ABSTRACT

An index of surface-water contamination potential was constructed for the Little Cross Creek Basin, a 9.7-square-mile, water-supply watershed in Cumberland County, North Carolina. The index was developed because previous water-quality investigations raised concerns regarding inputs of bacteria, suspended sediment, and phosphorus from nonpoint sources in the watershed. A geographic information system was used to build map overlays and to categorize and rate three factors that affect the transport of water and contaminants—land-surface slope, distance to water, and land use/land cover. Each factor was weighted to reflect its potential contribution to surface-water contamination; the factors then were combined to estimate susceptibility values for the entire watershed. The numerical susceptibility values were categorized to indicate lowest to highest potential for surface-water contamination, and a map was produced showing the spatial distribution of these categories within the watershed.

The susceptibility index for about 17 percent of the Little Cross Creek watershed is rated in the high or highest category. These areas have high slopes, short distances to the nearest surface water, impervious land cover, and land uses that generate contaminants. About 38 percent of the watershed area is rated as having low or lowest susceptibility to contamination. These areas contain flat terrain, greater distances to water, land cover that promotes infiltration, and land uses that pose little risk for generating contaminants. Approximately 43 percent of the watershed is in the moderate category of susceptibility. Open water, which is not rated, accounts for the remaining area.

The susceptibility index provides water-resource managers with a tool that can aid in prioritizing areas within the Little Cross Creek Basin for monitoring, protection, and remediation. Previous suspended sediment, total phosphorus, and fecal coliform data collected in the Little Cross Creek watershed support the results of the susceptibility analysis. Although this susceptibility index is specific to the Little Cross Creek Basin, the methods used to develop the index are transferable to other watersheds.

INTRODUCTION

Little Cross Creek is located in the Cape Fear River Basin in the Coastal Plain Physiographic Province of North Carolina (fig. 1). The stream originates within the U.S. Army's Fort Bragg Military Reservation and flows in a southeasterly direction to its confluence with Cross Creek within the city of Fayetteville. Glenville Lake, which is the last in a series of four impoundments of Little Cross Creek, is a source of public drinking water for residents of Fayetteville and surrounding urbanized areas in Cumberland County. Investigations previously conducted by the Public Works Commission (PWC) of the City of Fayetteville, the North Carolina Division of Water Quality, and the U.S. Geological Survey (USGS) raised concerns regarding levels of fecal coliform bacteria, suspended sediment, and phosphorus in Little Cross Creek. Because no municipal or industrial facilities are permitted to discharge effluent in the watershed, elevated levels of these constituents probably are associated with nonpoint sources such as stormwater runoff.

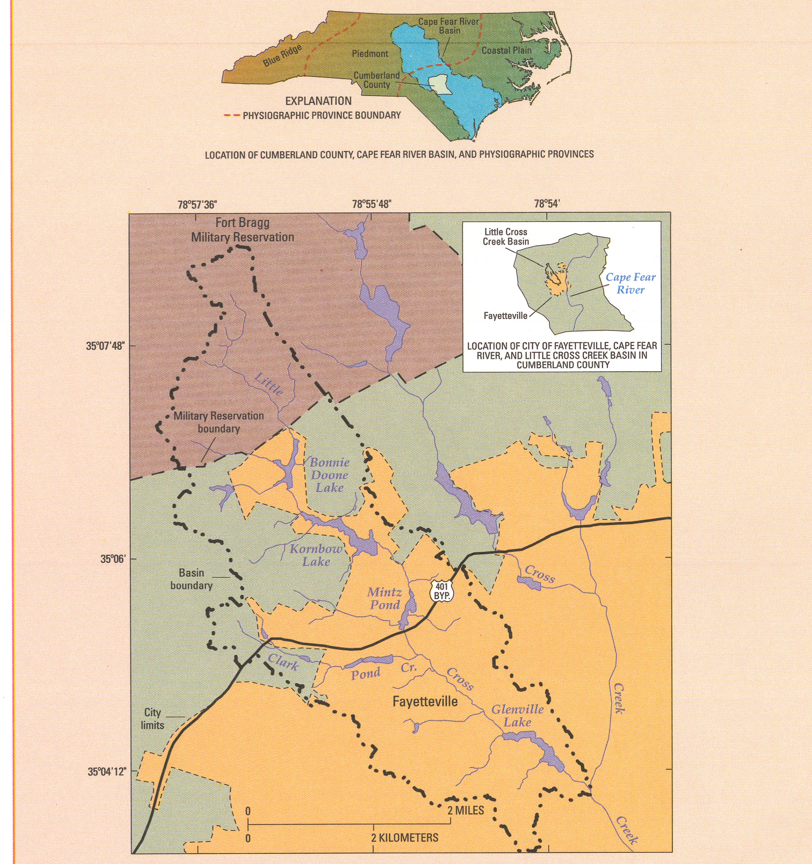


Figure 1. Location of Little Cross Creek Basin in Cumberland County, North Carolina.

Protection of public water supplies and source waters is a high priority for water-resource managers throughout the Nation, including managers working to protect water quality in Little Cross Creek. Knowledge of factors that influence susceptibility to contamination is an important tool for establishing and attaining water-supply protection goals. Management practices can be designed and implemented most effectively when based on an understanding of how watershed characteristics influence surface-water susceptibility. Identification of areas that are highly susceptible to contamination enables managers to prioritize these areas for monitoring, protection, or remediation.

In order to facilitate the management and protection of Little Cross Creek, the PWC requested that the USGS provide information about the susceptibility of areas within the 9.7-square-mile watershed to contamination from surface sources of pollution. A susceptibility index was developed by using an overlay and index method (National Research Council, 1993) to integrate several factors that affect the transport of water and contaminants through the watershed. A geographic information system (GIS) was used to develop and analyze spatial data sets that contain topographic, hydrologic, and cultural information. Modular programming techniques and data structures were used to ensure that the susceptibility analysis can be easily refined in the future, as data with better resolution or more up-to-date information become available.

During a previous investigation, the USGS evaluated water quality, including suspended sediment, nutrients, and bacteria levels, at several stream sites in the Little Cross Creek Basin (Giorgino and Middleton, 2000). These data, which were collected from October 1996 to January 1998, were used to evaluate the appropriateness of the susceptibility index developed for Little Cross Creek.

The USGS has conducted numerous contamination-susceptibility studies. The Federal Safe Drinking Water Act Amendments of 1996 required that all States determine the susceptibility of each public water supply to contamination (U.S. Environmental Protection Agency, 1997). In North Carolina, the USGS assisted the Public Water Supply Section of the North Carolina Department of Environment and Natural Resources with a statewide susceptibility assessment of water-supply wells and surface-water intakes (Eimers and others, 2000). In addition to the statewide study, the susceptibility of ground water to contamination has been rated for Orange County, North Carolina (Terziotti and Eimers, 1999). The USGS also assessed surface- and/or ground-water vulnerability in South Carolina (Lanier and Falls, 1999), New Jersey (Vowinkel and others, 1996), Rhode Island (Desimone and Ostiguy, 1999), and Washington (Erwin and Tesoriero, 1997). Additional studies of the vulnerability of drinking-water supplies are ongoing in several States.

Purpose and Scope

This report describes the factors and methods of classification that were used to compute a susceptibility index to surface contamination for the Little Cross Creek watershed in Cumberland County, North Carolina. The areal extent of each index category is summarized, and susceptibility values are compared to water-quality data collected at six sites in the Little Cross Creek watershed.

The susceptibility index is not a measure of actual contamination but an evaluation of the potential for surface-water contamination based on land-surface characteristics. Therefore, this index is appropriate for evaluating the potential for particulate and dissolved contaminants to be transported to surface water by way of overland runoff. Ground water is not included in this index but may provide an important transport mechanism for dissolved constituents.

Acknowledgments

The authors are grateful to colleagues in the Public Works Commission of the City of Fayetteville for their assistance in this collaborative project, especially Charles (Chad) W. Ham, Ken Rutherford, Tina Spegal, and Lang Nguyen. Tina Belanger of the Cumberland County Tax Administrator's Office provided descriptions of categories in a data base that was used to construct a land-use/land-cover data layer. William A. Battaglin, Douglas A. Harned, Gerard McMahon, Michael L. Strobel, and Sandra C. Cooper of the USGS provided thoughtful technical and editorial review comments that improved the quality of this report.

METHODS OF SUSCEPTIBILITY ANALYSIS

Three factors were used to compute the relative susceptibility index—land-surface slope, distance to water, and land use/land cover. Each contributing factor was derived from individual GIS spatial data layers or from the analytical combination of more than one GIS layer (table 1). The spatial resolution of each factor depends on the data set(s) from which it was derived. In a similar manner, the resolution of the final susceptibility index is constrained by the coarsest resolution of the individual factors. In this study, the highest scale among the contributing data sets is 1:1,200, which is equivalent to a resolution of 5 feet. Therefore, a 5- by 5-foot cell size was used to produce the final susceptibility index for the watershed.

Table 1. Sources of GIS data for relative susceptibility factors

Contributing factor	Source data layer	Year of origin	Scale or resolution of data
Land-surface slope	Cumberland County 2-foot contour coverage	1996	1:1,200 scale
	Fort Bragg 2-foot contour coverage	1985	1:1,200 scale
Distance to water	Generated from stream coverage, based on contour coverages and field verification	2000	1:1,200 scale
Land use/land cover	Cumberland County land parcels data base	2000	1:1,200 scale
	Cumberland County Tax Administrator's (OASIS) data base	2000	1:1,200 scale
	Cumberland County orthophotographs	1996	0.5-foot resolution
	Fort Bragg structures and roads coverage	1994	1:400 scale
	Digital orthophoto quarter quadrangles	1993	3-meter resolution

Values for each of these three factors were categorized and assigned a contamination-potential rating (CPR) on a scale of 1 to 10. A rating of 1 reflects the lowest CPR for a given factor, and a 10 reflects the highest CPR for a factor. Preliminary CPR's were based on literature review and previous susceptibility rating systems (O'Hara, 1996; Terziotti and Eimers, 1999; Eimers and others, 2000). Ratings were modified based on consensus by the technical reviewers of the report and comparisons of instream water quality in Little Cross Creek with results of the susceptibility analysis. Source data and the methods used to derive each contributing factor are described in detail in the following sections of the report.

In addition to the three factors that were selected for inclusion in the final rating, soil hydrologic group was considered as a contributing factor to susceptibility. Soil hydrologic groups are used by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), to develop standard runoff curves for use in rainfall-runoff modeling and engineering applications (U.S. Soil Conservation Service, 1985). These groups also have proven useful for predicting elevated concentrations of nitrate-nitrogen in midwestern streams (Mueller and others, 1997) and for describing geographic differences in sediment and nutrient concentrations within the Albemarle-Pamlico drainage basin in North Carolina and Virginia (McMahon and Harned, 1998).

Ultimately, soil hydrologic groups were not used in the susceptibility rating for the Little Cross Creek watershed for several reasons. First, because this watershed is highly urbanized, the natural characteristics of native soils are suppressed by soil compaction, earth-moving activities, the introduction of fill materials, and impervious covers, such as pavement and buildings. Second, the inclusion of soils had a minimal effect on preliminary susceptibility ratings for the watershed, probably because much of the geographic variability in soil hydrologic groups was reflected in the slope and distance to water factors. Finally, the 1:24,000-scale layer for soil hydrologic groups did not overlay well with some finer-scale data components that were developed for the Little Cross Creek watershed, such as the stream network. Soil hydrologic groups could be considered for susceptibility analysis of other watersheds where soil-drainage characteristics are more varied and especially for applications in large watersheds or regional studies with less urbanization.

Land-Surface Slope

Slope is used as an indicator of potential runoff or infiltration of precipitation. Susceptibility to surface-water contamination at a given point is greater when infiltration is low and runoff is high. Flat terrain (low-percent slope) indicates areas of low runoff and high infiltration potential. Steep terrain (high-percent slope) indicates areas of high runoff and low infiltration potential. Contamination-potential ratings were assigned to slope categories so that lowest slopes received the lowest rating and highest slopes received the highest rating (table 2).

Table 2. Land-surface slope categories and ratings

Slope values (percent)	Contamination-potential rating	Square miles in watershed[a]	Percent of watershed[a]
Less than or equal to 2	1	3.06	31.5
Greater than 2 to less than or equal to 5	3	2.72	28.1
Greater than 5 to less than or equal to 10	5	2.16	22.2
Greater than 10 to less than or equal to 20	8	1.26	13.0
Greater than 20	10	.25	2.6

[a]Open water accounts for 0.26 square mile or 2.6 percent of the Little Cross Creek watershed. Areas of open water are not rated.

A slope data base for the Little Cross Creek Basin was generated from the 2-foot surface-elevation contour lines furnished by the City of Fayetteville and Fort Bragg Military Reservation. The contour lines were tagged with elevation values, and a digital elevation model (DEM) was produced by using the TOPOGRID function of ARC/Info[1] GIS software (Environmental Systems Research Institute, Inc., 1994). Slope values and a watershed boundary were generated from the DEM by using ARC/Info GIS software.

Upland areas in the Little Cross Creek watershed are gently undulating with relatively low slopes (fig. 2). Streams in this region of North Carolina tend to cut deeply into the landscape over time, so that the steepest terrain commonly is found along streambanks (Daniels and others, 1984). This pattern is evident in the Little Cross Creek Basin (fig. 2). In addition, slopes are steep in localized areas along manmade berms, roadside ditches, and embankments.

Distance to Water

Distance to water is a measure of the straight path that contaminants would travel from any point within the watershed to the nearest body of water. Because an accurate digital water-features layer did not exist for the Little Cross Creek watershed, one was generated from the DEM developed for the watershed. GIS software was used to analyze the surface elevation model and to determine areas where streams would most likely form given the direction of flow across the surface and the accumulation of flow based on up-slope values of elevation. The layer of highest accumulated flow was resampled to a representation of streams. Changes to this preliminary stream coverage were made based on field verification.

Distance to water was calculated by using the Euclidean distance function of ARC/Info GIS software; thus, results represent straight distances to water and do not consider topographic features that may influence localized flow patterns. The relatively even distribution of slopes around streams (fig. 2) indicates that this generalized approach to estimating distance is acceptable for the Little Cross Creek watershed. Distance to water was categorized into six classes. Areas of the watershed that were within the closest category were given the highest contamination potential rating. Areas farthest from bodies of water were given the lowest rating (fig. 3; table 3).

[1]The use of firm, trade, and brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 3. Distance to water categories and ratings

Distance to water (feet)	Contamination-potential rating	Square miles in watershed[a]	Percent of watershed[a]
Greater than 1,600	1	0.97	10.0
Greater than 800 to less than or equal to 1,600	3	2.82	29.0
Greater than 400 to less than or equal to 800	5	2.59	26.7
Greater than 200 to less than or equal to 400	7	1.48	15.3
Greater than 100 to less than or equal to 200	9	.78	8.0
Less than or equal to 100	10	.81	8.3

[a]Open water accounts for 0.26 square mile or 2.6 percent of the Little Cross Creek watershed. Areas of open water are not rated.

Land Use/Land Cover

Land use/land cover substantially influences the potential for surface-water contamination and runoff. Land use refers to human and natural activities that occur on the land and the potential for these activities to generate contaminants. Land cover refers to physical properties of the land surface that influence whether precipitation infiltrates or flows overland to streams.

A land-use/land-cover data set was generated for the Little Cross Creek watershed because no existing data were available with the level of detail and accuracy desired for a watershed of this small size. Categories were derived from five primary sources of data (table 1). For the Fort Bragg Military Reservation area of the watershed, 1993 digital orthophotographs and an existing coverage of roads and buildings were used to digitize land-use/land-cover features and to assign land-use/land-cover codes. For the rest of the watershed, Cumberland County tax data base (OASIS), land-parcel delineations, and 1996 digital orthophotographs were used. A tax data base code describing land use was associated with most land parcels. Some of the land-use classes from OASIS were reassigned by using a modified Anderson land-use/land-cover classification system (table 4; Anderson and others, 1976). Parcels that either lacked codes or overlapped multiple codes were assigned to a land-use category that was interpreted from the digital orthophotographs. In addition, all parcels larger than 2 acres, excluding lakes, roads, and residential parcels, were verified with the orthophotographs. During this process, land use for parcels covering about 38 percent of the watershed outside of the Fort Bragg Military Reservation were photo-verified.

State, Federal, and local sources also were checked for sites or facilities with high pollution potential. Geographic data bases from the North Carolina Department of Environment and Natural Resources indicated that the Little Cross Creek watershed contains no permitted wastewater dischargers, hazardous substance disposal sites, or livestock or poultry operations. Parcels identified as hazardous-waste sites in the U.S. Environmental Protection Agency Envirofacts data base (U.S. Environmental Protection Agency, 2000) were coded commercial/industrial. The City of Fayetteville stormwater permit application (Ogden Environmental and Engineering Services, 1993) lists several industrial facilities that are potential sources of pollutants in the Little Cross Creek watershed; corresponding parcels in the land-use/land-cover layer were checked to ensure that these were coded commercial/industrial.

Table 4. Land-use/land-cover categories and ratings

Land-use/land-cover category	General description or example	Contamination-potential rating	Square miles in watershed	Percent of watershed
Forest	Areas dominated by trees. Identified as acreage in the Cumberland County tax data base, or evidence of a predominantly tree-covered parcel in orthophotographs.	1	2.43	25.0
Wetlands	Areas of forested, shrubland, or non-woody vascular perennial vegetation where the soil or substrate is periodically saturated or covered with water. Identified as submerged land, or swamp/waste in the Cumberland County tax data base, or evidence of wetlands in orthophotographs.	2	<.01	<.1
Water	All areas of open water. Mapped as lakes or open water.	not rated	.26	2.6
Grasses	Vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, and golf courses. Identified as acreage in the Cumberland County tax data base, or evidence of maintained open space in orthophotographs.	4	.15	1.5
Barren	Bare rock, sand, silt, gravel, or other earthen material with little or no vegetation regardless of its inherent ability to support life. Identified as acreage in the Cumberland County tax data base, and evidence of bare earth in orthophotographs.	5	.05	.5
Transitional	Areas dynamically changing from one land cover to another, often because of changes in land-use activities. Parcels identified as acreage or commercial in the Cumberland County tax data base, and evidence of disturbed or cleared land in orthophotographs.	5	.26	2.7
Low-intensity residential	Residential development. Most commonly single-family housing areas, especially suburban neighborhoods. Identified as residential within the Cumberland County tax data base, or evidence of residential dwelling in orthophotographs, and parcel acreage greater than one-fifth of an acre.	7	3.01	31.0
High-intensity residential	Residential development. Densely built urban centers, apartment complexes, and row houses. Identified as multifamily residential, or common area in the Cumberland County tax data base, or evidence of residential dwelling(s) in orthophotographs, and parcel acreage less than or equal to one-fifth of an acre.	9	.83	8.5
Commercial/Industrial/Transportation	Land used for the manufacture of products or sale of goods. Identified as commercial in the Cumberland County tax data base, roads in parcels data base, or evidence of commercial or industrial activity or transportation corridor in orthophotographs.	10	2.72	28.1

Contamination-potential ratings for the land-use/land-cover categories reflected both flow-impedance and pollution-generation characteristics (table 4). For example, high ratings were assigned to commercial/industrial/transportation (10) and high-intensity residential (9) categories, because these land uses contain high percentages of impervious surfaces that favor runoff (such as asphalt and buildings) and have high potential for contamination from suspended solids, bacteria, fertilizers, pesticides, petroleum products, and other pollutants. Conversely, forested lands were given a low rating (1), because they generally are pervious and pose less threat from contaminant use and production.

The relative ratings assigned in this study were consistent with previously reported percentages of impervious area and water-quality conditions in different urban land-use classes in Fayetteville (Ogden Environmental and Engineering Services, 1993). Furthermore, stormwater monitoring conducted in Fayetteville from 1995 to 1999 showed that a high-density residential site in the Little Cross Creek Basin had high concentrations of fecal coliform bacteria. A commercial site had relatively higher concentrations of suspended solids and phosphorus compared to sites in other land-use settings (Mr. John D. Fersner, Ogden Environmental and Engineering Services, written commun., August 3, 1999).

The spatial distribution of land-use/land-cover categories illustrates the urban nature of the Little Cross Creek watershed (fig. 4). Sixty-eight percent of the basin is developed, with residential land accounting for nearly 40 percent of the total area (table 4). Forested land accounts for 25 percent of the basin. Water, wetlands, grasses, barren land, and transitional land make up the remaining 7 percent. It should be noted that other categories in the Anderson classification scheme, such as those describing agricultural land uses, are not included in table 4 because these land uses currently do not occur in the Little Cross Creek Basin.

Susceptibility Ratings

Land-surface slope, distance to water, and land use/land cover were treated as contributing factors in evaluating relative surface-water susceptibility. As noted previously, the values of the three factors were categorized and assigned contamination-potential ratings on a scale of 1 to 10. To compute susceptibility values, each factor also was weighted (table 5). The weights are subjective measures that reflect the relative importance of the factor in determining susceptibility to surface-water contamination. The rated and weighted factors were combined, resulting in a susceptibility value ranging from 10 to 100 for each 5- by 5-foot cell (table 5). Finally, susceptibility values were grouped into five equal-interval categories of susceptibility—lowest, low, moderate, high, and highest (see fig. 5 to the right and table 6 below).

Table 5. Example calculation of susceptibility value for one 5- by 5-foot cell

Factor	Cell value or category (from GIS)	Contamination-potential rating (CPR)	Factor weight (W)	Total (T) ($T_i = CPR_i \times W_i$)
Land-surface slope (percent)	4	3	3	9
Distance to water (feet)	500	5	3	15
Land use/land cover	Low-intensity residential	7	4	28
		Susceptibility value = $T_1 + T_2 + T_3 = 52$		

Table 6. Susceptibility ranges and categories

Susceptibility value range	Susceptibility category	Square miles in watershed[a]	Percent of watershed[a]
10 to 28	Lowest	0.94	9.7
29 to 46	Low	2.73	28.2
47 to 64	Moderate	4.14	42.6
65 to 82	High	1.41	14.6
83 to 100	Highest	.22	2.3

[a]Open water accounts for 0.26 square mile or 2.6 percent of the Little Cross Creek watershed. Areas of open water are not rated.

RESULTS

Areas with a combination of high slopes, short distances to water, and land uses with probable contaminant sources have the highest susceptibility ratings. Areas of the watershed that contain low slopes, long distances to water, and land uses with low contamination potential have the lowest susceptibility ratings (fig. 5). The lowest susceptibility category encompasses about 10 percent of the watershed area. Twenty-eight percent of the watershed is in the low category. The majority (43 percent) of the watershed is in the moderate susceptibility category. Fifteen percent of the watershed is in the high category, and 2 percent is categorized as having the highest susceptibility to contamination (table 6). Approximately 3 percent of the watershed is open water; these areas were not rated.

In a previous study, investigators noted that water quality varied spatially within the Little Cross Creek watershed (Giorgino and Middleton, 2000). Differences among sites for concentrations of suspended sediment, total phosphorus, and fecal coliform bacteria were related to stormwater runoff, land-use differences, and to whether sites were located downstream from impoundments that trapped these constituents. The observed water-quality conditions are useful for evaluating the results of the susceptibility index. Maximum and median concentrations of suspended sediment, total phosphorus, and fecal coliform bacteria at Little Cross Creek sites S1, S2, S3, S4, S5, and S7 can be compared to mean susceptibility ratings for the entire drainage area of each site (fig. 6; table 7).

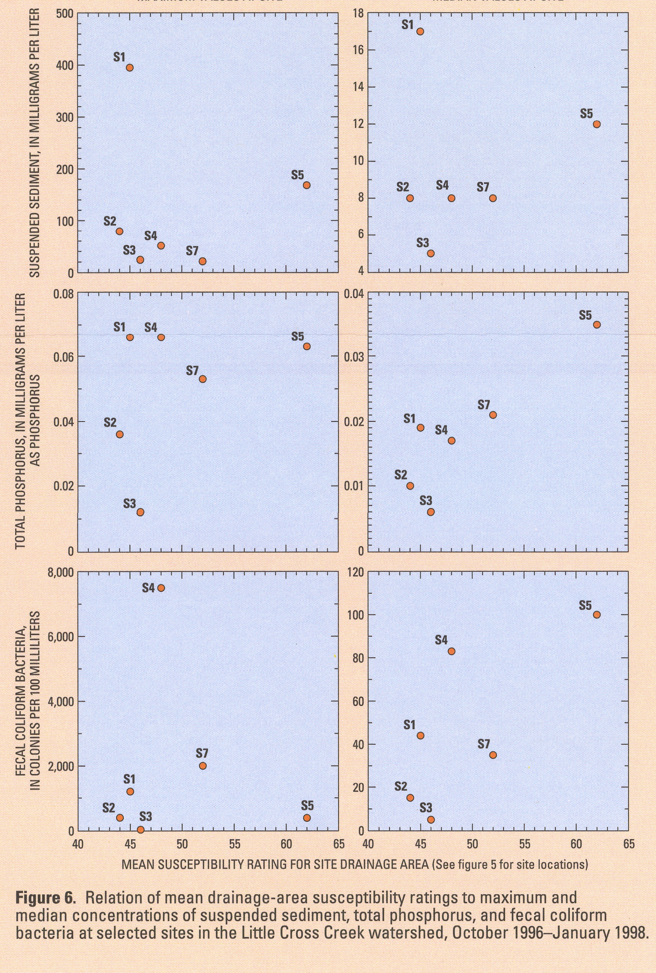


Figure 6. Relation of mean drainage-area susceptibility ratings to maximum and median concentrations of suspended sediment, total phosphorus, and fecal coliform bacteria at selected sites in the Little Cross Creek watershed, October 1996–January 1998.

Table 7. Water-quality data and susceptibility values for sites in the Little Cross Creek watershed. Chemistry data were collected from October 1996 to January 1998 (Giorgino and Middleton, 2000)
[mg/L, milligrams per liter; P, phosphorus; col/100 mL, colonies per 100 milliliters]

Site (fig. 5)	Mean susceptibility rating for area draining to site	Suspended sediment concentration (mg/L) Maximum	Suspended sediment concentration (mg/L) Median	Total phosphorus concentration (mg/L as P) Maximum	Total phosphorus concentration (mg/L as P) Median	Fecal coliform bacteria (col/100 mL) Maximum	Fecal coliform bacteria (col/100 mL) Median
S1	45	395	17	0.066	0.019	1,200	44
S2	44	79[a]	8	.036	.010	400	15
S3	46	24	5	.012	.006	30	5
S4	48	51	8	.066	.017	7,500	83
S5	62	168	12	.063	.035	390	100
S7	52	21	8	.053	.021	2,000	35

[a]A maximum concentration of 1,590 mg/L was attributed to sample contamination (Giorgino and Middleton, 2000).

Elevated concentrations of suspended sediment were observed at site S1 upstream from Bonnie Doone Lake (figs. 5, 6; table 7), along with several fecal coliform values that exceeded the North Carolina water-quality criterion of 200 colonies per 100 milliliters (North Carolina Department of Environment and Natural Resources, 2000). Suspended-sediment and total phosphorus concentrations increased during rain events. The land area draining to site S1 is mostly in low and moderate susceptibility categories; however, the immediate vicinity of the site is rated high (fig. 5). These results indicate that runoff from the unpaved road crossing at this location may be a localized source of contamination, exacerbated by steep slopes and proximity to the stream.

Water-quality conditions at site S3 were characterized by low concentrations of sediment, phosphorus, and bacteria (fig. 6; table 7). Observed conditions correspond with the low mean susceptibility rating (46) for the drainage area of this site. Low to moderate ratings predominate within the drainage area for site S3, reflecting the relatively low amount of development and relatively large percentage of forested land (figs. 4, 5). Water quality at this site also is affected by Bonnie Doone Lake and Kornbow Lake, which effectively trap incoming particulates and phosphorus (Giorgino and Middleton, 2000).

The mean susceptibility rating (48) for the drainage area of site S4 is in the moderate category (fig. 6; table 7), whereas areas close to the site rated in the high and highest susceptibility categories (fig. 5). The mean susceptibility rating for the subbasin downstream from site S3 was 55, reflecting the shift to more urbanized land uses in the lower Little Cross Creek watershed (fig. 4). Levels of fecal coliform bacteria frequently exceeded 200 colonies per 100 milliliters at site S4, especially during storm events. Suspended-sediment and total phosphorus concentrations also increased during storms at this location (Giorgino and Middleton, 2000). Site S4 receives runoff from the Highway 401 Bypass and surrounding commercial, industrial, and residential areas.

The drainage area of site S5 had the highest mean susceptibility rating (62) of all the sites in the Little Cross Creek Basin (fig. 6; table 7). Site S5 drains land that is heavily developed with a mixture of roads, residential areas, and commercial and industrial sites (fig. 4). During the previous USGS water-quality investigation, site S5 had the highest median phosphorus concentrations (fig. 6), areal phosphorus loads, and the highest median concentration of fecal coliform bacteria in the Little Cross Creek Basin (Giorgino and Middleton, 2000).

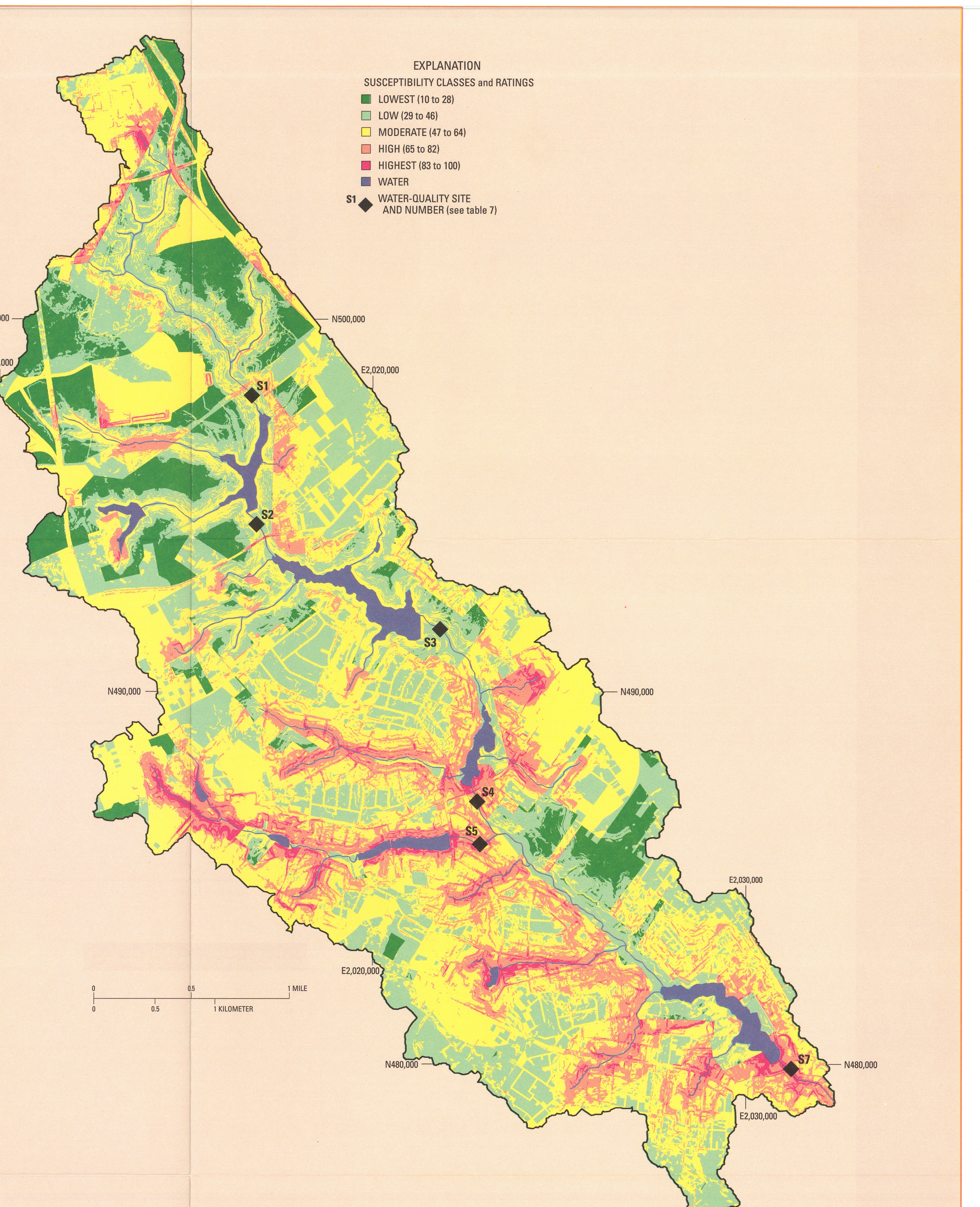


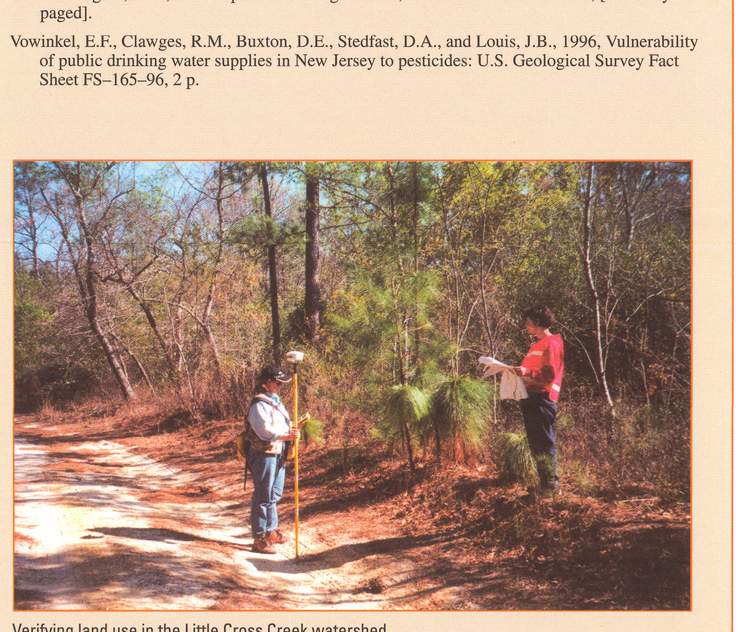
Figure 5. Susceptibility of surface water to contamination in the Little Cross Creek watershed.

SUMMARY AND APPLICATION

A susceptibility index of surface-water contamination potential was generated for the Little Cross Creek watershed in Cumberland County, North Carolina. The index was constructed by using a GIS to build, categorize, and rate three factors that contribute to the surface-water susceptibility to contamination—land-surface slope, distance to water, and land use/land cover. Soil hydrologic group was evaluated as a contributing factor but was not included in the final susceptibility rating index. The selected factors were weighted and combined to create susceptibility values for the entire watershed. The numerical susceptibility values were categorized to reflect lowest to highest contamination potential throughout the watershed. Most of the Little Cross Creek watershed (43 percent) has a moderate susceptibility to contamination, while 17 percent of the watershed is in the high or highest categories of susceptibility. Review of water-quality data collected in the watershed support the results of the susceptibility analysis.

The susceptibility index can be a valuable planning tool for the PWC. Using a modular GIS approach to construct the susceptibility index ensures that the index can be refined in the future to incorporate more detailed contaminant-source information or more up-to-date land-use characteristics. This index is not a measure of actual contamination but an evaluation of the potential for surface-water contamination within a watershed based on physical properties of the land surface and land use. Results reflect conditions for periods when the source data layers were developed. This index is further limited by the fact that it contains no ground-water component, and ground water may provide an important transport mechanism for contaminants to surface waters. Nevertheless, water-resource managers can use this information to help guide activities when surface-water use is involved in planning decisions. Results of this investigation cannot be used to evaluate single parcels because of the scale at which the data are available. However, this information can be used to evaluate the susceptibility of general areas to determine how vigilant resource managers must be in protecting surface-water resources.

A stream flowing through a residential area in the Little Cross Creek watershed.



Verifying land use in the Little Cross Creek watershed

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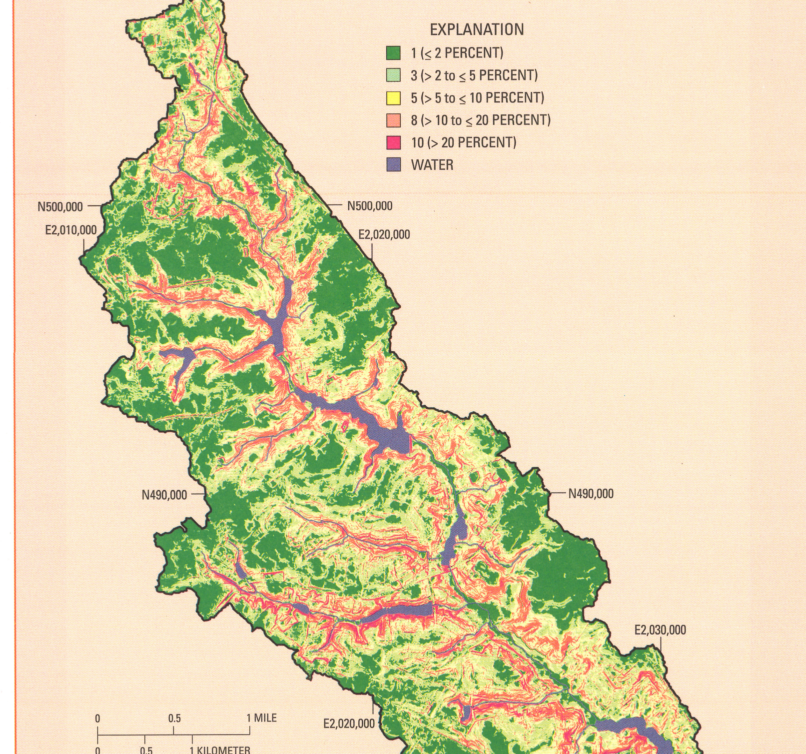

Figure 2. Land-surface slope ratings.

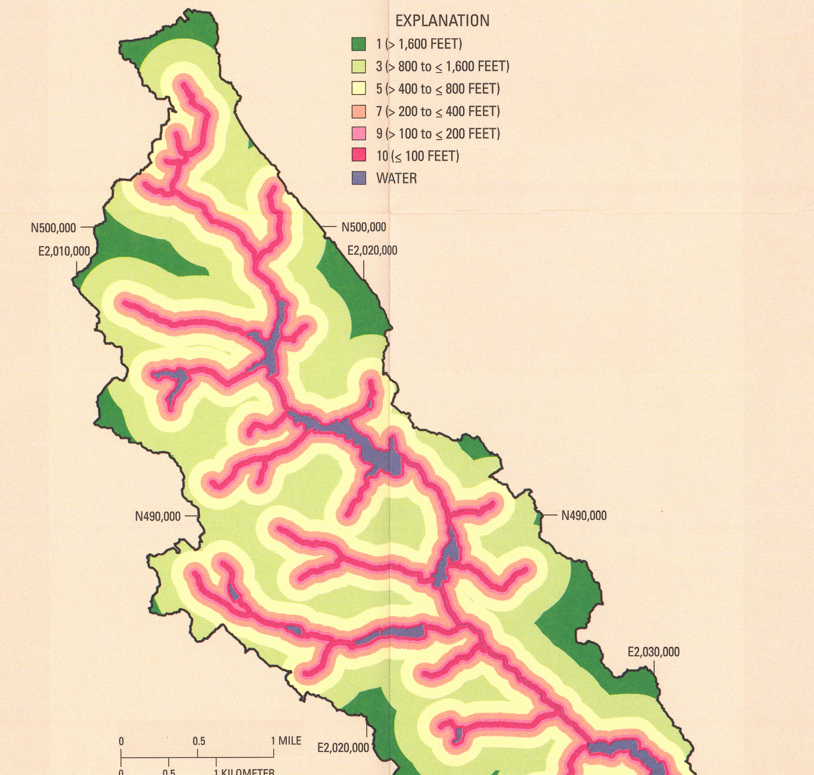

Figure 3. Distance to water ratings.

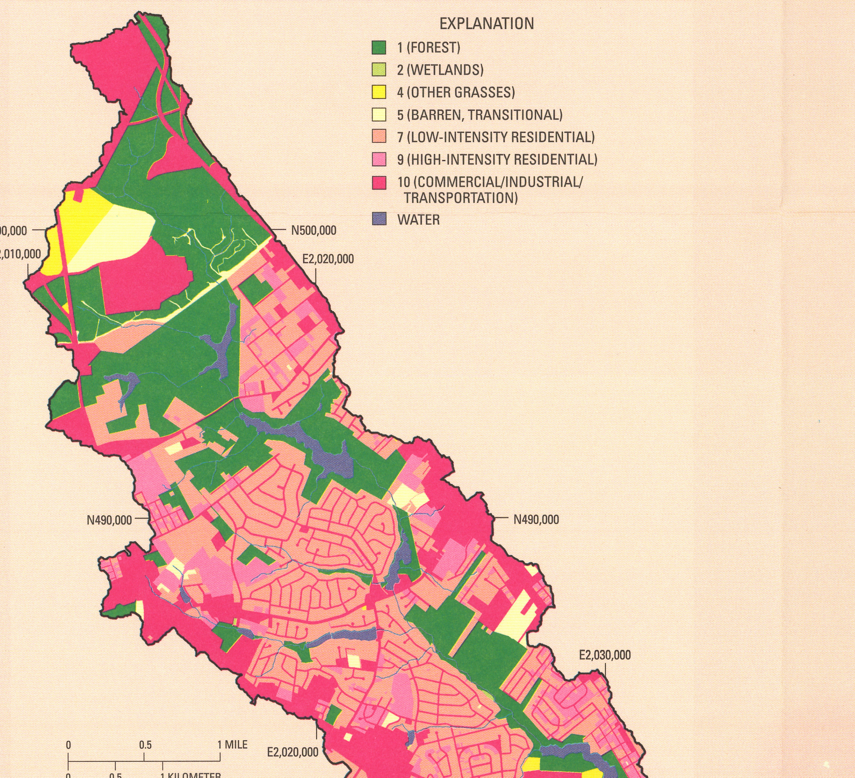

Figure 4. Land-use/land-cover ratings.

Base maps obtained from the City of Fayetteville and Fort Bragg Military Reservation
Projection based on North Carolina state plane feet
1983 North American Datum

Susceptibility Index to Surface Contamination for the Little Cross Creek Watershed, Cumberland County, North Carolina

by

M.J. Giorgino and Silvia Terziotti

2001