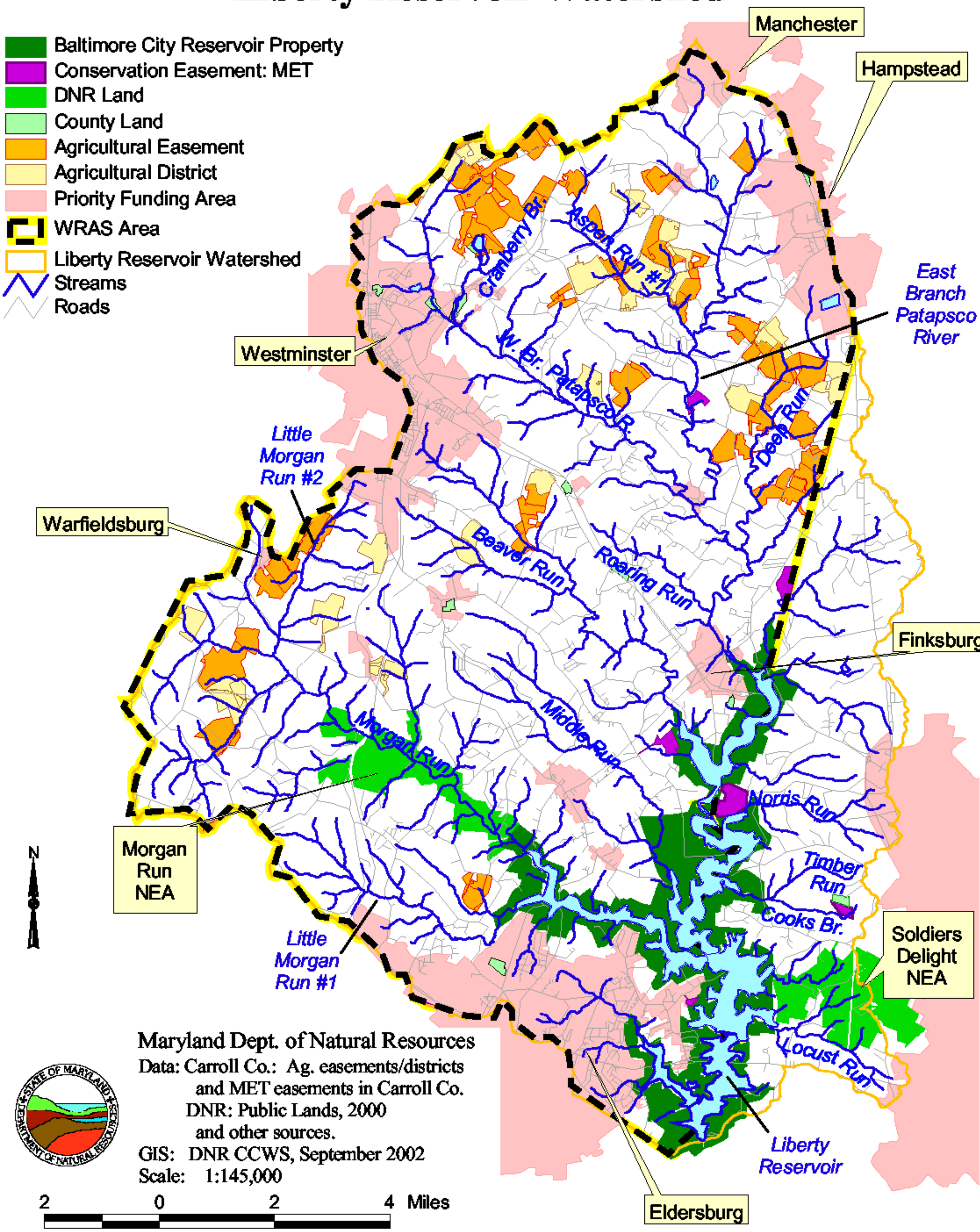
Map 14 Forest Interior
Liberty Reservoir Watershed



Maryland Dept. of Natural Resources
Data: DNR Natural Heritage Prog., 1994
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 15 Protected Land and Smart Growth
Liberty Reservoir Watershed



Maryland Dept. of Natural Resources

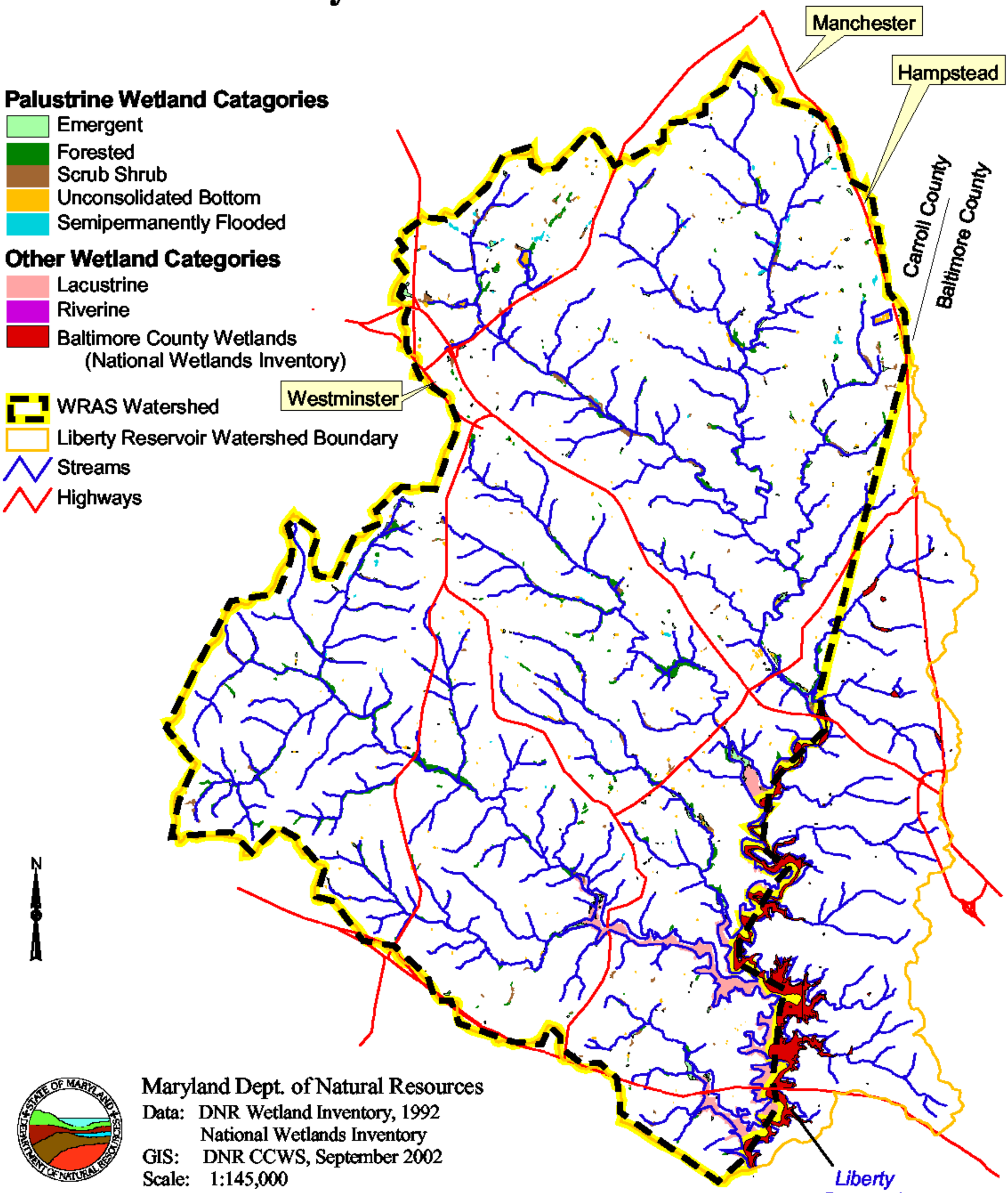
Data: Carroll Co.: Ag. easements/districts
and MET easements in Carroll Co.
DNR: Public Lands, 2000
and other sources.

GIS: DNR CCWS, September 2002

Scale: 1:145,000

2 0 2 4 Miles

Map 16 Wetlands
Liberty Reservoir Watershed



Palustrine Wetland Catagories

- Emergent
- Forested
- Scrub Shrub
- Unconsolidated Bottom
- Semipermanently Flooded

Other Wetland Categories

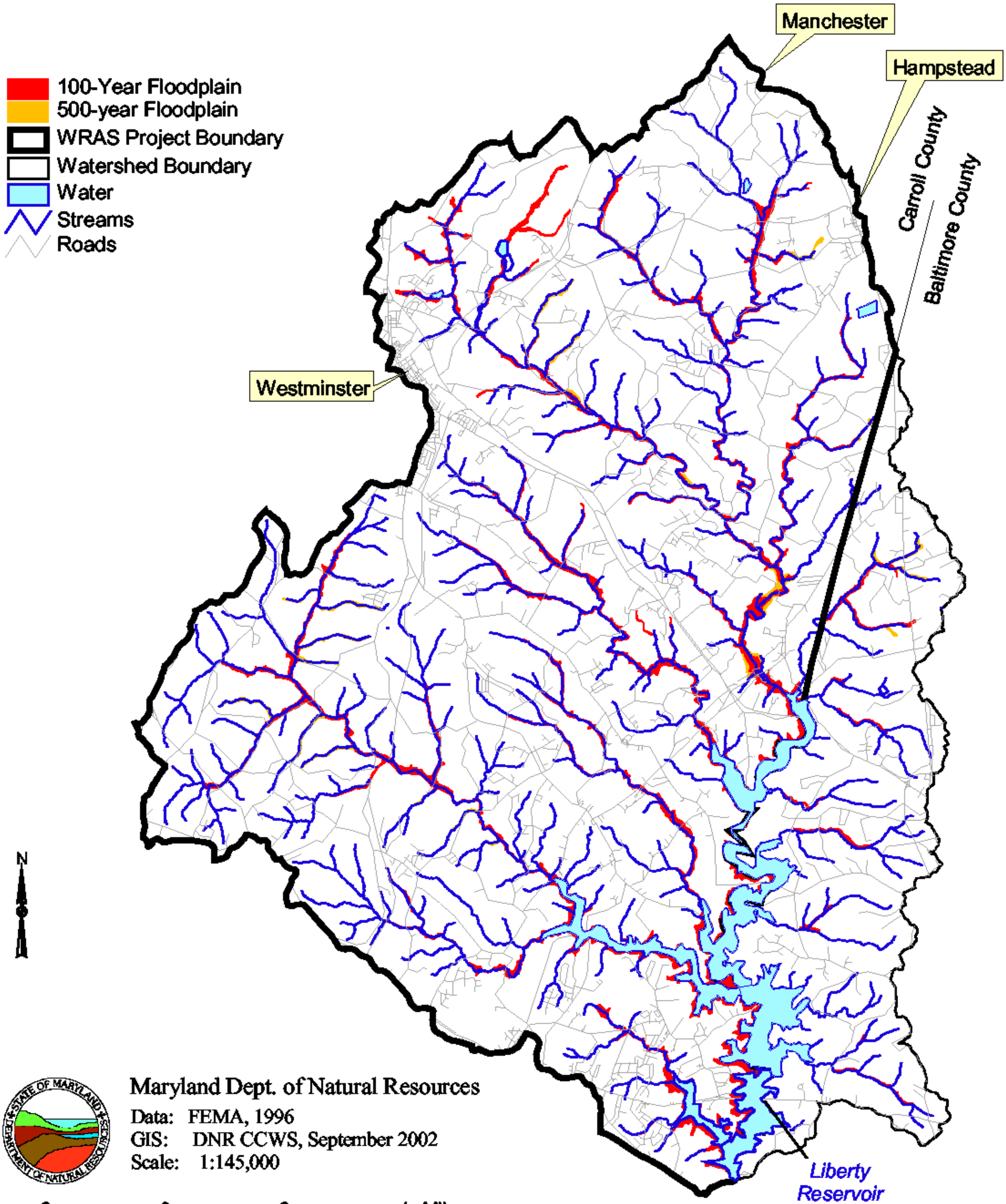
- Lacustrine
- Riverine
- Baltimore County Wetlands (National Wetlands Inventory)

- WRAS Watershed
- Liberty Reservoir Watershed Boundary
- Streams
- Highways

Maryland Dept. of Natural Resources
Data: DNR Wetland Inventory, 1992
National Wetlands Inventory
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 17 Floodplains
Liberty Reservoir Watershed



Maryland Dept. of Natural Resources

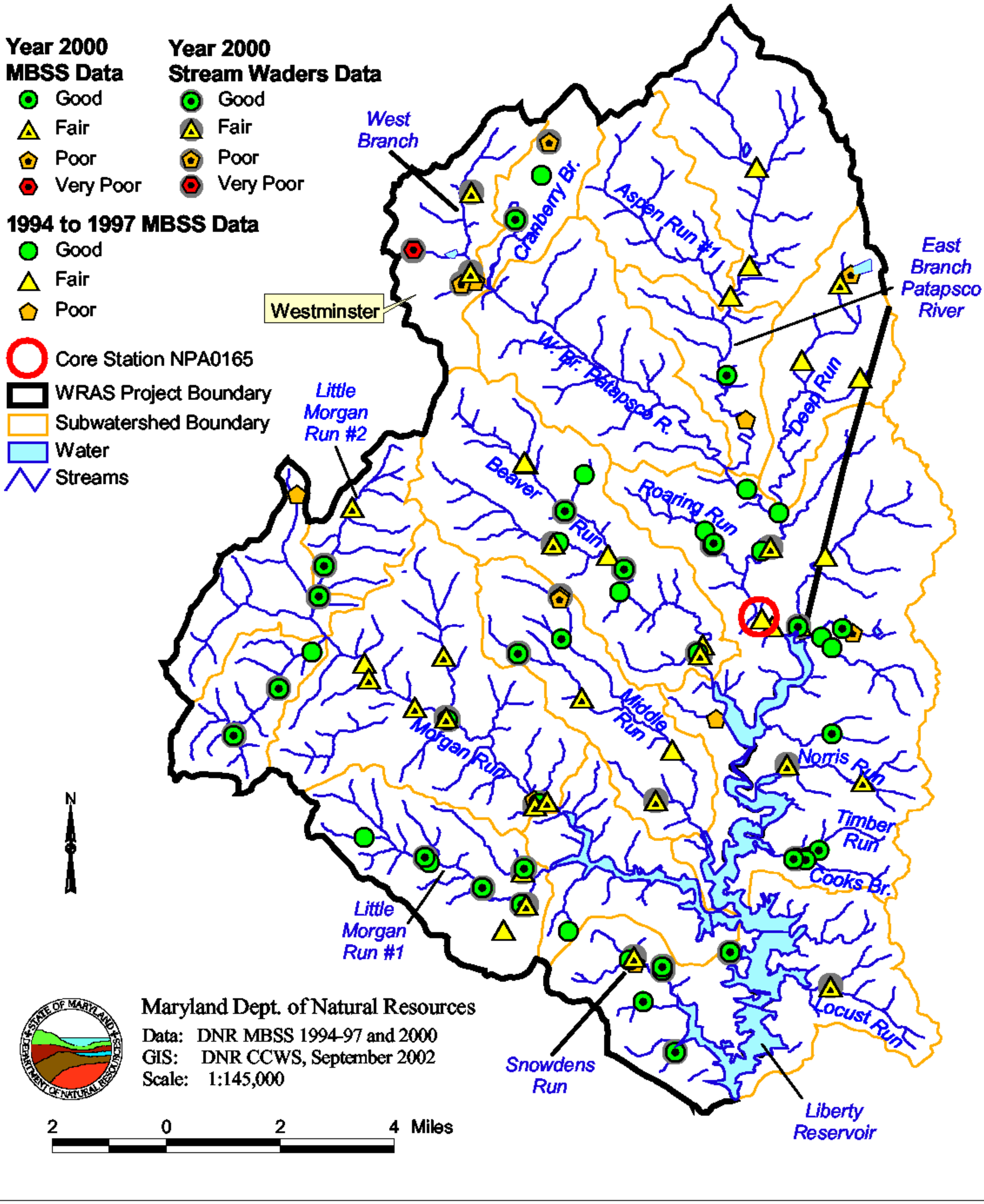
Data: FEMA, 1996

GIS: DNR CCWS, September 2002

Scale: 1:145,000

2 0 2 4 Miles

Map 18 Benthic Index
Liberty Reservoir Watershed



Map 19 Fish In Nontidal Streams
Liberty Reservoir Watershed

Year 2000 MBSS Fish Index

- Good
- Fair
- Poor
- Very Poor
- Brook Trout found at this site during the MBSS sampling.

1994 to 1997 MBSS Fish Index

- Good
- Fair
- Poor
- Brook Trout found at this site during the MBSS sampling.

- Blockage to Fish Movement
- WRAS Project Boundary
- Subwatershed Boundary
- Water
- Streams

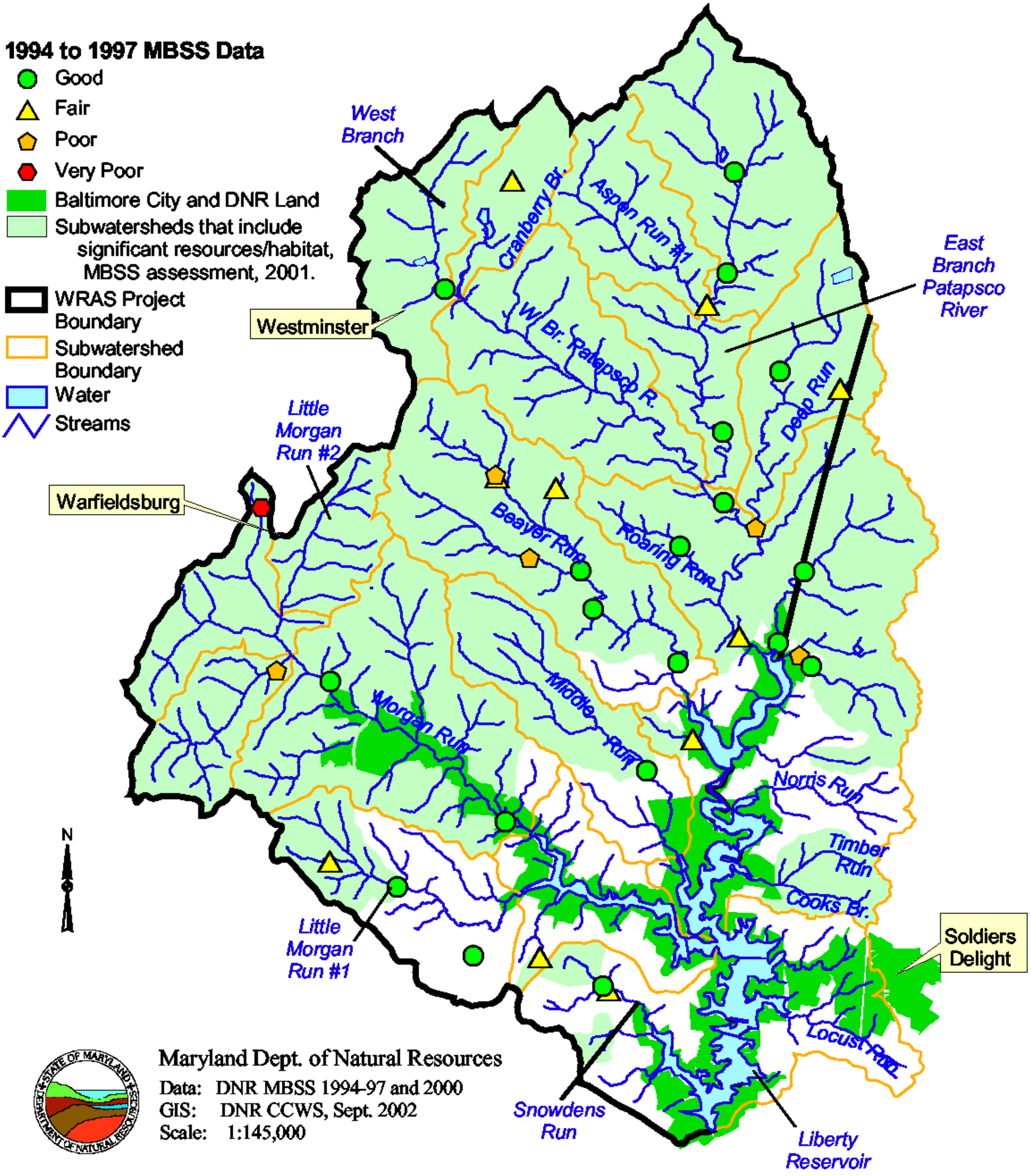
PA004
West Branch
Cranberry Br.
Aspen Run #1
East Branch Patapsco River
Westminster
W. Br. Patapsco R.
Deep Run
Little Morgan Run #2
Beaver Run
Roaring Run
PA027
PA028
Morgan Run
Middle Run
Norris Run
Timber Run
Cooks Br.
Little Morgan Run #1
Snowdens Run
Locust Run
Liberty Reservoir

N

Maryland Dept. of Natural Resources
Data: DNR MBSS 1994-97 and 2000
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 20 Physical Habitat Index
Liberty Reservoir Watershed



Map 21 Senstive Species
Liberty Reservoir Watershed

Sensitive Species Project Review Area (SSPRA)

WRAS Watershed

Watershed Boundary

Water

Streams

Roads

NOTE; Of the three types of areas tracked in Maryland for sensitive species, only the SSPRA is identified in the Liberty Reservoir watershed. The other two, Natural Heritage Areas and Wetlands of Special State Concern, are not currently identified in the watershed.

Manchester

Hampstead

Westminster

East Branch Patapsco River

Soldiers Delight

Liberty Reservoir

N

Maryland Dept. of Natural Resources

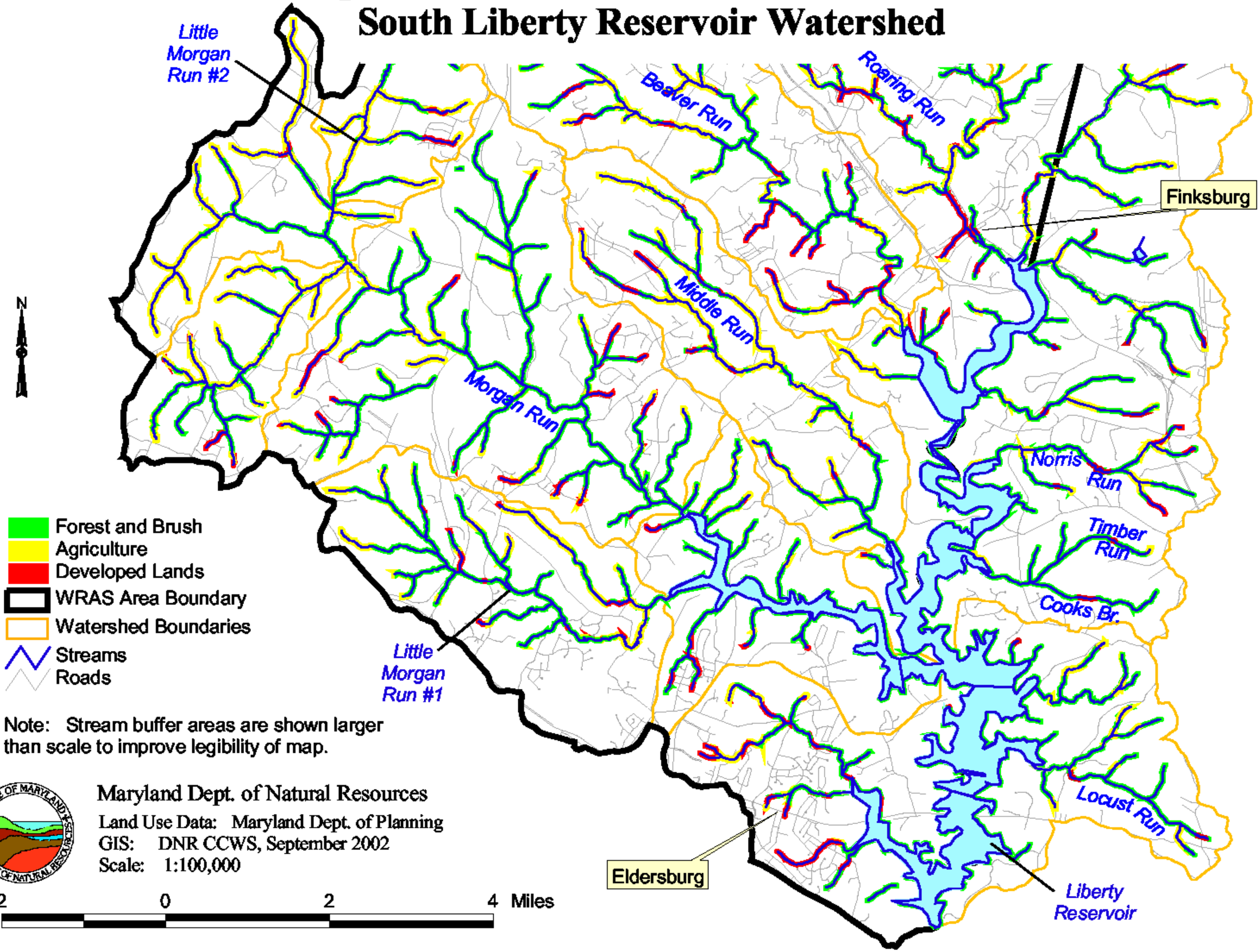
Data: DNR Natural Heritage Prog., 1997

GIS: DNR CCWS, September 2002

Scale: 1:145,000

2 0 2 4 Miles

Map 22A Stream Buffer Land Use Scenario
South Liberty Reservoir Watershed



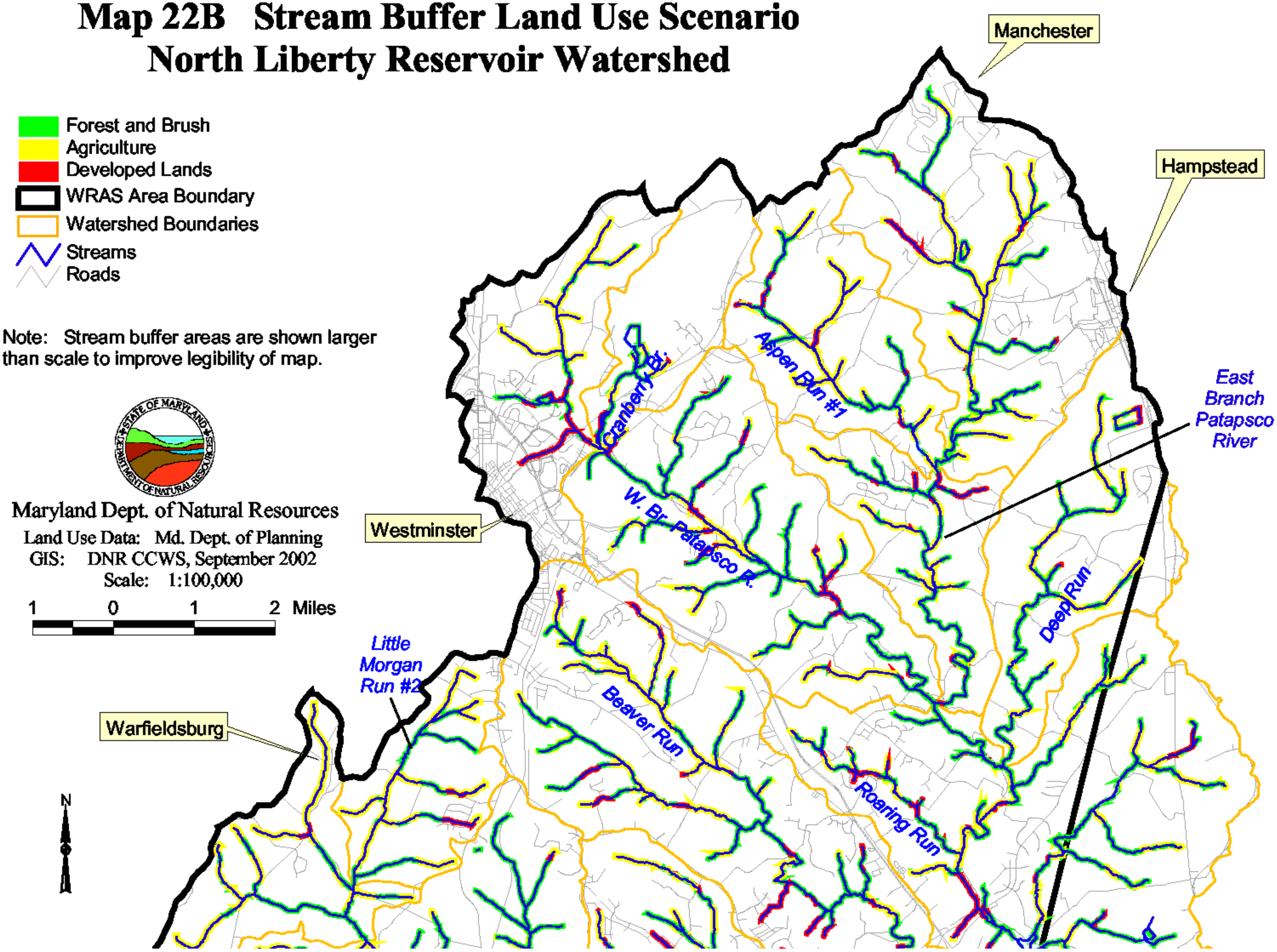
Note: Stream buffer areas are shown larger than scale to improve legibility of map.

Maryland Dept. of Natural Resources

Land Use Data: Maryland Dept. of Planning
GIS: DNR CCWS, September 2002
Scale: 1:100,000

2 0 2 4 Miles

Map 22B Stream Buffer Land Use Scenario
North Liberty Reservoir Watershed



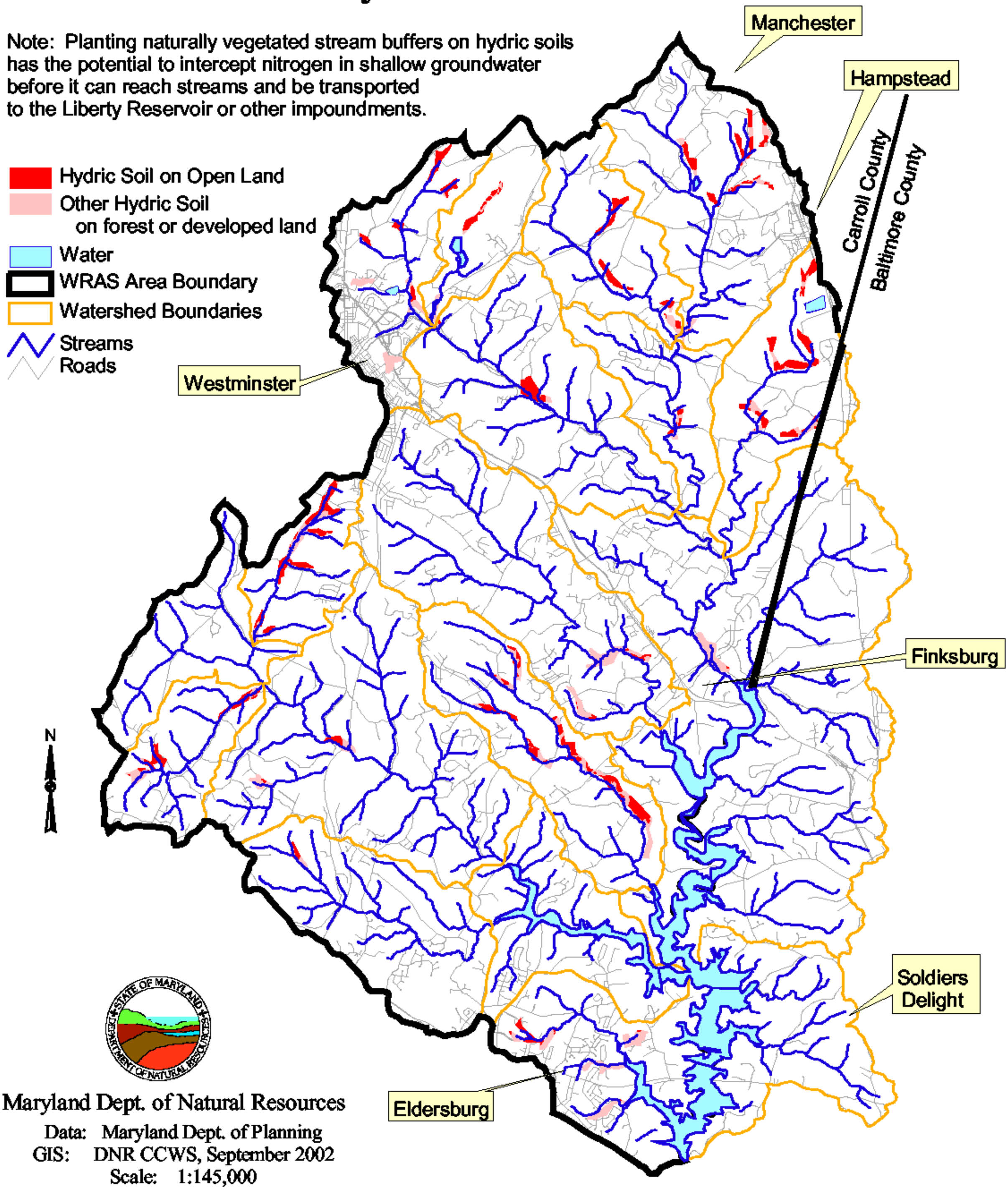
Note: Stream buffer areas are shown larger than scale to improve legibility of map.

Maryland Dept. of Natural Resources
Land Use Data: Md. Dept. of Planning
GIS: DNR CCWS, September 2002
Scale: 1:100,000

1 0 1 2 Miles

Map 23 Stream Buffer Hydric Soil On Open Land Scenario
Liberty Reservoir Watershed

Note: Planting naturally vegetated stream buffers on hydric soils has the potential to intercept nitrogen in shallow groundwater before it can reach streams and be transported to the Liberty Reservoir or other impoundments.

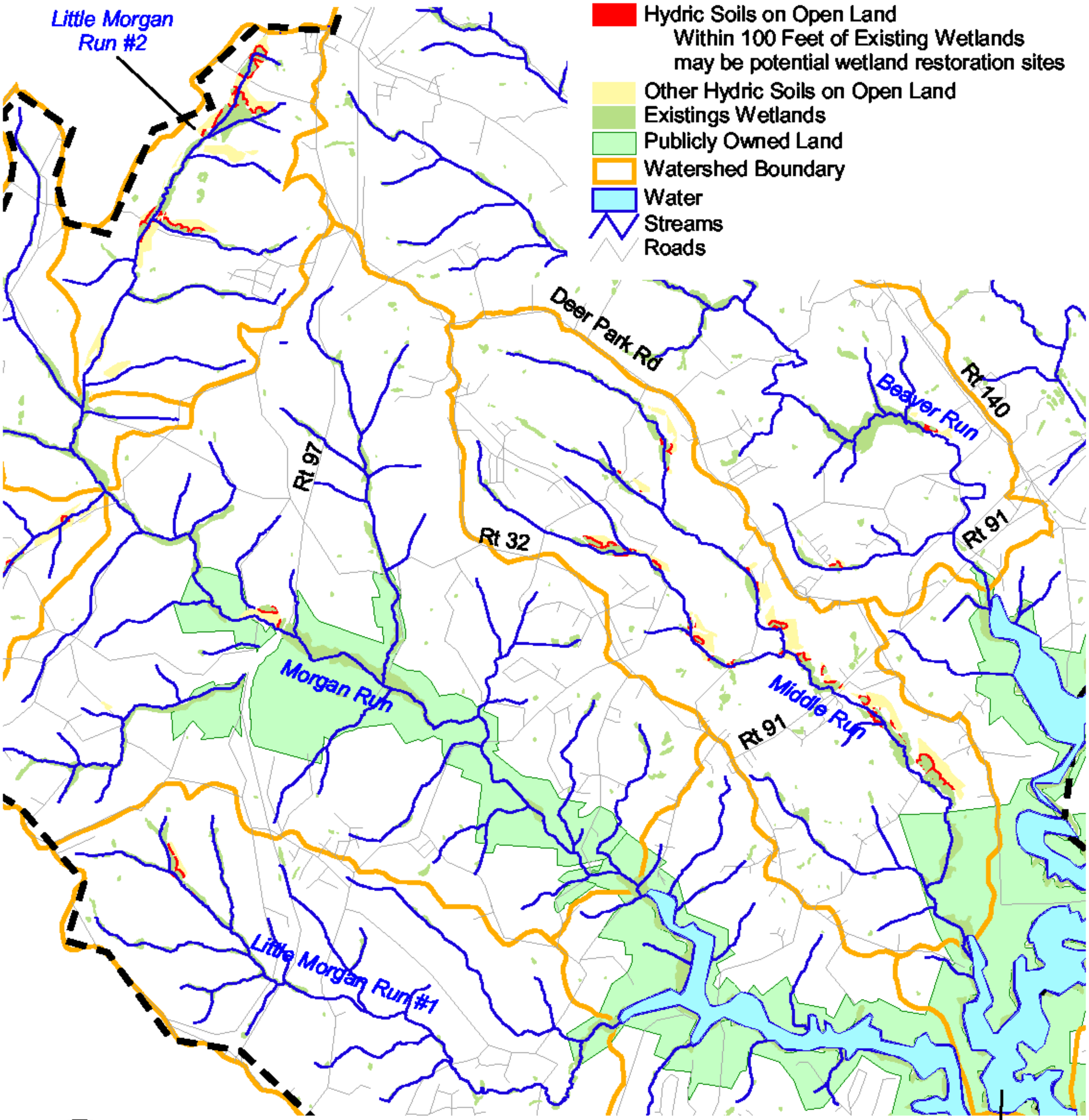


Maryland Dept. of Natural Resources

Data: Maryland Dept. of Planning
GIS: DNR CCWS, September 2002
Scale: 1:145,000

2 0 2 4 Miles

Map 24 Hydric Soils Near Wetlands
Morgan Run / Middle Run Subwatersheds
Liberty Reservoir Watershed



Maryland Dept. of Natural Resources
Data: DNR Wetland Inventory, 1992
GIS: DNR CCWS, September 2002
Scale: 1:50,000

N

2 0 2 4 Miles