FINAL REPORT

WATERSHED ASSESSMENT OF BALLENGER CREEK FREDERICK COUNTY, MARYLAND

Prepared for

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EXECUTIVE SUMMARY

Ballenger Creek was selected as the second watershed to be assessed under Frederick County's National Pollution Discharge Elimination System (NPDES) stormwater permit (Permit Number MD0068357) because of extensive recent and future development in the watershed, given its close proximity to the City of Frederick. The focus of this watershed assessment was to assess conditions in the watershed, identify water quality problems and opportunities to improve water quality, and develop a water quality plan. The assessment involved a stream characterization survey, collection of visual inspection data from the surrounding watershed, and use of a variety of ancillary data sources. Methods previously utilized in the County's Lower Bush Creek watershed assessment were also employed in this study.

Description of the Watershed

The Ballenger Creek watershed is approximately 14,955 acres (23.4 square miles) in size. It is a fourth order stream that has been designated by Maryland Department of Environment (MDE) as Class III Natural Trout waters. Ballenger Creek drains eastward into the Monocacy River, a National Scenic River. Ballenger Creek watershed lies within the Western Division of the Piedmont Physiographic Province, a region characterized by gently rolling terrain and slow-flowing streams. The eastern third of the watershed is underlain by a limestone formation known as the Frederick Valley, in which in which karst terrain features are evident. In general, land use in the north-central portion of the watershed, bordering the City of Frederick, consists largely of residential subdivisions, while the area east of U.S. Route 270 is largely commercial/industrial and includes a limestone quarry. The western half of the watershed contains a mix of agricultural uses as well as low density residential properties. Scattered, large forested tracts remain within the watershed, often in areas of steeper slopes along the Catoctin front. Vegetation and landcover in the Ballenger Creek watershed consist of agricultural land, forested areas (deciduous and coniferous), oldfield (transitional vegetation), wetlands, and developed areas (residential, commercial and industrial). Wetlands in the watershed are generally very linear and are associated with Ballenger Creek and its tributaries.

Environmental Assessment of Existing Conditions

Six long-term monitoring stations were established on the mainstem of Ballenger Creek. Field activities involved testing water quality parameters, quantifying physical habitat, conducting a qualitative habitat assessment, and sampling benthic macroinvertebrates and fish. Spring and fall field surveys during 2000 indicate that the stream supports a variety of fish and invertebrate biota, including several sportfish species. Analysis of habitat condition, benthic Index of Biotic Integrity (IBI), and fish IBI scores show that most ratings fall within the second highest category for each index (i.e., good or sub-optimal). Additional stream data from Maryland Biological Stream Survey supplemented the County's field data collection efforts and showed that conditions in Ballenger Creek's headwater streams and upper reaches generally ranged from poor to fair. Given the long history of human habitation and agricultural land use in the region,

streams are far from pristine; however, much of Ballenger Creek and its tributaries appear to be in moderately good condition at present. Wildlife surveys indicated good biodiversity of birds and mammals, particularly in the watershed's vegetated areas.

A visual inspection was conducted to characterize the types and locations of watershed stressors likely to impact water quality. Stressors observed in Ballenger Creek fell into several categories, including hydrologic alterations, agriculture, new construction, industrial/commercial land use, maintenance at some stormwater management (SWM) facilities, and karst features.

The central portion of the Ballenger Creek watershed is currently served by public water and sewer, while rural portions of the watershed are served by residential wells and septic systems. The Ballenger Creek Growth Area is served by the County public water system. Public sewer service is provided by the County's Ballenger Creek Wastewater Treatment Plant (WWTP). Approximately half of the watershed falls within the County's 20-year planned water and sewer service areas.

An inventory of pollution sources was conducted to identify potential chemical stressors. The County's stormwater database reported a total of 114 SWM facilities within the watershed. According to MDE and U.S. Environmental Protection Agency (USEPA) databases, 18 facilities in the watershed have NPDES discharge permits. An on-line review of USEPA's Toxic Releases Inventory and Comprehensive Environmental Response, Compensation, and Liability Information System databases revealed no significant threats likely to adversely affect watershed conditions.

Land use and population projections were made to characterize and predict future environmental conditions, particularly in relation to stream water quality and stormwater management. Residential land use is expected to expand from its current 16 percent to about 36 percent in 2020, while agricultural uses are projected to decrease from its current 59 percent to about 30 percent. An estimated 17,761 people resided in the watershed in 2000, and by 2020, the watershed's population is expected to exceed 30,000. Employment trends demonstrate substantial commercial and industrial growth in the watershed, with approximately 21,020 persons employed in the watershed in 2000, a number projected to reach more than 37,000 by 2020.

Assessment of Water Quality Problems and Identification of Opportunities for Improvement

Problems affecting water quality in Ballenger Creek and its tributaries are predominantly associated with urban and agricultural nonpoint sources. General problem types evident in Ballenger Creek and its tributaries include alterations of natural flow regimes, sediment deposition, and physical habitat degradation. In many cases, problems are minor, particularly where the presence of existing SWM facilties or extensive forest buffer has provided some protection from the impacts of nearby land uses. More severe impacts were apparent at particular

locations, especially in the lower sections of Ballenger Creek where karstic features re-route surface runoff and streamflows underground, create instabilities in existing best management practices (BMPs), and otherwise increase the complexity of SWM issues. Taken individually, many of the activities in the watershed likely have little detrimental effect; however, the cumulative effect of these activities throughout the watershed can be of greater concern.

Water quality problems within Ballenger Creek fall into ten groups centered around the following issues: karst, hydrologic modification, livestock access to stream, cropland runoff, failing septic systems, new construction, future development, industrial/commercial development, existing structures, and stream restoration. Site-specific and/or general programmatic opportunities were identified for each problem that would help improve water quality within the watershed.

Watershed Water Quality Plan

The most promising opportunities that address water quality problems in Ballenger Creek watershed were selected as part of a watershed water quality plan. Further implementation will depend cost, available funding, feasibility, and the likelihood of success in improving or sustaining stream habitat and water quality. Items include general programmatic approaches as well as more site-specific opportunities. Actions will address the primary threats to water quality, including stormwater runoff from existing development, stormwater management issues in karst areas, livestock access to streams, agricultural runoff, and future construction and development. A proposed schedule and preliminary cost estimate was developed for each recommendation.

Programmatic refinements to Frederick County's SWM activities are expected to be particularly important because they address water quality impacts across the County and not just in Ballenger Creek watershed. As such, the following programmatic approaches are recommended:

- Formation of a management committee to coordinate SWM efforts between County agencies
- Development of a karst ordinance to supplement the County's Stormwater Ordinance
- Development of a karst overlay zone to identify areas in which special SWM measures would be required
- Development of procedures for managing stormwater issues in coordination with agricultural agencies and neighboring jurisdictions
- Continuation of current initiatives to reduce stormwater impacts from roads

- Implementation of a combination of program activities to address stormwater management issues in areas where restoration measures or new BMPs are initiated

- Utilization of the County's Forest Resource Ordinance to target off-site mitigation plantings in riparian areas to restore forested stream buffers

Site-specific opportunities to improve water quality were identified at several locations in the watershed. These opportunities were classified into two categories: BMPs and stream restoration. A third category contains recommendations for further study, for instances were insufficient information was available to fully assess impacts or develop specific recommendations.

The following actions associated with BMPs are recommended in the Ballenger Creek watershed:

- Construction of a structural BMP demonstration project to research karst issues related to stormwater management

- Re-inspection of three existing SWM structures to assess potential maintenance needs observed during the watershed assessment

Restoration of destabilized stream channels is a valuable tool that can help return streams to a more natural condition, and thereby prevent additional degradation of water quality, habitat, and biological resources. The following stream restoration actions are recommended:

- Restoration of Ballenger Creek at Ballenger Creek Elementary School

- Restoration of Ballenger Creek at Ballenger Creek Park

- Restoration or enhancement of the riparian buffer from Ballenger Creek Park to the mouth of Ballenger Creek

- Feasibility investigation for restoring Ballenger Creek just upstream of New Design Road

Further study is recommended to fully assess water quality impacts associated with the following issues:

- Evaluation of surface and groundwater chemistry in the vicinity of existing SWM facilities to assess groundwater impacts in karst areas

- Evaluation of potential chemical impacts to water quality from a scrapyard and truck repair facility on Reichs Ford Road

The final recommendation of this plan is to continue watershed monitoring to evaluate the effectiveness of water quality improvements. Specifically, the six Ballenger Creek watershed monitoring stations should be reevaluated every two years, and results documented in a separate study report as well as summarized in the County's NPDES Annual Report. Additionally, supplemental visual inspections and photographic documentation of specific site locations should be conducted at least every two years to monitor effectiveness of management actions. Trends and recommendations from each round of supplemental visual inspections should also be documented in a study report.

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1.0 INTRODUCTION

Ballenger Creek was selected as the second watershed to be assessed under Frederick County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer Systems Discharge Permit, Permit Number MD0068357. This watershed was considered a high priority for assessment because growth in the region has been expanding southward from the City of Frederick for some time into the north-central and eastern portions of Ballenger Creek's 23.4 square mile watershed. Large tracts of agricultural and forested land are present in the western half of the watershed; however, residential uses also appear to be slowly expanding in this area. As part of the overall NPDES support contract for Frederick County, Versar, Inc. began the assessment of Ballenger Creek watershed in March 2000.

Because geology, vegetation, and land use all influence watershed hydrology, water quality, and aquatic habitat, the focus of this study was to assess current conditions in the Ballenger Creek watershed, and then use this information to identify opportunities to improve water quality. As such, the watershed assessment was tailored to gather data on the watershed's natural resources and then consider rural and urban stormwater impacts in both the present and future. Knowledge of present and future stormwater impacts was then used to develop recommendations that will help Frederick County implement long-term strategies for stormwater management (SWM).

Data gathered in this assessment will also serve as a baseline against which the efficacy of future best management practices (BMPs) to control non-point source pollution can be measured. As additional BMPs are implemented, continued monitoring will provide data that can be compared to this baseline and other historical information. Any reduction in pollutants (i.e., improved water quality) provided by the new BMPs should be evident in the monitoring data. A process of adaptive management (based on the long-term monitoring), maintenance of existing BMPs, and the introduction of additional BMPs and source controls, should effectively reduce non-point source pollution within the study area.

This report documents the findings of the Ballenger Creek watershed assessment. Assessment components include a description of methods (Section 2), general description of the watershed (Section 3), an assessment of existing conditions in the watershed (Section 4), an assessment and ranking of water quality problems and identification of opportunities to improve water quality (Section 5), and development of a watershed water quality plan (Section 6).

2.0 METHODS

This assessment involved characterizing stream conditions, geology, land use, wildlife, infrastructure, pollution sources, and development patterns within Ballenger Creek watershed. This information was obtained via field sampling and visual surveys, telephone contacts, and reviews of existing databases, reports, and maps.

The methods employed in this watershed assessment followed those outlined in the Long-Term Monitoring Plan for the Peter Pan Watershed (Southerland et al. 1999) and the Watershed Assessment of Lower Bush Creek, Frederick County, MD (Roth et al. 1999a). Alternative procedures, if applicable, have been described in the following sections.

2.1 Stream Assessment

An important component of the watershed assessment involved the collection of physical, biological, habitat, and water quality information to assess conditions within Ballenger Creek. As shown in Figure 2-1, six monitoring stations were established along the mainstem of Ballenger Creek. These stations were established just below the confluence of several of the larger tributaries in order to help identify catchments that may adversely influence Ballenger Creek's overall condition.

Field sampling at the Ballenger Creek stations was implemented according to the schedule outlined in Table 2-1. Spring sampling was conducted on April 24-26, 2000. Fall sampling was conducted on September 29 and October 3-6, 2000.

Table 2-1. Sampling schedule for the watershed monitoring stations

Spring	Fall
Chemical water quality: ! multi-meter parameters, turbidity, and air temperature	Chemical water quality: ! multi-meter parameters, turbidity, and air temperature
Physical habitat: ! qualitative physical habitat assessment ! quantitative geomorphologic assessment	Physical habitat: ! qualitative physical habitat assessment
Biological monitoring: ! benthic macroinvertebrates	Biological monitoring: ! benthic macroinvertebrates ! fish

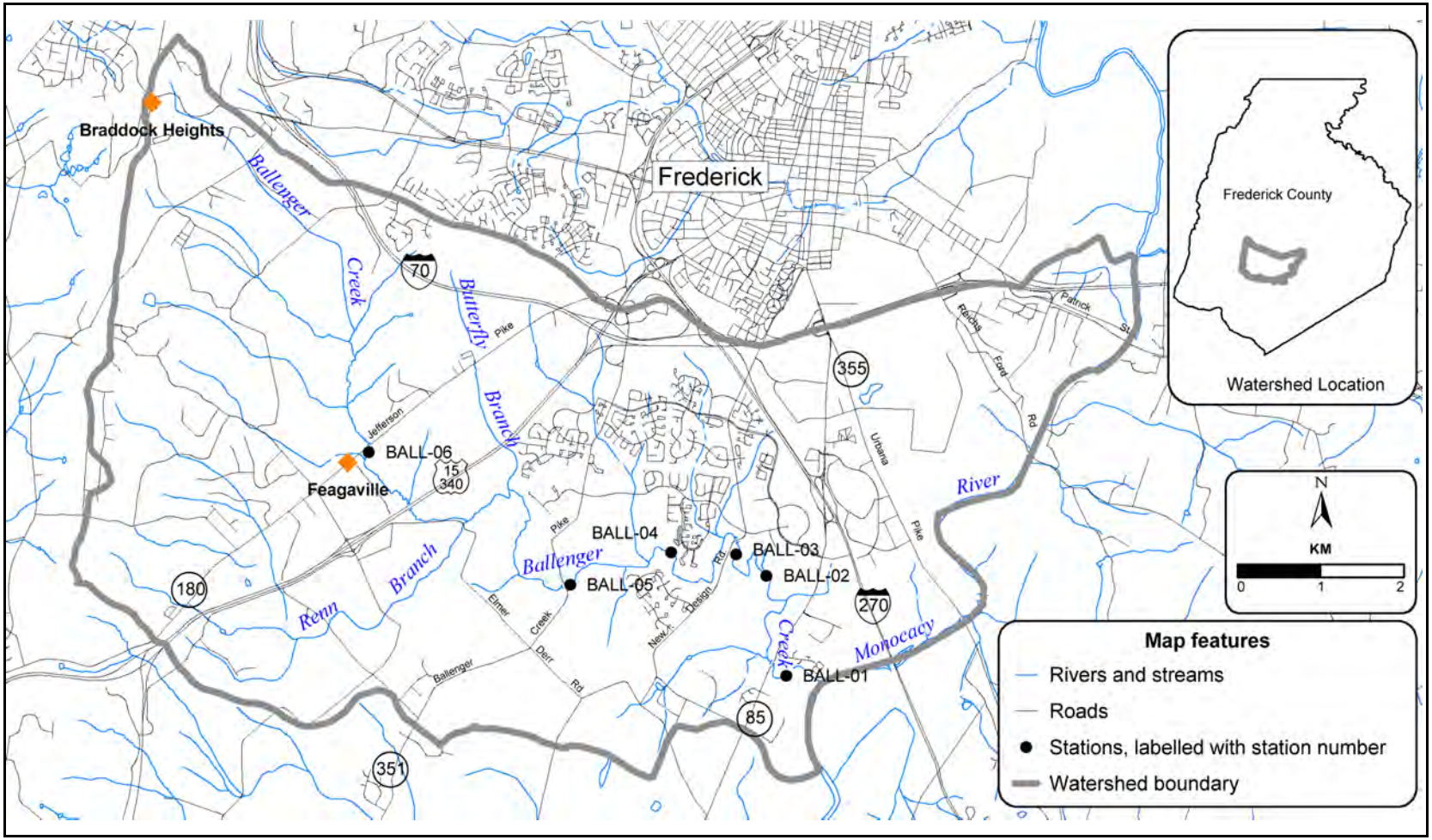

Figure 2-1. Ballenger Creek watershed, Frederick County, Maryland. Six stream sampling stations established in 2000 are shown.

Additional stream data from Ballenger Creek were extracted from Maryland Biological Stream Survey (MBSS) statewide databases and examined to supplement the County's data collection efforts. During spring and summer 1996, five sites in Ballenger Creek watershed were sampled by the MBSS (Figure 2-2), a program of the Maryland Department of Natural Resources (MDNR) designed to assess conditions in non-tidal streams statewide (Roth et al. 1999b). The site locations were randomly selected to characterize conditions statewide and in the Middle Potomac River basin, one of 17 large subunits of the state. MBSS collects data on water chemistry, physical habitat, and biota, including fish and benthic macroinvertebrates (Mercurio et al. 1999) using techniques similar to those employed in this field assessment.

2.2 Geologic Characterization

The geology of the Ballenger Creek watershed was characterized using soils maps from the Frederick County Soil Survey, recent state topographic and geological maps, and background information compiled by the County Department of Planning and Zoning. Soils of Frederick County were mapped as part of the 1960 Frederick County Soil Survey (Matthews 1960; Bard et al. 1985).

2.3 Land Use, Land Cover, and Vegetation Analysis

Frederick County provided current (1997) land use and land cover data for the Ballenger Creek watershed. This data was part of a state-wide dataset prepared by the Maryland Office of Planning (MOP). Additional data sources used in land cover analysis included County zoning maps, comprehensive plans (FCDFZ 1991, 1992) and Trends and Issues Reports (FCDPZ 1999a,b) for Frederick and Adamstown Regions, a Frederick County street atlas (ADC 1998), and field verification during March through October 2000.

Vegetation and land cover within the watershed were also examined by photo interpretation of recent, low-altitude aerial photography. Aerial photographs used for the study were 3.75-minute series (quarter-quadrangle) digitally-rectified orthophotos produced by the MDNR in 1993, as well as quarter-quadrangle aerial photographs taken by Frederick County on March 31, 2000. The aerial photographs also characterized the overall areal extent of each of the upland vegetation and land cover types.

2.4 Wildlife and Threatened and Endangered Species

This assessment did not attempt to quantify wildlife directly; animals, however, were recorded from observations made in the watershed during a reconnaissance survey on July 20, 2000, and during numerous trips to the area for previous studies conducted during the summers of 1996 and 1999. To augment field observations, written inquiries were made to the Maryland Natural Heritage Program regarding the presence of species of concern within the watershed boundaries.

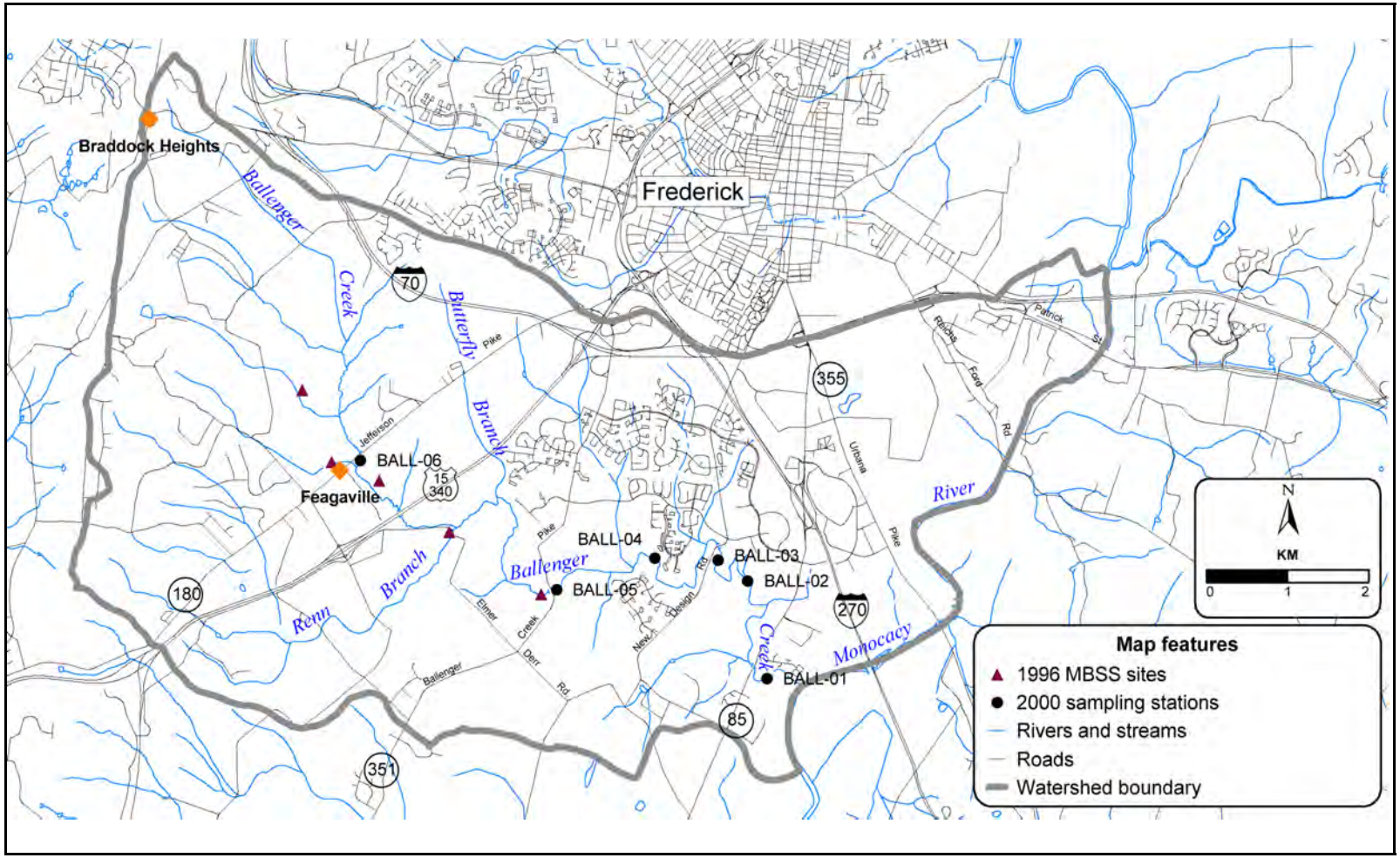

Figure 2-2. Stream sampling stations (2000) and Maryland Biological Stream Survey Sites (1996) in Ballenger Creek watershed.

2.5 Visual Inspection for Potential Watershed Stressors

A visual inspection of the watershed was conducted on July 18 and 20, 2000 to identify potential stressors on stream water quality. Prior to the visual survey, County, State, and U.S. Environmental Protection Agency (USEPA) databases, as described in Section 2.7, were reviewed to identify the location of facilities that may involve the release of pollutants to surface water. Owing to the large number of facilities identified in the database review, only a selected number of facilities were identified for observation in the field. During the visual inspection, experienced personnel drove through the watershed and observed conditions at most of the stream and road crossings, as well as a large number of stormwater management facilities. Customized data sheets were used to record watershed and stream stressors likely to be observed in a watershed such as Ballenger Creek. Notes and photographs were taken at many of these locations to document stream and watershed conditions. To assess conditions at locations without road access, topographic maps and 1993 and 2000 aerial photographs were examined.

2.6 Infrastructure Analysis

Staff of the Frederick County Planning and Zoning Department, Health Department, and Department of Public Works were contacted regarding relevant information on water, sewer, and transportation infrastructure. Information sources included County and regional plans, several County reports, and hard copy and digital maps.

2.7 Inventory of Pollutant Sources

Using a Geographic Information System (GIS), site locations from Frederick County's SWM facility database and Maryland Department of the Environment's (MDE) NPDES permit tracking database were plotted on a map of Ballenger Creek watershed to determine the number and type of outfalls located within the watershed (Figure 2-3). Databases maintained by MDE (NPDES) and the USEPA (Permit Compliance System, Toxic Releases Inventory, and the Comprehensive Environmental Response, Compensation, and Liability Information System) were searched to identify permitted point source discharges or known sources of contaminants within Ballenger Creek watershed. Field checks were done at several sites near the watershed perimeter to verify that they drain to Ballenger Creek and not to adjacent watersheds. Other potential pollution sources observed during field visits and inspection of aerial photographs were recorded as part of this inventory.

2.8 Zoning and Population Projections

Current land use, zoning, and population data were compiled to estimate current and future (year 2020) environmental conditions in the Ballenger Creek watershed, particularly in relation to water quality and stormwater management. Current GIS land use data were obtained from the MOP 1997 land use maps supplied by Frederick County. Examination of the land use data

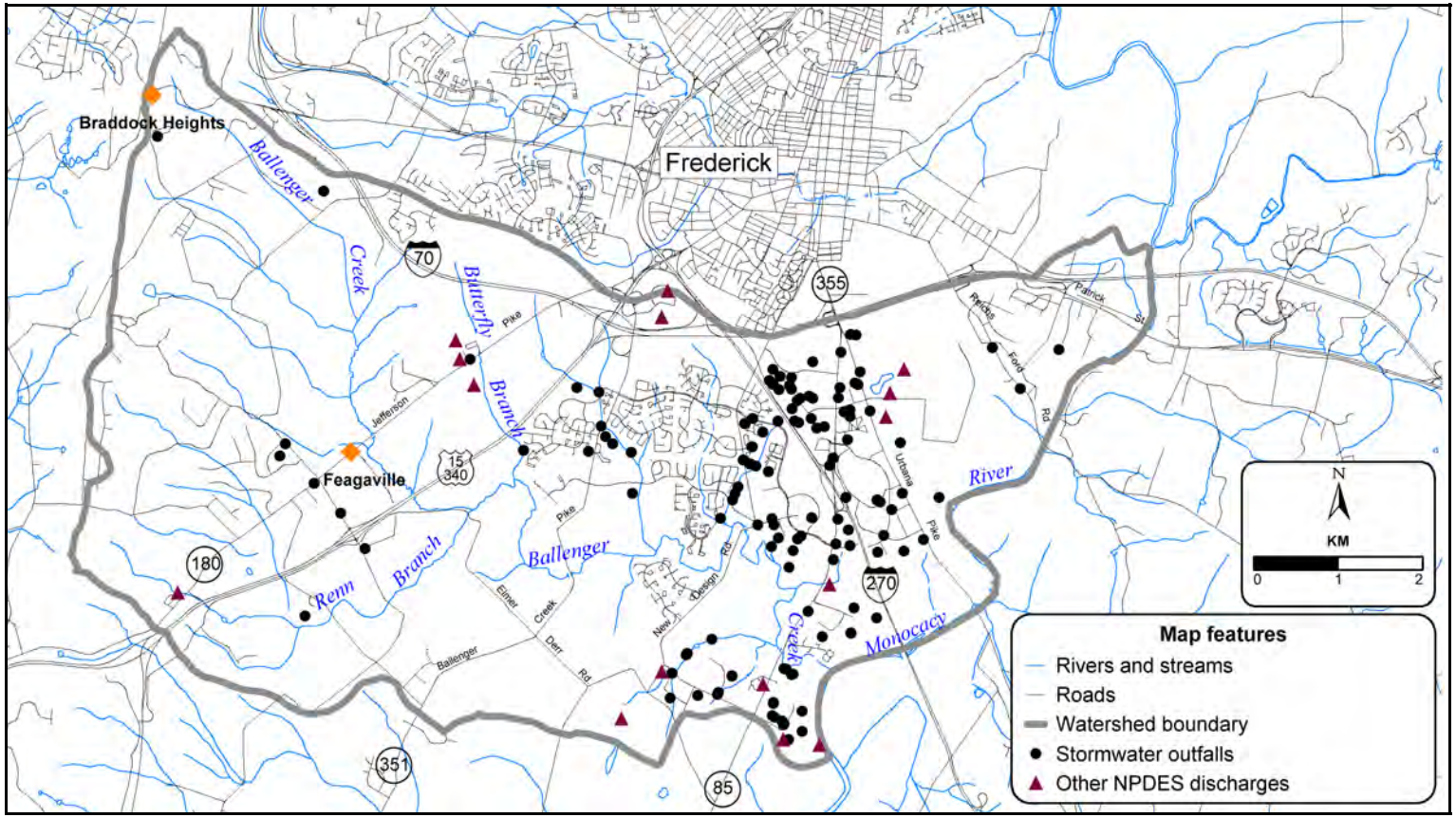

Figure 2-3. Stormwater management facilities and other NPDES point source discharges within Ballenger Creek watershed

indicates that MOP incorrectly classified Ballenger Creek Park as "extractive", perhaps due to construction at or adjacent to the park at the time the land use was observed. Zoning information for the watershed was digitized from the Frederick and Adamstown Region Plans (FCDPZ 1992, 1991) and from 1995 City of Frederick Zoning District Maps (City of Frederick 1995).

Current and future populations within the Ballenger Creek watershed were derived from data provided by Frederick County Department of Planning and Zoning (Dudley, 2000). The County supplied population, housing, and employment projections through the year 2020 for a set of 22 traffic analysis zones (TAZs) covering the area of the watershed. Because some TAZs extended outside the watershed boundary, TAZ boundaries were digitized from a map provided by the County, and GIS was used to calculate the proportion of area of each TAZ falling within the watershed. Proportions were then multiplied by the County's TAZ demographic statistics, and values then summed to estimate the watershed's current and future population, number of households, and employment.

Future land use projections for the Ballenger Creek watershed were based upon the most recent zoning maps available (1991, 1992, and 1995), and represent an ultimate future "build out" condition in the watershed in which each area was assumed to be completely developed according to its zoned use. Because 22 agricultural, residential, commercial, industrial, and resource conservation zoning classifications were represented in the watershed, each zoning class was assigned to one of the MOP land use classifications to facilitate comparison of existing and projected future land use data (Table 2-2). These future land use projections represent conditions in approximately 20 years (e.g., year 2020). These projections are conservative in that all parcels are assumed to be developed to their highest potential use allowable under current zoning regulations, regardless of ownership or current regulations limiting the intensity or extent of development on a given parcel.

2.9 Impervious Surface

The amount of impervious surface within the Ballenger Creek watershed was calculated by assigning a percent impervious value to each land use class (Table 2-3). The percent impervious values were then multiplied by the area of their respective land uses, followed by summing the products. The total was then divided by the total area to produce a percent impervious value for the Ballenger Creek watershed.

Table 2-2. Frederick County and City of Frederick Zoning classes with their assigned land use classes

Zoning Class	Land Use Class
Agriculture	Agriculture
City (undefined)	City (outside watershed)
City - neighborhood commercial (B-1)	Commercial
City - planned industrial (M0)	Industrial
City - limited employment (M1)	Industrial
City - general employment (M2)	Industrial
City - medium-density residential (R3)	Medium-density residential
City - medium-density residential (R4)	Medium-density residential
General commercial	Commercial
General industrial	Industrial
Limited industrial	Industrial
Mineral mining	Extractive
Office/research industrial	Industrial
Planned unit development	Medium-density residential
Residential (R1)	Low-density residential
Residential (R3)	Low-density residential
Residential (R5)	Medium-density residential
Residential (R8)	Medium-density residential
Residential (R12)	High-density residential
Residential (R16)	High-density residential
Resource conservation	Forest/Brush
Village/town center	Commercial

Table 2-3. Percent impervious values assigned to land use in Ballenger Creek watershed (after Camp, Dresser, McGee 1997; CWP 1998)

Land Use	Percent Impervious
Low-density residential	15
Medium-density residential	35
High-density residential	60
Commercial	90
Industrial	80
Institutional	35
Extractive*	80
Open Urban Land	5
Cropland	3
Pasture	3
Feeding Operations	3
Agricultural building	3
Deciduous forest	1
Evergreen forest	1
Mixed forest	1
Brush	1
Bare ground*	80

* Estimated values

3.0 DESCRIPTION OF THE WATERSHED

The Ballenger Creek watershed, designated as Frederick County Watershed M-20, is 14,955 acres (23.4 square miles) in size. Ballenger Creek is a fourth order stream that has been designated by MDE as Class III Natural Trout Waters (FCDPZ 1998). The creek drains eastward into the Monocacy River, which it joins at the Monocacy National Battlefield. The Monocacy is a National Scenic River, but has also been placed on MDE's 303(d) list of waters impaired by nonpoint source pollution. The geology, soils, general land use, vegetation, and land cover found within the Ballenger Creek watershed are described in the following sections.

3.1 Geological Setting

As reviewed in the Frederick County Comprehensive Plan (FCDPZ 1998), Frederick County lies within two of the three geologic provinces in Maryland, the Piedmont Province and the Appalachian Province. The Piedmont Province extends westward from Washington D.C. and Baltimore to Catoctin Mountain and is divided into an Eastern and Western Division. The Ballenger Creek watershed is located within the Western Division, which is characterized by gently rolling terrain and slow-flowing streams. The watershed is primarily composed of three geologic areas; a limestone formation area known as the Frederick Valley, the Triassic Plain made up of harder rock materials overlying limestone formations, and a quartize formation that underlies Catoctin Mountain on the western edge of the watershed (Figure 3-1).

Frederick Valley is a large area of limestone bedrock, the Frederick Limestone formation, which ranges in age from Middle Cambrian to Early Ordovian (Figure 3-2). Most of the bedrock consists of thin-bedded, dark bluish gray limestone with thin, shaley partings. Some thick-bedded, light gray, high calcium limestone, massive dolomite, and quartize limestone also occur in a strip along the center of the valley. Because the limestone is easily eroded and dissolved in the humid climate of eastern North America, the bedrock of the Frederick Valley has formed a low-lying, level terrain. Cavernous zones and solution channels that permit underground drainage are common in the limestone bedrock of the Frederick Valley. Soils are irregular in depth but generally thick. Knobs or pinnacles of the more resistant bedrock layers protrude from beneath the soil cover in many places.

The **Triassic Plain** lies in a narrow strip of the Oxford formation south of Frederick City between the Frederick Valley and Catoctin Mountain that consists of red-colored shales and sandstones. These materials include a conglomerate of limestone cobbles and pebbles cemented over time with a mix of calcareous mud and sand. A dark greenish-gray to black igneous rock, known as diabase, has also intruded along fracures in the crust in this area. The diabase rocks are hard and resistant to weathering and have formed knobby hills and short narrow ridges. Soils developed on the Triassic Plain are thin, clayey to sandy, and lie upon the relatively undecomposed bedrock. This part of the region is characterized by rolling topography and swiftly flowing streams.

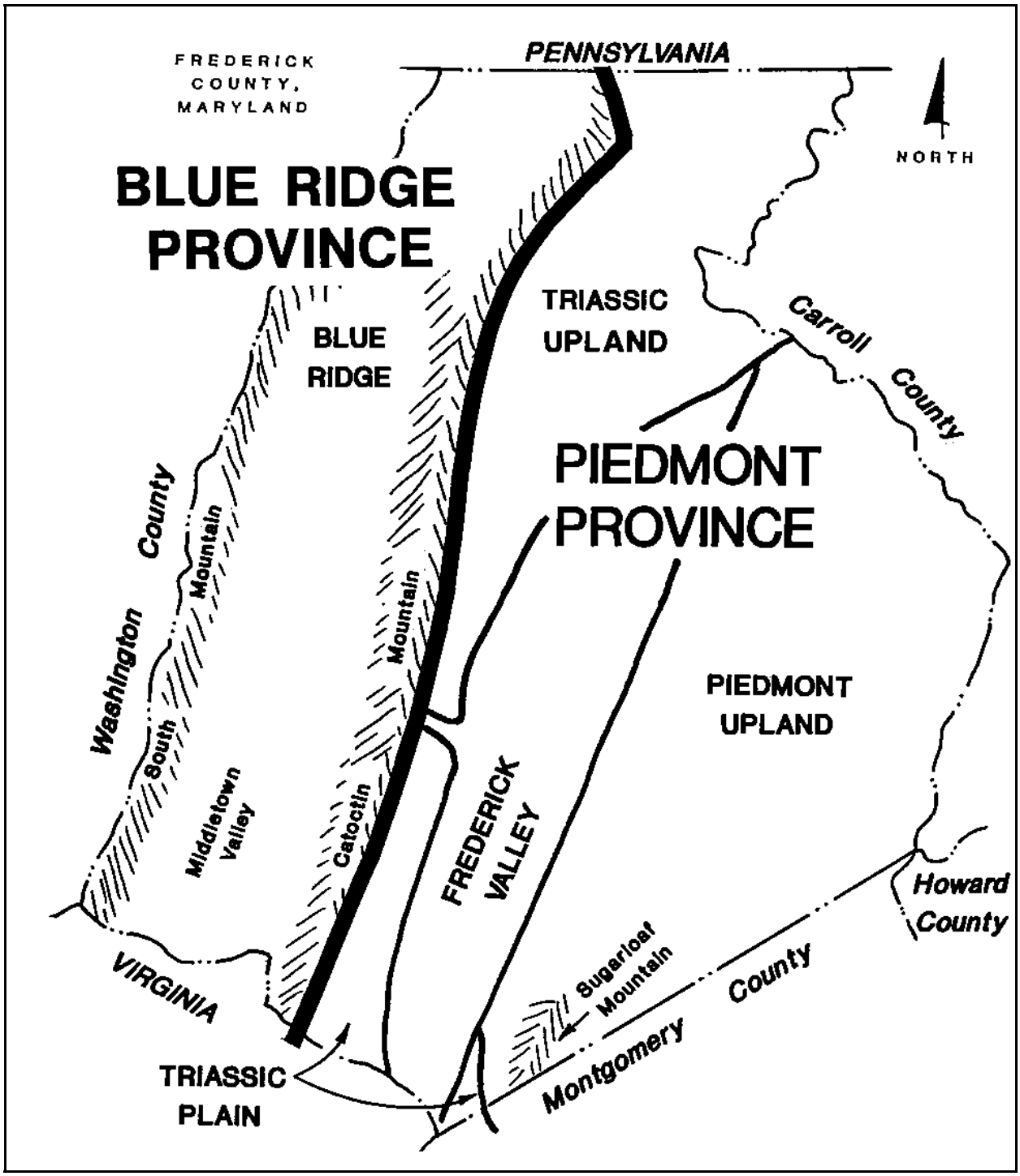

Figure 3-1. Physiographic provinces within Frederick County (FCDPZ 1998)

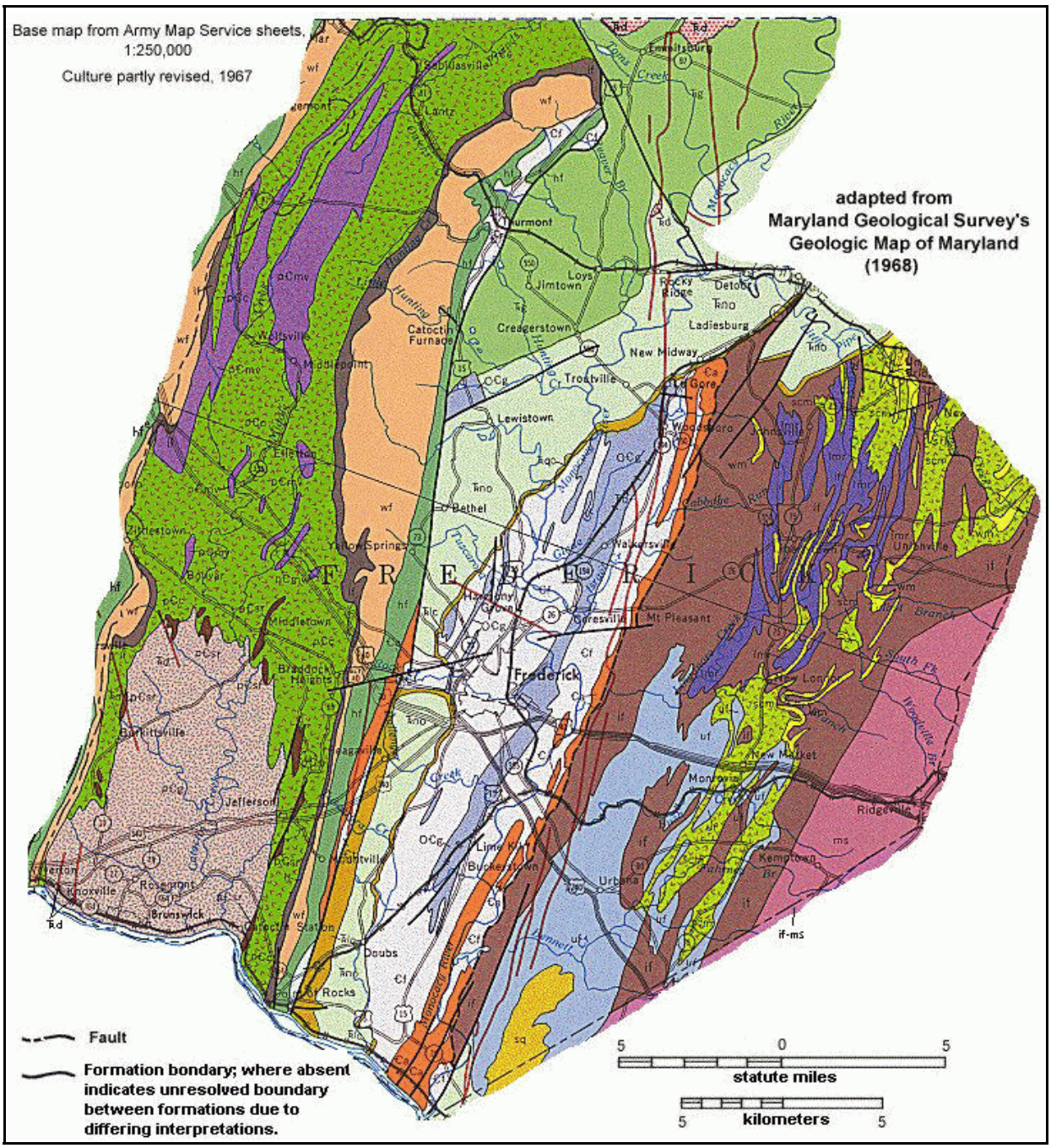

Figure 3-2. Geologic map of Frederick County (Maryland Geologic Survey 1968)

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TRIASSIC

Diabase Sills and Dikes
Sills: greenish-gray to black, medium-grained;
dikes: greenish-gray to black, medium- to fine-grained; local contact metamorphic aureoles.

Newark Group

Gettysburg Shale
Red shale and soft red sandstone, siltstone; estimated thickness less than 5,000 feet.

New Oxford Formation
Red, maroon, and gray sandstone, silts tone and shale; basal conglomerate member: From vicinity of Maryland Rte. 73 and southward, limestone conglomerate with red and gray calcareous matrix; northward, quartz conglomerate with red sandy matrix; estimated total thickness 4,500 feet.

ORDOVICIAN

Grove Limestone
Dark gray to light dove, thick-bedded limestone; dolomite beds in lower part; highly quartzose limestone at base; Upper Cambrian to Lower Ordovician in age; thickness approximately 590 feet.

CAMBRIAN

Frederick Limestone
Blue, slabby, thin-bedded limestone and minor shale; contains Upper Cambrian (Trempealeauian) fuanule; thickness approximately 480 feet.

Tomstown Dolomite
Interbedded light gray to yellowish-gray, thin- to thick-bedded dolomite and limestone; some shale layers; gradational contact with Antietam; thickness 200 to 1,000 feet.

Chilhowee Group

Antietam Formation
White to dark gray and brown, thick-bedded, fine- to coarse-grained quartzite with thin argillaceous partings; first occurrence of Lower Cambrian fossils; cleavage generally obscures bedding; increasingly metamorphosed and phyllitic toward east; estimated thickness 300 to 800 ft.

Harpers Formation
Brown to dark bluish-gray banded shale, light bluish-gray, finely laminated phyllite; distinctively pale purple in basal part; bedding obscured by cleavage; increasingly metamorphosed toward east from shale to slate and phyllite; estimated thickness 2,000 feet.

Weverton Formation
Interbedded white to dark gray, thin-bedded micaceous, ferruginous, and sericitic quartzites, phyllites, and white, thick-bedded, ledge-making quartzites; some gray to brown ferruginous quartz conglomerate and purple-banded phyllite; thickness approximately 100 feet in south, increases to 425 feet in north.

Loudoun Formation
Upper conglomerate member: Quartz and granitic pebbles in pale purple phyllitic matrix; basal phyllite member: Pale purple, discontinuous, lenticular; members are in gradational contact; total thickness 0 to 200 feet.

LATE PRECAMBRIAN (?)

Metarhyolite and Associated Pyroclastic Sediments
Metarhyolite: Dense, blue, cryptocrystalline, with white feldspar phenocrysts and glassy quartz; red porphyritic metarhyolite at contact with Catoctin Metabasalt; Pyroclastic sediments: Tuff breccia, blue slaty tuff, white tuffaceous sericitic schist, and banded green slate.

Catoctin Metabasalt
Thick-bedded metabaslt with amygdaloidal layers and secondary veins of quartz, calcite, and epidote; interbedded green tuffaceous phyllite and blue amygdaloidal metaandesite.

Swift Run Formation
Sericitic quartzite and phyllite; blue and green tuffaceous slate with sericitic blebs; some white marble with interbedded phyllite.

PRECAMBRIAN

Granodiorite and Biotite Granite Gneiss
Light gray to pale green, fine-grained, granodiorite gneiss, and dark gray biotite granite gneiss with some augen gneiss; in places a sheared muscovite-biotite gneiss; local biotite schist bands; intruded by metadiabase feeder dikes of Catoctin Metabasalt.

Figure 3-2. (Continued)

Catoctin Mountain is one of the most visible and distinctive natural features in the area and its ridge represents the watershed's western boundary. The mountain is composed of a thick layer of quartize bedrock of Early Cambrian age comprised of several formations, including the Antietam and Harpers (Figure 3-2). This ridge is the eastern edge of a great fold in the Earth's crust which once arched over the Middletown Valley area to the west of the watershed. The quartzite typically found in the ridge is very resistant to weathering and erosion, in comparison to the more erodable formations in the adjacent Piedmont, which enables the ridges to stand out in topographic relief as mountains. On Catoctin Mountain, the soils are thin and stony because of soil creep and erosion.

3.1.1 Karstic Terrain

This watershed is crossed by a belt of limestone conglomerate that runs from north of the confluence of the Monocacy and Potomac Rivers, angling upward beyond the watershed boundaries through Frederick City to the Town of Woodsboro. Bedrock in this area includes limestone suspended in a mixture of other geologic materials. Limestone is a carbonate rock and is subject to weathering and the formation of solution channels and sinkholes. In this karst terrain, groundwater flows within a natural underground system of interconnected channels that collectively transmit water. These karstic lands are very sensitive to hydrogeologic changes. Stresses induced by human activity exacerbate environmental problems that are naturally inherent within karst terrain. Environmental concerns include (1) introduction of contaminants into the groundwater, (2) sinkholes (i.e. sudden collapse of land surface), and (3) flooding during or following intense storms. These problems are accelerating with the expanding development and urbanization (FCDPZ 1998). The formation of solution channels in the limestone bedrock creates problems when human activity, such as excessive pumping of groundwater or human-induced changes in surface water flows de-water cavities near the the surface. When the supporting water is removed, the weight of the overburden and any structures on the surface cause the roof of the cavity to collapse, forming a sinkhole. Their presence in a particular area indicate that additional sinkholes may develop there in the future. Karst terrain in the Ballenger Creek watershed is a major concern for County planners and stormwater managers, and as such is discussed in more detail throughout this report.

3.1.2 Topography

Topographic maps show that the watershed generally slopes from west to east (USGS 1977, 1984, 1993). The highest point in the Ballenger watershed is in its headwaters along the east slope of Catoctin Mountain, specifically just west of Edgemont where elevations reach 859 feet. The mouth of Ballenger Creek at its confluence with the Monocacy River is the lowest point in the watershed, with an elevation slightly less than 240 feet. Average elevation within the watershed is approximately 450 feet.

3.1.3 Soils

Eight principal soils series are found within the watershed area, including Duffield, Athol, Penn, Chandler, Croton, Rough Stony Land, Lindside and Hagerstown. With the exception of the Chandler and Rough Stony Land series, the soils can be classified as prime farmland within most seasons and conditions. Other soils series are present within the watershed, but are found in small, scattered parcels. The major soil groups, as mapped by the Frederick County Soil Survey (Matthews 1960), within the watershed boundaries are described below.

1. **Duffield silt loams,** 3 to 8 percent slopes, moderately eroded (DeB2**)** is the predominant soil type throughout eastern part of the watershed, along Route 180 from Buckeystown north to Route 40. This Duffield series also contains elements of Frankstown silt loam and consists of deep, well-drained soils that developed from impure limestones. Permeability is moderate. These soils occur in the broad, shallow Frederick Valley, and are drained by the Monocacy River. They are fertile, highly productive, and easy to manage. They are also extensive throughout the County, and are one of the most important soils in the county for agriculture. Duffield soils are not considered hydric.

2. **Athol gravelly loam,** 3 to 8 percent slopes, moderately eroded (AbB2) and Athol Gravelly Loam, 0 to 3 percent slopes (AbA) are also a predominant soil types, especially in the more western areas (east of the mountains) of the watershed. The Athol series consists of deep, well-drained soils formed in materials weathered from conglomerate or breccia, and cemented by a red matrix. Permeability in these soils is moderate. In color, the Athol soils resemble soils in the Penn series (with which they are associated), but have a greater available water capacity. Athol soils are fairly extensive in Frederick County. They generally occur in places where the underlying limestone merges with shale and limestone. Athol soils are not considered hydric.

3. **Penn-Lansdale loam,** 0 to 8 percent slopes, moderately eroded (PhB2), and Penn Loam, 0 to 8 percent slopes, moderately eroded (PbB2) are predominantly found in the western sections of the watershed, in association with the Athol soils. The Penn series consists of moderately deep, well-drained soils on uplands. They formed from weathered purplish-red or dark red shale and sandstone. Permeability is moderate or moderately rapid. Penn soils occur in the valley between the Catoctin Mountain in the west and the Piedmont Plateau to the east. With the exception of the Manor soils of the Piedmont Plateau, they are more extensive than any other soils in the county and in this watershed. Penn soils are not considered hydric.

4. **Chandler and Talladega channery loam,** 10 to 20 percent slopes, moderately eroded (CeC2), Chandler and Talladega silt loams, 0 to 10 percent slopes, moderately eroded (CgB2), and Chandler and Talladega silt loam, 20 to 35 percent slopes, moderately eroded (CgD2) are the predominant soils found on the east slope of the

Catoctin ridge within the watershed. This series consists of moderately deep, somewhat excessively drained soils on the mountains and the foot slopes. These soils have developed from highly micaceous materials weathered from rather hard talcose schist and mica-schist that, in many places, contains intrusions of hard, white quartzite or quartzose schist, or both. Chandler soils are extensive in Frederick County and occur primarily on the east slope of the Catoctin ridge. The Chandler soils are relatively low in fertility and are not productive for agriculture; they are also droughty and erodible. Chandler and Talladega soils are not considered hydric.

5. **Croton silt loam**, 0 to 8 percent slopes (CtB), has a permeability that is moderately slow to slow. Are found mainly in the northeastern areas of the watershed near Pike Branch at Ballenger Creek. The Croton series consists of deep, poorly drained soils developed from weathered red shale and sandstone of Triassic age. The soils occur in upland faults and depressions, and around heads of drainage areas. These soils are associated primarily with soils of the Penn and Readington series and are not considered hydric.

6. **Rough stony land (Re)** is found along the top of the entire length of the Catoctin ridge. Rough stony land consists of areas so rough, broken, stony, and rocky that they cannot be used for any kind of agriculture. Fragments ranging from small stones to large boulders are strewn on the surface and imbedded in the soil. Outcrops of hard rock are common. In some of the largest areas, stones consist of sandstone or quartzitic sandstone. In other large areas, the stones are primarily hard greenstone. Some smaller areas contain the fragments of micaceous schist or other rock material. Rough stony land is located in the western mountainous areas of the watershed, such as Catoctin Mountain. Many of the slopes are strongly broken and complex. Most of the areas mapped in this type are forested. Rough stony land soils are not considered hydric.

7. **Lindside silt loam,** 0 to 3 percent slopes (LkA), and Lindside silt loam, local alluvium, 0 to 3 percent slopes (LmA) consists of deep, moderately well-drained soil on flood plains and in upland depressions. The Lindside soils are found in the eastern-most areas of the watershed, along the Arundel Branch of Ballenger Creek. Most of these soils formed in recent alluvial material. Many small areas have developed in material accumulated by gravity and local washing action on foot slopes. Permeability is moderately slow or moderate. These soils are fairly fertile; however, those on flood plains are very wet and are frequently flooded. The subsoil may be silty clay loam or clay loam in some places. In some areas a few pieces of fine gravel consisting of chert, limestone, or shale are in the upper three soil horizons. They are more common in the local alluvium phases of this soil series. In many places the soil is underlain by thick deposits of rounded gravel. Lindside soils are not considered hydric, with the exception of areas that possess inclusions of soils from the Melvin series.

8. **Hagerstown loam,** 0 to 8 percent slope (HbB2), and silt loams 3 to 8 percent slope (HeB2) and 8 to 15 percent slope (HeC2). The Hagerstown series consists of deep, well drained soils, formed in material weathered from rather hard, pure limestone. Permeability is moderate. These soils are highly productive if well managed. Normal Hagerstown soils are generally deep but have some limestone near the surface, with occasional rock outcrops. Hagerstown loams are not considered hydric.

3.2 General Land Uses

Ballenger Creek watershed contains a mixture of land use types, but is primarily influenced by its proximity to the City of Frederick. In general, the north-central portion of the watershed consists largely of residential subdivisions. The area east of I-270 is largely used for commercial or industrial uses, with several large businesses centered around the Genstar Stone Products limestone quarry. The corridor along State Route 85 (MD 85; Buckeystown Pike) is lined with commercial businesses. Five large industrial parks are located just west of MD 85 (ADC 1998). The half of the watershed west of Ballenger Creek Pike contains a mix of agricultural as well as low density residential properties. Scattered, large forested tracts remain within the watershed, often in areas of steeper slopes along the Catoctin front.

One area, approximately 240 acres, located at Elmer Derr Road and Ballenger Creek Pike is listed as an agricultural district under the Maryland Agricultural Land Preservation Program (Maryland Greenways Commission 1996). Under this easement program, development rights are sold and held in perpetuity by a land conservation foundation. Because of high development pressure, it is unlikely that many additional lands in the watershed will be added to this program.

There are three areas of parkland within the watershed. A portion of the Monocacy National Battlefield, approximately 480 acres, is located in the southeast. Two county parks, Ballenger Creek Park (approximately 240 acres) and Braddock Heights Park, (approximately 250 acres) are located, respectively, in the central and northwestern corner of the watershed. Development in these areas is unlikely.

The Ballenger Creek Trail, a streamside walking trail project, is currently being considered by the Maryland Greenways Commission and Frederick County Trials, Inc. According to a Site Analysis and Preliminary Master Plan prepared by Human & Rohde, Inc., the proposed trail would parallel the north side of Ballenger Creek, extending upstream from the Monocacy River to the Ballenger Creek Park (S. Molena, Human & Rohde, Inc., personal communication, 2000; Human & Rohde, Inc., 2000).

Statewide land use data from 1997, developed by the MOP, were used to characterize general watershed land cover. These data show the watershed to be dominated by agriculture (59 percent of watershed area) with smaller amounts of residential and commercial/industrial/office development and forest/brush vegetation. Aerial photographs from April 2000 indicated several

areas that have undergone substantial land use change since 1997. A more thorough and detailed discussion of current and future land use activities may be found in Section 4.8.

3.3 Vegetation and Land Cover

Vegetation and land cover play a role in maintaining water quality, and are evaluated in this watershed assessment. Vegetation and land cover in the Ballenger Creek watershed consists of agricultural land, forested areas (deciduous and coniferous), oldfield (transitional vegetation), wetlands, and developed areas (residential, commercial, and industrial). With the exception of developed land, these land cover types are described in more detail below. Most vegetation within developed areas is limited to lawns or cultivated species and as such will not be addressed further in this section. The estimated aerial extent of each as a percentage of the overall study area is presented.

A vegetation field survey was conducted in June 2000 to identify major plant species found in the Ballenger Creek watershed. Plant species observed during this recent survey as well as those reported during a 1996 study conducted in the vicinity of the watershed are presented in Appendix A, Table A-1.

Agricultural Land

As previously mentioned, agricultural land covers approximately 59 percent of the Ballenger Creek watershed. The principal crops planted at the time of the June 2000 field survey were soybeans, corn, and wheat. Generally, several varieties of soybeans are planted in this area including full season and partial season types. The partial season varieties are typically planted in late March or early April in the area, after an early season crop such as winter wheat is harvested. Dairy farms in the area typically plant hay, legumes, and corn fodder crops.

Forested Areas

Frederick County has one of the lowest rates of forest cover in Maryland. Much of what was formerly dense hardwood forests has been converted to farmland, residential, or industrial areas. Forested areas cover approximately 13 percent of the Ballenger Creek watershed. Because of the generally developed nature of the area, upland forest is usually located within areas having topographic constraints toward development such as the steep slopes and ridges abutting and within the Catoctin Mountain Range on the western boundary of the watershed. It is in this area where the largest contiguous forested parcels are located. Large sections of riparian forests are also found adjacent to streams, the Monocacy River, and roads. Significantly forested parcels in the watershed area occur in parkland and/or riverine areas along Ballenger Creek and the Monocacy River. Smaller parcels and forested lots are scattered throughout the watershed.

Forest types in the Ballenger Creek watershed vary between the uplands and lowlands. The tree canopy in the western contiguous forested areas is relatively dense, and ranges in height from

about 50 feet to about 80 feet. The forest also possesses moderately dense shrub and herbaceous layers. Principal trees in western upland forest areas include silver maple, pignut hickory, slippery elm, tulip poplar, black oak, and chestnut oak. Spicebush and Japanese honeysuckle are the predominant species in the shrub/woody layer of the upland forest. The herbaceous layer is often sparse in certain forested parcels owing to the shade created by the dense tree and shrub layer. Predominant herbaceous species throughout include mayapple, white avens, jumpseed, and clearweed.

Principal riverine trees along Ballenger Creek and its tributaries include hackberry, black cherry, tree of heaven, tulip poplar, red maple, and slippery elm. In the shrub layer of these wetter regions, poison ivy, Japanese honeysuckle, tartarian honeysuckle, multiflora rose, and spicebush are the principal species. In the herbaceous layer, wingstem, pokeweed, wicker microstegium, and several unidentified polytrichum moss species were observed.

Oldfield

Mapping analysis and field observation indicated that oldfield areas within the Ballenger Creek watershed are typically found at the edges of cultivated fields and abandoned lots. The oldfield observed in the study area was predominantly herbaceous with few scrubby trees and shrubs, and was dominated by broomsedge, yarrow, late flowering boneset, white snakeroot, and butter-and-eggs. The small trees that are scattered within the areas of oldfield or occur around the periphery (generally at the outer edge of cultivated fields and upland deciduous forest) included tree of heaven, black locust, black cherry, and sassafras.

Wetlands

Approximately 7,325 acres of Frederick County (approximately 1.7 percent of the county) were mapped as wetlands by the National Wetlands Inventory during the late 1970s. About 6,355 acres (87 percent) of these wetlands were vegetated; the remaining 970 acres were unvegetated wetlands (primarily open waters of ponds and lakes). The most abundant vegetated wetland types in Frederick County were non-tidal deciduous forested (3,775 acres) and non-tidal emergent (1,789 acres).

Wetlands Features Inventory maps for the study area were obtained from MDNR and reviewed (MDNR 2000a-e). These maps are based on photointerpretation of high altitude, color aerial photography using the Cowardin et al. (1979) classification system. Wetlands within the Ballenger Creek watershed are generally very linear, small, and isolated, and are frequently associated with Ballenger Creek and its tributaries. Isolated wetlands (i.e., not associated with any of the creeks or tributaries in the watershed) are generally herbaceous and are very small (2 acres or less). Several exceptions to this are the man-made wetlands (PUBHx) at the Genstar Stone Products quarry and the Essroc Materials quarry near English Muffin Way.

Several of the identified wetlands areas within the Ballenger Creek watershed were investigated during a vegetation survey conducted in June 2000. Principal vegetation was noted during the reconnaissance by spot-checking the two major types of wetlands (forested and herbaceous), as described below. Investigators noted during the field survey that plant communities in some wetlands have changed since the 1993 aerials were taken. For instance, some large wetland areas located along Renn Road in the southwest portion of the watershed seem to have been impacted by a reduced water supply, as evident by their reduced size and changes in the plant community.

Forested Wetlands

Typical species found in the tree layer of the forested wetlands surveyed were green ash, red maple, silver maple, box elder, black willow, sycamore, and eastern cottonwood. The predominant shrubs in the shrub layers are spicebush, southern arrowwood, multiflora rosa (found in dry to wet places), speckled alder (in wettest places), as well as small saplings of the predominant tree species. The herbaceous layer in the forested wetlands is typically sparse. Jewelweed, several smartweed species, clearweed, honeysuckle, greenbriar, royal fern, Christmas fern, trillium, jack-in-the-pulpit, and false nettle are the most abundant species.

Herbaceous Wetlands

In herbaceous wetlands found in the watershed, predominant species generally include jewelweed, common rush, black rush, reed canary grass, cattail, barnyard grass, rice cut grass, water smartweed, reed canary grass, straw-colored cyperus, arrow leaved tearthumb, sensitive fern, and sallow sedge, joe pye weed, poison hemlock, angelica, and iris species. Depending on wetness, degree of human disturbance, and other factors (such as cattle grazing), the shrub layer is moderately dense to nonexistent in some wetlands; principal shrub and woody vine species include spicebush, red osier dogwood, poison ivy, black willow, and multiflora rose, pussy willow, speckled alder, and southern arrowwood. The species of trees scattered in the herbaceous wetlands were black willow, green ash, black locust, tree of heaven, and tulip poplar.

4.0 ASSESSMENT OF EXISTING CONDITIONS IN BALLENGER CREEK WATERSHED

The environmental assessment of Ballenger Creek watershed involved the collection of field data from six stream stations as well as the characterization of the entire watershed using a variety of ancillary data sources. Methods used to collect these data are summarized in Section 2.

4.1 Chemical, Physical, and Biological Assessment of Selected Stream Sites

As part of this investigation, six long-term monitoring stations were established on the mainstem of Ballenger Creek (Figure 2-1). Photographs of these stations have been included as a photographic log in Appendix B. Spring field activities were conducted April 24-26, 2000 and involved testing water quality parameters, quantifying physical habitat, conducting a qualitative habitat assessment, and sampling benthic macroinvertebrates at the six Ballenger Creek stations. Fall field activities were conducted on September 29 and October 3-6, 2000, and included testing water quality parameters, a qualitative habitat assessment, and sampling for benthic macroinvertebrates and fish.

Results from field water quality testing indicate that April and October 2000 water quality parameters for Ballenger Creek were generally indicative of healthy stream conditions (Table 4-1). Water temperatures were cool, with the highest temperature observed at BALL-02 (17.11 °C) during the fall sampling. Dissolved oxygen (DO) concentrations remain in a range considered healthy for aquatic biota. As expected in typical Maryland Piedmont streams, April and October pH values indicated that the streams are well-buffered from the effects of acid deposition. Specific conductivity measurements in Ballenger Creek tended to increase with distance downstream, with fall values ranging from 0.437 micro-Siemens per centimeter (mS/cm) at BALL-06 to 0.614 mS/cm at BALL-01. This trend in conductivity, which is within a normal range for streams of this type, likely results from the intermixing of groundwater as the stream passes through Frederick Valley's limestone region. Turbidity readings were within normal ranges, though the April 2000 values indicate that Ballenger Creek was more turbid in the spring.

Based upon the April 2000 data presented in Table 4-2, physical conditions within the lower third of Ballenger Creek watershed are strongly influenced by the underlying limestone geology. Portions of Ballenger Creek, such as at BALL-03, are very narrow, deep, and have near-vertical banks, especially in areas where clayey soils or bedrock outcroppings are present. Portions of the creek that have softer, more easily eroded substrate, such as BALL-05 and BALL-06, are characteristically wider, shallower, and have more gently sloping banks (Gordon et al. 1992). Ballenger Creek's slope is fairly steep as it flows down from the Catoctin front, but is more moderate in the lower reaches monitored in this study. Stream gradient was very low at stations BALL-04 and BALL-06. Limited sight distance at BALL-06 prevented the inclusion of a relatively steep riffle section when the slope was surveyed, therefore this measurement is somewhat lower than expected. Particle size distributions indicated that median particle

diameters (D50) at each station are fairly coarse, ranging in size from fine sand (BALL-04) to small cobble (BALL-01), with gravel at three of the remaining four stations. The amount of tree cover was very good, with only one station (BALL-05) having less than 70 percent cover. No change in the bank pins was observed between April and October 2000, however, field crews were not able to observe the bank pin at BALL-05 due to the significant growth of thick vegetation along the stream bank.

Table 4-1. Summary of field water quality data from Ballenger Creek

Station ID	Date Sampled	Air Temperature (ºC)	Water Temperature (ºC)	Dissolved Oxygen (mg/l)	pH	Specific Conductivity (mS/cm)	Turbidity (NTU)
BALL-01	4/26/00	10.0	11.93	10.28	7.36	0.457	11.4
	10/6/00	7.2	16.10	5.22	7.76	0.614	4.5
BALL-02	4/26/00	7.2	10.36	9.88	7.04	0.414	8.2
	10/5/00	10.0	17.11	8.83	8.14	0.559	4.5
BALL-03	4/25/00	12.8	11.77	9.87	7.34	0.396	12.5
	10/4/00	7.2	15.67	7.06	7.82	0.558	6.4
BALL-04	4/25/00	12.8	11.26	8.94	6.81	0.362	12.2
	10/5/00	7.2	16.09	5.75	7.96	0.485	5.0
BALL-05	4/24/00	18.3	13.36	11.60	7.03	0.320	6.7
	9/29/00	10.0	12.38	10.96	7.43	0.420	8.5
BALL-06	4/24/00	12.8	10.14	9.66	6.78	0.289	5.4
	10/3/00	10.0	12.86	8.21	7.22	0.437	4.6

Table 4-2. Summary of qualitative physical data from Ballenger Creek

Station ID	Date Sampled	Avg. Wetted Width (m)	Avg. Channel Width (m)	Avg. Thalweg Depth (m)	Slope	Discharge (cfs)	Discharge (cms)	D50 (mm)	Avg. Percent Canopy Cover
BALL-01	4/26/00	9.97	14.37	0.38	0.003	57.77	1.636	70	93%
BALL-02	4/26/00	9.50	11.20	0.75	0.001	32.15	0.910	35	73%
BALL-03	4/25/00	5.40	8.10	0.75	0.001	37.99	1.076	0.49*	100%
BALL-04	4/25/00	7.50	11.00	0.64	0.00008	37.27	1.055	0.125	80%
BALL-05	4/24/00	6.50	12.50	0.57	0.003	33.32	0.944	20	5%
BALL-06	4/24/00	4.72	8.64	0.41	0.00007	12.5	0.354	5	77%

* Pebble count not performed in 4/00 due to water depth (bottom out of reach). Pebble count performed on 10/4/00.

Because stream discharge normally increases as drainage area increases, the discharge measurements results were interesting. Discharge between stations BALL-05 [33.32 cubic feet per second (cfs)] and BALL-02 (32.15 cfs) remained relatively constant, despite additional flows entering the mainstem from Pike, King, and Arundel Branches. In addition, Quarry Branch was

observed to disappear underground once it reached a wet pond at Crestwood Boulevard, approximately 0.25 miles northeast of Ballenger Creek. The lack of increase in discharge and the occurrence of karst in the vicinity of these stations may indicate that Ballenger Creek is a losing stream, in which water is diverted out of the channel and into the underlying geology. Ritter et al. (1995) note that in karst regions, large portions of the total streamflow may follow a sub-surface pathway that may or may not parallel the stream channel's route on the surface, and the influence of these sub-surface routes on streamflow depends greatly on the degree of interconnection and transmissivity of the underground passageways. In addition, discharge almost doubles by the time Ballenger Creek reaches station BALL-01, which may subsequently indicate that groundwater is re-entering the stream channel prior to its confluence with the Monocacy River. However, these conclusions are based on data from only one point in time and should be re-examined once additional discharge data become available.

A qualitative habitat assessment for riffle/run prevalent streams, developed by Barbour and Stribling (1994), was used to assess physical habitat at each Ballenger Creek station in April and October 2000. Scores for the assessment are divided into the four categories shown in Table 4-3.

Table 4-3. Scoring classes for qualitative habitat assessments in riffle/run prevalent streams (Barbour and Stribling 1994)

Category	**Range**
Optimal	166 - 200
Sub-Optimal	113 - 153
Marginal	60 - 100
Poor	0 - 47

Quantitative habitat scores at the six Ballenger Creek stations were primarily within the sub-optimal category, with scores remaining relatively unchanged between April and October 2000 (Table 4-4). These habitat scores were not in the optimal category predominantly because of a lack of instream cover for fish, elevated embeddedness and sediment deposition, and poorly vegetated and unstable banks; all typical symptoms of heavy human influence on a watershed. In particular, embeddedness scores for BALL-05 were lower because direct summer sunlight caused heavy periphyton growth on the stream substrate, which then helped trap sediment in the interstitial spaces between the gravel.

Fish and benthic macroinvertebrate populations at each site were evaluated using Indices of Biotic Integrity (IBI; Karr et al. 1986). The IBI is a widely accepted multi-metric indicator used for biological assessment; it is recommended in USEPA's RBPs (Barbour et al. 1999) and employed by many state and local water quality programs nationwide. The IBI compares the condition of biological assemblages to that of a least-disturbed reference condition. Individual metrics quantitatively describe attributes of the biological community; a series of these metrics

Table 4-4. Summary of qualitative habitat data from Ballenger Creek

Station ID	Date Sampled	Instream Cover (Fish) (0-20)	Epifaunal Substrate (0-20)	Embeddedness (0-20)	Channel Alteration (0-20)	Sediment Deposition (0-20)	Frequency of Riffles (0-20)	Channel Flow Status (0-20)	Bank Vegetative Protection Left Bank (0-10)	Bank Vegetative Protection Right Bank (0-10)	Bank Stability Left Bank (0-10)	Bank Stability Right Bank (0-10)	Riparian Vegetative Zone Width Left Bank (0-10)	Riparian Vegetative Zone Width Right Bank (0-10)	Total Qualitative Habitat Score (Max. 200)	Habitat Assessment Category
BALL-01	4/26/00	14	14	13	16	12	18	16	7	6	6	6	9	9	146	Sub-Optimal
	10/6/00	13	16	15	20	14	19	16	9	8	8	7	8	9	162	Sub-Optimal to Optimal
BALL-02	4/26/00	12	15	10	19	11	13	17	7	8	7	6	8	9	142	Sub-Optimal
	10/5/00	15	13	8	18	16	8	18	7	8	6	7	10	10	144	Sub-Optimal
BALL-03	4/25/00	14	14	10	17	16	13	17	7	6	6	6	9	1	136	Sub-Optimal
	10/4/00	14	15	13	15	14	14	15	8	7	8	7	10	8	148	Sub-Optimal
BALL-04	4/25/00	11	12	5	18	11	5	15	3	4	3	4	7	9	107	Marginal to Sub-Optimal
	10/4/00	14	15	6	19	9	17	13	1	2	5	5	2	8	116	Sub-Optimal
BALL-05	4/24/00	8	18	17	15	16	16	15	5	5	4	4	4	2	129	Sub-Optimal
	10/4/00	8	19	8	17	17	18	19	9	9	6	8	7	5	150	Sub-Optimal
BALL-06	4/24/00	14	14	7	18	7	11	17	9	9	9	9	1	2	127	Sub-Optimal
	10/3/00	13	12	11	17	13	16	16	5	7	8	7	6	5	136	Sub-Optimal

are scored and combined into a single index. Originally developed for midwestern fish communities (Karr et al. 1986), the IBI approach has been adapted for a variety of regions (Simon and Lyons 1995) and taxonomic groups, including freshwater macroinvertebrates (e.g., Fore et al. 1996, Barbour et al. 1996). For this assessment, fish and macroinvertebrate IBIs were calculated using protocols developed for use in neighboring Montgomery County (Van Ness et al. 1997; Keith Van Ness, personal communication, 2000).

The benthic macroinvertebrate IBI was calculated by first classifying benthic taxa with respect to their pollution-tolerance value, using the designations given in Van Ness et al. (1997). Taxa not listed in Van Ness et al. (1997) were classified according to Lenat (1993) or Stribling et al. (1998). Tolerance values are on a scale from 0 to 10, with a score of 10 representing the most pollution-tolerant taxa, particularly with regard to organic pollution. Benthic assessments often employ this type of tolerance rating to calculate an overall biotic index (Hilsenhoff biotic index) as a weighted average of tolerance scores for the benthic community (e.g., Bode et al. 1991; Lenat 1993). In this assessment, following Montgomery County protocols, the biotic index was calculated as one component of the benthic IBI. Biotic index and Benthic IBI scores are divided into four classes as shown in Table 4-5.

Table 4-5. Scoring classes for benthic macroinvertebrate indices

Hilsenhoff Biotic Index		**Benthic IBI**	
Class	*Range*	*Biological Integrity Class*	*Range*
Good	0 - 4.5	Excellent	36 - 40
Fair	4.51 - 6.5	Good	26 - 35
Poor	6.51 - 8.5	Fair	17 - 25
Very Poor	8.51 - 10	Poor	8 - 16

Benthic organisms were identified from subsamples taken at the six Ballenger Creek stations in April and October 2000. As indicated in Table 4-6, the number of taxa at each station is good, showing a relatively diverse population of invertebrates. In general, October biotic index scores were somewhat better than those in April. With the exception of a good rating at BALL-03 in October, all biotic index scores were fair, indicating a moderate level of degradation. Benthic IBI scores, which integrate results from the individual metrics, were rated good at four stations and fair at two stations in April 2000. Benthic IBI scores remained the same between April and October at four stations, while BALL-01 dropped two points in the fall to receive a fair rating and BALL-04 gained two points in October to receive a good rating. A list of benthic taxa found within Ballenger Creek has been included in Appendix A, Table A-2.

Table 4-6. Summary of benthic macroinvertebrate results from Ballenger Creek						
Station ID	**Date Sampled**	**Number of Taxa**	**Hilsenhoff Biotic Index**	**Hilsenhoff Rating**	**Benthic IBI**	**Benthic IBI Rating**
BALL-01	4/26/00	26	6.08	fair	26	good
	10/6/00	18	4.85	fair	24	fair
BALL-02	4/26/00	29	5.32	fair	26	good
	10/5/00	24	4.97	fair	28	good
BALL-03	4/25/00	39	5.96	fair	30	good
	10/4/00	21	4.50	good	26	good
BALL-04	4/25/00	36	5.97	fair	24	fair
	10/4/00	28	5.56	fair	26	good
BALL-05	4/24/00	34	5.20	fair	28	good
	10/4/00	31	4.82	fair	28	good
BALL-06	4/24/00	16	5.25	fair	18	fair
	10/3/00	21	5.48	fair	20	fair

The fish IBI was calculated by first classifying fish species with respect to their tolerance level, trophic level, and designation as pioneering species as per Van Ness et al. (1997). Tolerance refers to a species' known ability to tolerate a variety of types of environmental degradation such as siltation, lowered flows, low dissolved oxygen, and contaminants. Species are classified as tolerant, intermediate, or intolerant. Six categories of trophic levels were used: generalist, insectivore, omnivore, invertivore, piscivore, or herbivore. Pioneering species were identified as those dominant in fluctuating environments, such as streams affected by temporary desiccation and/or anthropogenic stress. The number of fish with visually identifiable disease or anomalies (e.g., growths, lacerations, external parasites, etc.), indicating the level of environmental stress, were also utilized. The individual metrics were then used to calculate fish IBI scores and assign narrative ratings (Table 4-7).

Table 4-7. Scoring classes for the fish IBI	
Biological Integrity Class	**Range**
Excellent	4.5 - 5.0
Good	3.3 - 4.4
Fair	2.2 - 3.2
Poor	1.0 - 2.1

Results from the electrofishing survey and fish IBI have been summarized in Table 4-8. The overall condition of Ballenger Creek's fish population is good, with fish IBI ratings ranging from excellent (BALL-06) to fair (BALL-03). The survey indicates good species diversity in Ballenger Creek, as well as the presence of a relatively high number of species intolerant to

environmental stress. The number of individuals with anomalies was fairly high. Fish abundance was surprisingly low at BALL-01 and BALL-03, given the size of the stream and the drainage area at these stations, and should be closely examined in any future studies. Results also indicate a low number of riffle benthic insectivorous individuals (29) and minnow species (Cyprinidae) which is likely due to the lack of riffle at this station. Station BALL-06 scored in the excellent category largely due to the low number of anomalies and pioneer species, and a high number of intolerant species for a second order stream. It should also be noted that Ballenger Creek has been designated by MDE as Class III Natural Trout waters. Four small brown trout were collected and released at BALL-06. Their size (87 mm to 109 mm) indicates that trout populations are naturally reproducing in the stream. Based upon visual observation of the watershed, it is anticipated that additional trout habitat and populations exist upstream from this location. A list of fish species found within Ballenger Creek is included in Appendix A, Table A-3.

Table 4-8. Summary of fish results from Ballenger Creek

Station ID	Date Sampled	Number of Species	Number of Intolerant Species	Proportion of Tolerant Individuals	Proportion of Pioneers	Individuals with Anomalies	Fish IBI	Fish IBI Rating
BALL-01	10/6/00	16	5	39.9%	25.0%	18.2%	3.44	good
BALL-02	10/5/00	20	3	36.1%	24.6%	30.9%	3.67	good
BALL-03	10/4/00	15	5	52.0%	11.8%	21.3%	3.00	fair
BALL-04	10/5/00	15	3	22.8%	55.5%	26.9%	3.89	good
BALL-05	9/29/00	12	3	40.8%	25.0%	43.9%	4.11	good
BALL-06	10/3/00	11	3	6.8%	4.8%	5.9%	4.78	excellent

An integrated analysis of the chemical, physical, and biological data for Ballenger Creek indicate that conditions within the stream have been somewhat impacted by historical and recent land use activities within the catchment. Only one of the ratings for habitat condition, benthic IBI, or fish IBI fell within the indexes' highest category (fish IBI for BALL-06); most fell within the second highest category for each index, with a few in the third category and none in the last. To some degree, these conditions are typical for streams in this region, and reflect the area's history of both agricultural activities and more recent urban development. However, Ballenger Creek is not severely degraded at present and care should be taken to prevent further degradation of this valued natural resource.

Statistical analysis was not performed on these data as the small sample size, namely a maximum of two data points for each station, would not produce statistically meaningful results. Additional data collected during the future years of this study will expand the data set greatly and future reports will contain a more descriptive and analytical review.

4.2 Additional Stream Data from Maryland Biological Stream Survey

Five of MBSS's randomly selected sampling locations were located in the upper portions of Ballenger Creek and 1996 data from these stations (Roth et al. 1999b) have been used to supplement the County's field data collection efforts. These data indicate that conditions in Ballenger Creek watershed generally ranged from poor to fair in 1996 (Table 4-9). Key results are described below:

Water Chemistry. Instream nitrate-nitrogen concentrations were somewhat elevated at all five MBSS sites, ranging from 2.39 milligrams per liter (mg/l) at an unnamed tributary to Ballenger Creek (near Mt. Phillip Rd.) to 4.57 mg/l at Ballenger Creek Pike on the mainstem. Values greater than 1 mg/l generally indicate anthropogenic contributions of nitrogen.

Physical Habitat and Geomorphology. Three of the MBSS sites were on the mainstem of Ballenger Creek (MBSS sites 307, 230, and 204) and two were on unnamed tributaries upstream of Jefferson Pike (MBSS sites 115 and 117). Physical habitat quality, as assessed by a reference-based index combining multiple habitat parameters (Hall et al. 1999), was rated as fair at two mainstem sites, very poor at one mainstem site, and poor at both unnamed tributary sites (all indicators rated on a scale of good, fair, poor, very poor). Channelization or channel alteration was reported at all of the stations except MBSS site 204 in Feagaville, which received a fair physical habitat score. A riparian buffer was reported as absent from all five stations; four of the five sites had adjacent agricultural land.

Biological Assessment. Four to 13 fish species were found at the MBSS sites and fish IBI scores indicated fair to good conditions at all mainstem sites, and poor conditions at the tributary sites. Benthic IBI ratings were poor in the mainstem sites and also at one of the tributary sites; one tributary site was rated fair. These ratings were somewhat lower than those observed in 2000 sampling performed as part of the watershed assessment, perhaps due to high flow conditions in spring 1996. One mainstem and one tributary site were rated as good by the Hilsenhoff biotic index, with the remaining three sites rated as fair.

Land Use. Agriculture is the dominant land use upstream of the three mainstem sites and one tributary site, and ranges from approximately 53 percent to 64 percent of catchment area. Forested land use dominates the catchment of the remaining tributary site (60 percent). Urban land use is less than five percent for each site. The dominance of agricultural land uses likely contributed to the lower fish IBI and physical habitat scores noted by the MBSS in the tributary sites. Fish IBI scores were somewhat higher than their respective benthic IBI scores, and this is a likely reflection of the fact that fish indices are less sensitive to agricultural impacts than are benthic indices.

Table 4-9. 1995-97 MBSS sites in Ballenger Creek watershed, Frederick County, MD

Site ID	Average Wetted Width (m)	Average Thalweg Depth (cm)	Discharge (cfs)	Riparian Buffer Width (m)	Physical Habitat Index (0-100)	Physical Habitat Index Rating	Catchment Area (acres)	% Urban Land Use	% Forest Land Use	% Agricultural Land Use	% Wetlands Land Use	
MBSS 115	1.33	14.3	0.46	0	18.5	Poor	663	1.8	40.9	57.0	0.0	
MBSS 117	1.93	19.0	0.80	0	19.5	Poor	436	0.5	59.6	38.5	0.0	
MBSS 204	4.33	33.5	8.29	0	48.8	Fair	3530	3.5	42.7	53.5	0.1	
MBSS 230	3.48	24.5	4.19	0	11.6	Very Poor	2598	4.2	31.3	63.9	0.5	
MBSS 307	7.03	55.0	10.35	0	70.6	Fair	7604	4.8	33.1	61.5	0.3	

Site ID	Benthic IBI	Benthic IBI Rating	Hilsenhoff Biotic Index	Hilsenhoff Index Rating	Fish IBI	Fish IBI Rating						
MBSS 115	2.56	Poor	2.40	Good	2.1	Poor						
MBSS 117	3.89	Fair	5.30	Fair	2.4	Poor						
MBSS 204	2.33	Poor	5.43	Fair	4.4	Good						
MBSS 230	2.78	Poor	4.41	Good	3.0	Fair						
MBSS 307	3.67	Poor	4.91	Fair	3.9	Fair						

Site ID	Spring pH	Spring Conductivity (mhos/cm)	Acid Neutralizing Capacity (ueq/L)	Nitrate Nitrogen (mg/L)	Sulfate (mg/L)	Dissolved Organic Carbon (mg/L)	Water Temp. (C)	DO (ppm)	Summer Conduc-tivity (mhos/cm)	Summer pH
MBSS 115	7.56	281.6	743.3	4.09	19.09	2.0	21.0	7.5	192.0	7.15
MBSS 117	7.23	190.2	440.1	2.39	15.12	1.2	21.0	8.8	145.0	7.11
MBSS 204	7.88	333.0	1592.0	4.16	17.36	1.4	14.1	9.2	298.0	8.75
MBSS 230	8.55	267.5	1051.2	4.54	17.81	1.8	13.5	10.1	222.0	7.34

4.3 Wildlife

A wildlife survey was performed in June 2000 and results from this survey indicate that wildlife species within the Ballenger Creek watershed are similar to those found elsewhere in the County. The survey indicates that forty-seven species of mammals are likely to occur in the Ballenger Creek watershed; five of which were documented during the field survey, including white-tailed deer, raccoon, eastern cottontail, gray squirrel, and woodchuck (Appendix A, Table A-4). Signs of white-tailed deer, including tracks and scats, were common throughout the area in forested, cropland and grassland habitats, and were observed in open grassland off Butterfly Lane. Woodchucks were infrequently observed, but evidence of their common occurrence was noted by the numerous burrows found along the edges of woodlands and adjacent to croplands. Gray squirrel were observed in forested habitats along the Catoctin Ridge in which chestnut oak was the dominant tree species. Raccoon were not observed, however, tracks were common throughout the study area, particularly along streams or wetland habitats. Sightings of coyotes have been reported within this area of the County. In June 1999, field crews glimpsed what appeared to be a tawny colored bobcat on Reichs Ford Road near the entrance to the County Landfill. According to the MDNR, black bears are occasionally observed in the vicinity of the Catoctin Ridge (Glenn Therres, MDNR, personal communication, 1999).

Seventy-four species of birds have been documented in the vicinity of the watershed in prior surveys since 1996 (Appendix A, Table A-5). Common resident birds identified throughout the watershed included American crow, blue jay, northern cardinal, American goldfinch, song sparrow, European starling, and mourning dove. Birds most common to grassland, cropland, and shrub-edge habitats included song sparrow and American robin and common grackle. Forested areas mostly along stream corridors were host to a number of common birds including red-bellied and downy woodpeckers, common flicker, Carolina chickadee, rufous-sided towhee, and gray catbird. Because of the timing of the survey in mid-summer, many transients or fall migrants were absent from the list, including many warbler species. Raptorial birds identified within the study area included red-tailed hawk and turkey vulture.

Herpetofauna of the Ballenger Creek watershed were represented in the survey only by the northern dusky salamander, *Desmognathus fuscus*. This species was common within a stream segment surveyed alongside Gold Mine Road.

A number of easily identifiable invertebrates were also noted from the survey. Butterflies included red-spotted purple (*Limenitis astyanax)*, tiger swallowtail (Papilio glaucus), and cabbage butterfly (*Pieris rapae*). Dragonfly species observed included green darner (*Anax junius*), common whitetail (*Libellula lydia*), and eastern amberwing (*Perithemis tenera*).

Aquatic organisms found within Ballenger Creek are listed in Appendix A, Tables A-2 and A-3. Many types of benthic macroinvertebrates were collected from the six stations throughout the watershed. These invertebrates include stoneflies, mayflies, caddisflies, dragonflies, damselflies, water beetles, water bugs, midges, horse and deer flies, crane flies, and many others. Fish from

eight taxonomic families (suckers, sunfish, sculpins, minnows, trout, perch, catfish, and eels) were collected from Ballenger Creek. Several species collected from larger portions of Ballenger Creek are considered to be sportfish, including brown trout, green sunfish, redbreast sunfish, rock bass, and largemouth bass.

4.4 Threatened and Endangered Species

In response to a request for an environmental review of the Ballenger Creek watershed, the MDNR Wildlife and Heritage Division reports that there are several records of Maryland-listed and federal-listed threatened and endangered flora and fauna within or adjacent to the study area (Table 4-10). However, the wildlife survey revealed that no mammal species listed as a "species of concern" are likely to occur in the watershed. In addition, no bird species listed as a "species of concern" were found in the watershed, although DNR Natural Heritage Service lists one species, the loggerhead shrike, as potentially occurring in this area.

Table 4-10. Threatened and endangered plants and animals cited by the Maryland Department of Natural Resources as potentially existing within appropriate habitats in the areas of southern Frederick County

Scientific Name	Common Name	State Status
PLANTS		
Amelanchier obovalis	Coastal Juneberry	endangered
Castilleja coccinea	Indian paintbrush	endangered
Scutellaria leonardii	Leonard's skullcap	threatened
Quercus macrocarpa	Mossy-cup oak	highly rare
ANIMALS		
Lanius ludovicianus	Loggerhead shrike	endangered

Explanation of State Status Categories (as defined by the Maryland Department of Natural Resources)

Endangered - a species whose continued existence as a viable component of the State's flora or fauna is determined to be in jeopardy.

In Need of Conservation - an animal species whose population is limited or declining in the State such that it may become threatened in the foreseeable future if current trends or conditions persist.

Threatened - a species of flora or fauna which appears likely, within the foreseeable future, to become endangered in the State.

Endangered Extirpated - a species that was once a viable component of the flora or fauna of the State, but for which no naturally occurring populations are known to exist in the State.

4.5 Visual Inspection for Watershed Stressors

A visual inspection of Ballenger Creek was conducted to identify the types and locations of potential watershed stressors likely to impact water quality. Although it was impractical to visually inspect the entire watershed, inspection efforts were targeted to characterize potential impacts from each land use type. This survey revealed that growth associated with the City of Frederick is expanding southward into the watershed. The north-central portion of the watershed consists largely of residential subdivisions generally less than five to ten years old. The area east of Interstate (I)-270 is generally commercial/industrial and has several large businesses centered around the Genstar Stone Products limestone quarry. The western half of the watershed contains a mix of agricultural as well as low density residential properties. Large tracts of forest were frequently observed in areas with steep slopes. Development in Ballenger Creek watershed appeared to be spreading southward between MD 351 and I-270, as well as westward along the I-70 corridor.

Hydrologic modifications, likely stemming from the area's long agricultural history and development predating current stormwater management regulations, were the most apparent past and potential stressor to Ballenger Creek watershed. Agricultural practices, especially historical ones, such as draining wetlands, channelizing streams, plowing perpendicular to slopes, clearing forests and riparian vegetation, and situating pastures next to streams, have increased sedimentation and water transport in streams across the country. Historical development practices without stormwater management controls also increase sedimentation and rapidly convey water to natural drainage systems. Impacts can also occur even with modern stormwater management controls in place as intense storms, similar to some of those passing through the County over the last few years, exceed the design capacity of the SWM facilities. These modifications (and events) often upset the dynamic equilibrium between velocity, flow resistance, stream discharge, sediment size, and sediment load that influences channel morphology (i.e., channel width, depth, and slope) in natural stream channels (Nunnally 1978; Rosgen 1993). Once the equilibrium has been upset, it can often take several decades to reestablish a balance – one that could be very different than previously exhibited by the stream. It also may not be possible for a morphologically-stable channel to develop, even after a considerable time (Keller 1975, 1978).

A number of locations along Ballenger Creek were observed to be severely incised and have destabilized banks due to changes in the stream's dynamic equilibrium. The loss of equilibrium is likely brought about by an increase in impervious surfaces in the watershed, the conversion of natural drainage pathways to concrete lined swales, and the increased flashiness which results from these changes. The increased flashiness exacerbates flood pulses within the stream channel, and helps create more frequent channel forming flows. Additional sediment from upstream instabilities can also cause downstream changes in channel morphology. Several potential restoration opportunities were identified, including (1) Ballenger Creek at the confluence of King and Arundel Branches, just upstream of New Design Road, (2) Ballenger Creek at Ballenger Creek Elementary School, and (3) Ballenger Creek at Ballenger Creek Park.

Several signs of the underlying limestone formations were evident during the visual inspection. Several tributaries to Ballenger Creek including Quarry, King, and Pike Branches were observed to have very low to no flows and are believed to transport water only during wet weather. In addition, several sinkholes were observed, including two that had opened up recently in the bottom of a stormwater pond. (Appendix C; Photo 11. These sinkholes have since been repaired.) The lack of surface water and the presence of sinkholes in the unlined stormwater pond indicate that water may quickly penetrate into the underlying aquifer. Given the rapid infiltration of surface water to groundwater, stormwater may be insufficiently treated by the stormwater management facility prior to infiltration and therefore, may contaminate groundwater. Private wells that predate the public water supply system may still be used for drinking and other uses by households, farms, and businesses. This aquifer is also likely to influence water quality in the Monocacy River.

Specific findings of the visual assessment, including several problem areas, have been summarized in Table 4-11 and locations are shown in Figure 4-1. Photographs taken during the visual inspection are included in Appendix C.

4.6 Infrastructure Analysis

4.6.1 Water and Sewer Service

Analysis of existing infrastructure shows that the central portion of the watershed, east of US 15/340 and west of Urbana Pike is currently served by public water and sewer (Figure 4-2). Rural portions of the watershed are served by residential wells and septic systems.

The Ballenger Creek Growth Area is served by the County public water system, supplied by a water intake on the Potomac River (New Design Water Plant, capacity 10 million gallons per day (mgd), FCDPZ 1999a, b). Water is pumped northward from the plant through a transmission main along New Design Road to Lime Kiln Road to Buckeystown Pike, to the Francis Scott Key Water Plant. To meet increased demand, in 1992 the State increased the County's water appropriation permit from 6 mgd to 10 mgd. By interconnecting with the Lake Linganore water supply, this source provides backup capacity for both systems.

The City of Frederick receives water from multiple surface water sources, all outside Ballenger Creek watershed. Emergency connections also link the City to the County's Ballenger Water System. In addition, private water well systems serve Concord Mobile Home Park and Valley View Mobil Home Park, both located on Jefferson Pike (MD 180).

The County has a Wellhead Protection Ordinance and is considering improvements to further protect County-owned public water supply wells as well as recharge areas for city wells which extend beyond municipal boundaries. Of concern are groundwater concentrations of nitrates and other contaminants (FCDPZ 1999b).

Table 4-11. Results from the Visual Inspection of Ballenger Creek watershed. Map ID refers to Figure 4-1, while Photo No. refers to photographs in Appendix C. These results are intended to characterize conditions within the watershed and therefore, do not necessarily represent problems.

Map ID	Description	Date(s) Observed	Photo No.
Agriculture:			
1	Livestock stresses were observed in Renn Branch at Renn Road. Trampled banks, poor vegetative cover, excessive sedimentation and erosion, and the introduction of animal wastes directly into the water were observed at this location (and are likely to occur elsewhere in the western half of the watershed). A golf course is located immediately upstream from this site. There is an approximately 2 m vegetated buffer along both sides of Renn Branch as it passes through the golf course.	July 2000	5
New Construction:			
2	The Country Meadows Retirement Community was being constructed on a several hundred acre site at 5955 Quinn Orchard Road. Site preparation appeared to involve significant earth moving and regrading, exposing large areas of bare soil. A drainage swale had been constructed along the toe of an approximately ½-mile long hillside to capture and route runoff from the construction site into a sediment basin. This basin appeared to be actively maintained. A small wetland was observed at the toe of the slope near the construction entrance on Ray Smith Road. This site has been reviewed by the State and County and was found to be in compliance.	July 2000	20 to 22
3	The MARC Frederick extension began construction in Spring 2000, and involves upgrading existing railroad tracks that cut northward across the eastern part of the watershed. One of the two Frederick stations is being constructed in the Ballenger Creek watershed, behind the Riverview Plaza on Urbana Pike. This will be called Monocacy Station and will provide parking for 800 cars. Efforts to upgrade the railroad line were observed at several locations and few erosion and sedimentation controls were apparent (this project is under State jurisdiction.). While the commuter line is likely to help reduce traffic on Interstate 270, it also has the potential to make commuting to Washington DC easier, and thereby increase development pressure in the area.	July 2000	23
4	New construction was evident in the headwaters of Butterfly Branch, north of Interstate 70. This portion of the watershed falls under the jurisdiction of the City of Frederick.	July 2000	--

Table 4-11. (Continued)

Map ID	Description	Date(s) Observed	Photo No.
Hydrologic Modifications:			
5	Channelization was observed in an unnamed tributary to Renn Branch, just west of the intersection of Elmer Derr and Renn Roads. This reach was unnaturally straight, and contained a considerable amount of cinder block and stone rubble. Channelization may have destabilized this reach, leading to headcutting and downstream sediment deposition.	July 2000	6
6	Concrete lined channels were observed in various locations within areas of older development. These channels are efficient at transporting water quickly; however, rapid flows can alter natural flow patterns and channel stability in receiving streams.	April 2000	12
7	A series of culverts for Pike Branch at Corporate Drive had a low, but steady flow of water. Both sets of pipe had a large riprap apron at the outlet. The riprap apron at one set of pipes was submerged under water; a large amount of sediment had accumulated in this pool. It was unclear whether the apron for the first set of pipes had been built to hold water or if stone had been washed/removed from the apron. The riprap apron at the second set of pipes was not submerged, however, a heavy coating of sediment was observed on the rocks.	July 2000	16
8	Roadside ditches along Clifton Road were very steep and the northern ditch discharged a large amount of sediment directly into the mainstem of Ballenger Creek. The southern ditch, however, was a good example of a roadside turnout, in which water and sediment were discharged into the forested riparian buffer rather than directly into the stream.	July 2000	–

Table 4-11. (Continued)

Map ID	Description	Date(s) Observed	Photo No.
Industrial/Commercial Land Uses:			
9	Two automobile scrap yards and a truck repair facility were located along Reichs Ford Road. One of the scrap yards was located adjacent to an unnamed tributary to the Monocacy River. Slopes were relatively steep in this area and the scrap yard on Ray Smith Road did not appear to have adequate stormwater controls to prevent materials from washing into the adjacent stream. Portions of this unnamed tributary were reinforced with boulder-sized riprap. [One scrapyard now falls under the jurisdiction of the City of Frederick. Scrap has been removed from this site and the property owner is currently working with MDE to address contaminated soils at the facility.]	July 2000	22
10	Quarrying operations and related industries, such as those found along Urbana Pike and Reichs Ford Road, pose a number of potential threats to water quality. Pumping to prevent filling with groundwater can influence regional groundwater elevations and flow directions. Discharge of the pumped water also can alter the quality and natural flow regimes of receiving waters. Dust produced during quarrying, crushing, and transporting can also impair plant growth, cause respiratory distress, and affect the water chemistry and physical habitat of streams. Dust was observed at these facilities; however, dust control practices were also observed. [Mining/quarrying activities fall under State jurisdiction. The Genstar Stone Products quarry, under their NPDES permit, discharges large quantities of groundwater, dust, and sediment to the Monocacy River.]	July 2000	8 to10
11	The mapped watershed boundary passes very close to the Frederick Municipal Airport and visual observation indicates that site grading and drainage pathwaths may route runoff from portions of this facility into Ballenger Creek's watershed. Stormwater contaminants typically associated with airports include copper, nickel, and other metals from tire wear, de-icing fluids and salt, fertilizers, herbicides, and petroleum hydrocarbons. In addition, future development near the airport looks imminent along Bowman Farm Service Road as recent improvements (i.e., curbs, fire hydrants, trees, street lights, and culvert pipes) were observed. [The area surrounding Bowman Farm Service Road was recently annexed by the City of Frederick and is no longer under County jurisdiction.	July 2000	--

Table 4-11. (Continued)

Map ID	Description	Date(s) Observed	Photo No.
Maintenance:			
12	The Frederick Industrial Regional Facility was a detention basin that needed additional maintenance. Woody vegetation around the weir had recently been removed, however animal burrows were present in the berm, as well as erosional scars. Several of the inlet pipes appear to be damaged and trash was observed in the basin.	July 2000	17
13	A number of maintenance issues were noted at the Wedgewood Regional SWM Facility. The forebay had accumulated a significant amount of sediment, and shrubs and other vegetation had become established in this area. Grass, trash, and other debris have collected in the vegetation below the outlet structure. Most notably, however, was the delta formed by riprap and soil washed from a swale on the north side of the basin. Maintenance crews were observed working on the eroded swale in early October 2000. [County staff indicated that construction is ongoing in this development so the structure is still serving as a sediment basin; it will be converted by the developer to a SWM facility upon completion of construction activities and County approval.]	July and October 2000	24 to 28
Other:			
14	Karst features, such as the sinkholes that form in the eastern third of the watershed, present special management situations. Not only must geotechnical studies be performed to adequately design buildings, roads, and other large structures, but extra effort must be taken to prevent stormwater and other pollution sources from contaminating the region's groundwater resources. Sinkholes were observed in the area, including in the floor of an unlined stormwater pond. [Sinkholes were subsequently repaired.]	April and July 2000	11, 19

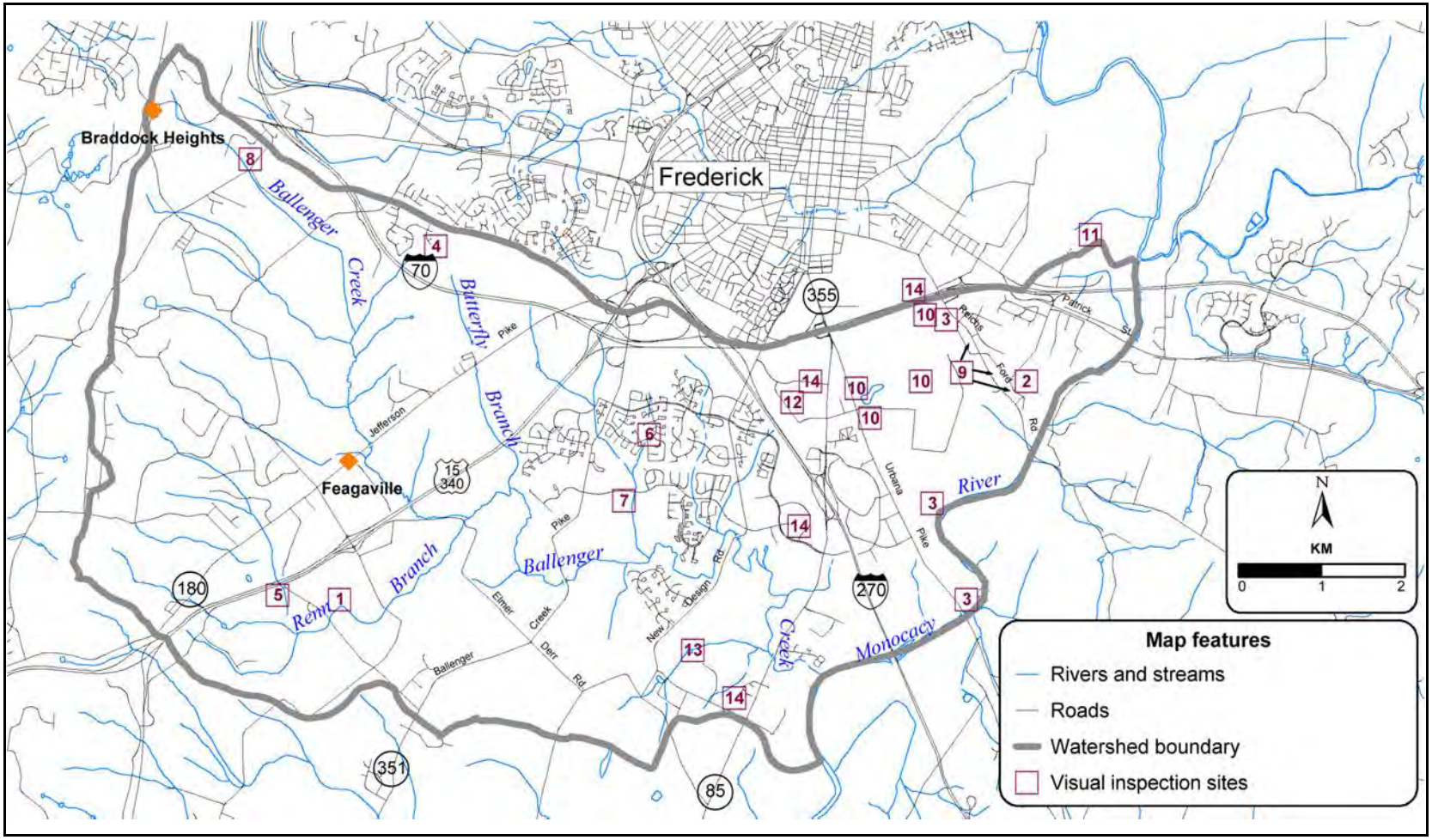

Figure 4-1. Visual inspection for watershed stressors within Ballenger Creek, Summer 2000. Location numbers of map refer to Table 4-11.

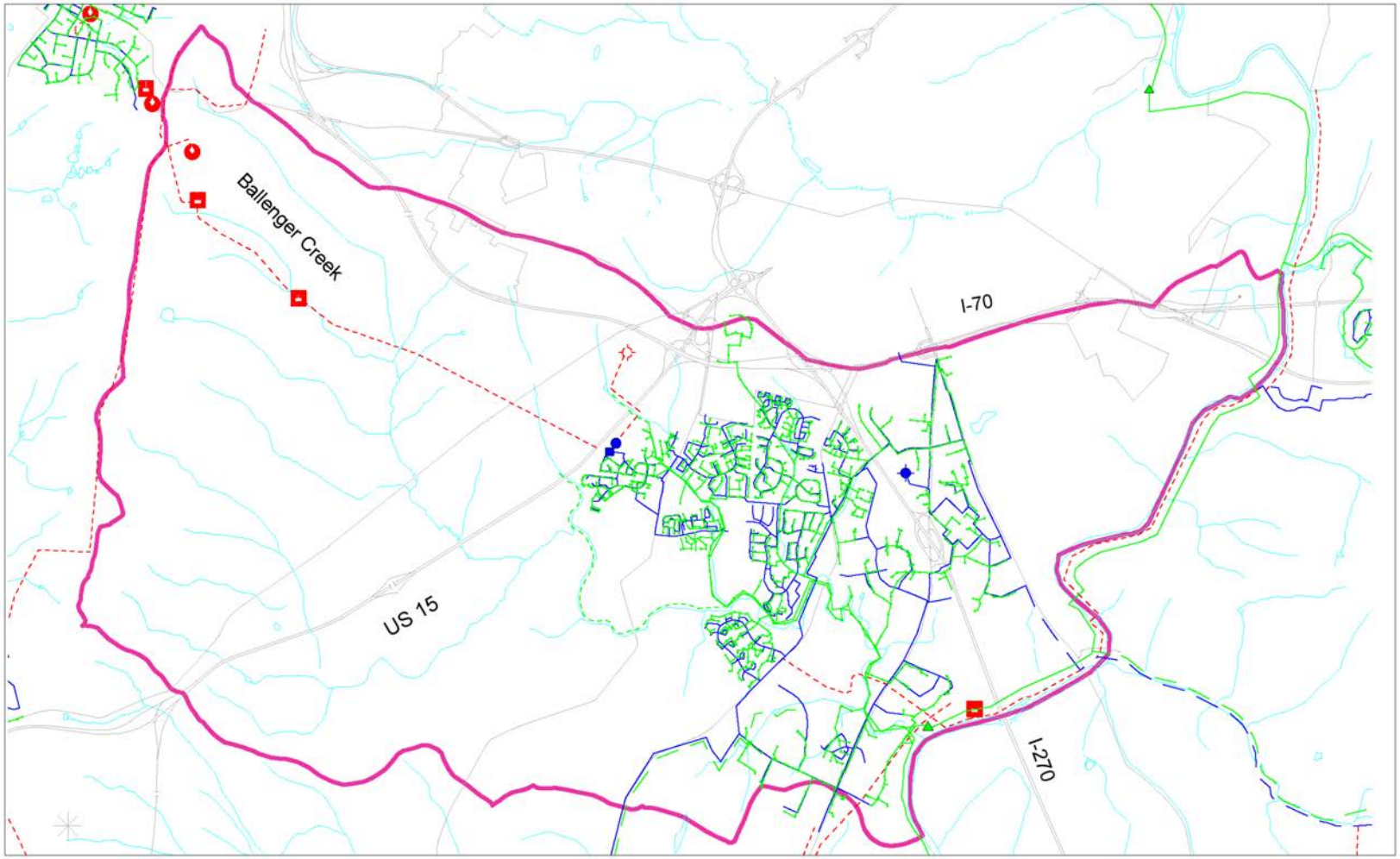

Figure 4-2. Major water and sewer infrastructure (existing and planned) within Ballenger Creek watershed

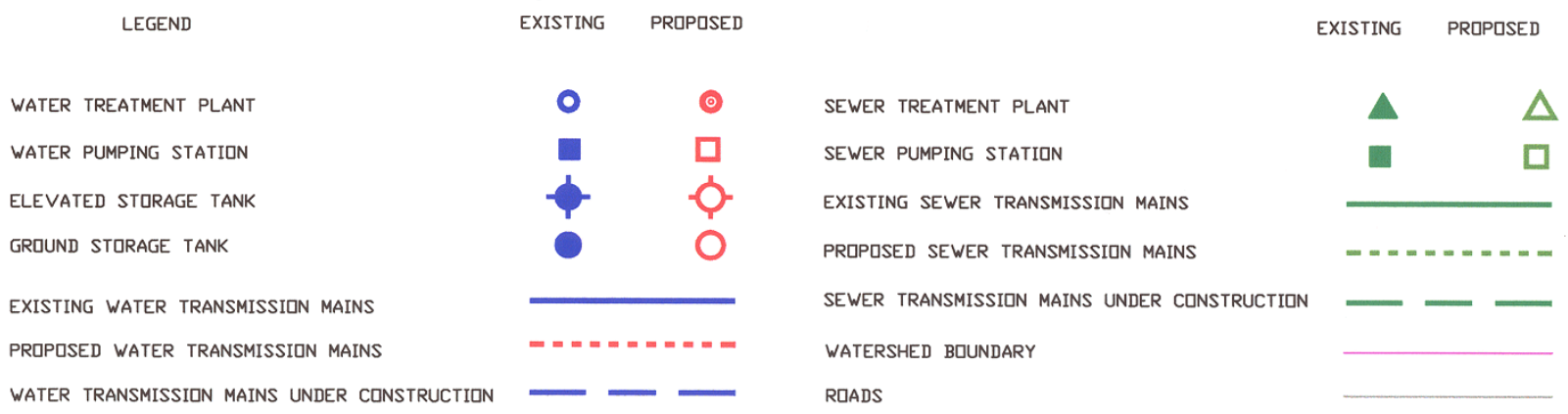

Figure 4-2. (Continued)

Public sewer service is provided by the County's Ballenger Creek Wastewater Treatment Plant (WWTP). The sewer service area extends throughout the Ballenger Creek Growth Area, north to the City of Frederick. Ballenger Creek WWTP, located on the north side of Ballenger Creek near the confluence with the Monocacy River, discharges to the Monocacy and has a capacity of 6 mgd (estimated average flow in 1997: 2.97 mgd; FCDPZ 1999b). To handle future growth, the County is planning to add McKinney WWTP, to be located on the south side of Ballenger Creek near the Monocacy River. Treated effluent from the McKinney plant will be discharged to the Potomac River through an outfall line Frederick City operates an 8 mgd WWTP that discharges to the Monocacy River. Future additional flows are planned to be diverted to the County's Ballenger Creek WWTP. Private treatment plants serve Concord Mobile Home Park, Valley View Mobil Home Park, and the new Life Foursquare Church.

Within the Ballenger Creek watershed, as in all rapidly developing areas of the County, adequate water and sewage capacity will be needed to accommodate the expected growth in the area's residential and commercial development. Approximately half of the watershed falls within the County's 20-year planned water and sewer service areas (Figure 4-3). As planned, service will extend east of Urbana Pike and west of Jefferson Pike, including Feagaville; the vicinity of Braddock Heights in the northwest corner of the watershed will also be served. Note that the actual timing of extensions of the current water and sewer lines within this planned area will to a large extent depend upon economic conditions and patterns of land development, because extensions are often funded by individual developers.

4.6.2 Transportation

Regional plans for Frederick and Adamstown include consideration of major roadways to handle the expected increase in traffic volume as more areas of the region are developed. Planned road designations and improvement projects within the watershed, according to the Regional plans, are as follows (FCDPZ 1991; FCDPZ 1992):

1) Freeway: I-70, I-270, US 15, and US 340

2) Interchanges: I-70/US 15/US 340 (missing ramps), I-70/I-270 (missing ramps), I-70/Mt. Philip Road (new grade separation), I-70/South Street (upgrade), I-70/MD 355 (upgrade), I-70/Jefferson Pike (upgrade), and I-270/MD 85 (upgrade)

3) Major arterial roads: US 40-A, MD 85, MD 355, New Design Road (bridges over highways), Ballenger Creek Pike (MD 351), Crestwood Boulevard, and new road between US15/340 and MD 351

4) Minor arterial roads: Reich's Ford Road, Corporate Drive, Jefferson Pike (MD 180), Butterfly Lane, Elmer Derr Road, and English Muffin Way

5) Collectors: Clifton Road

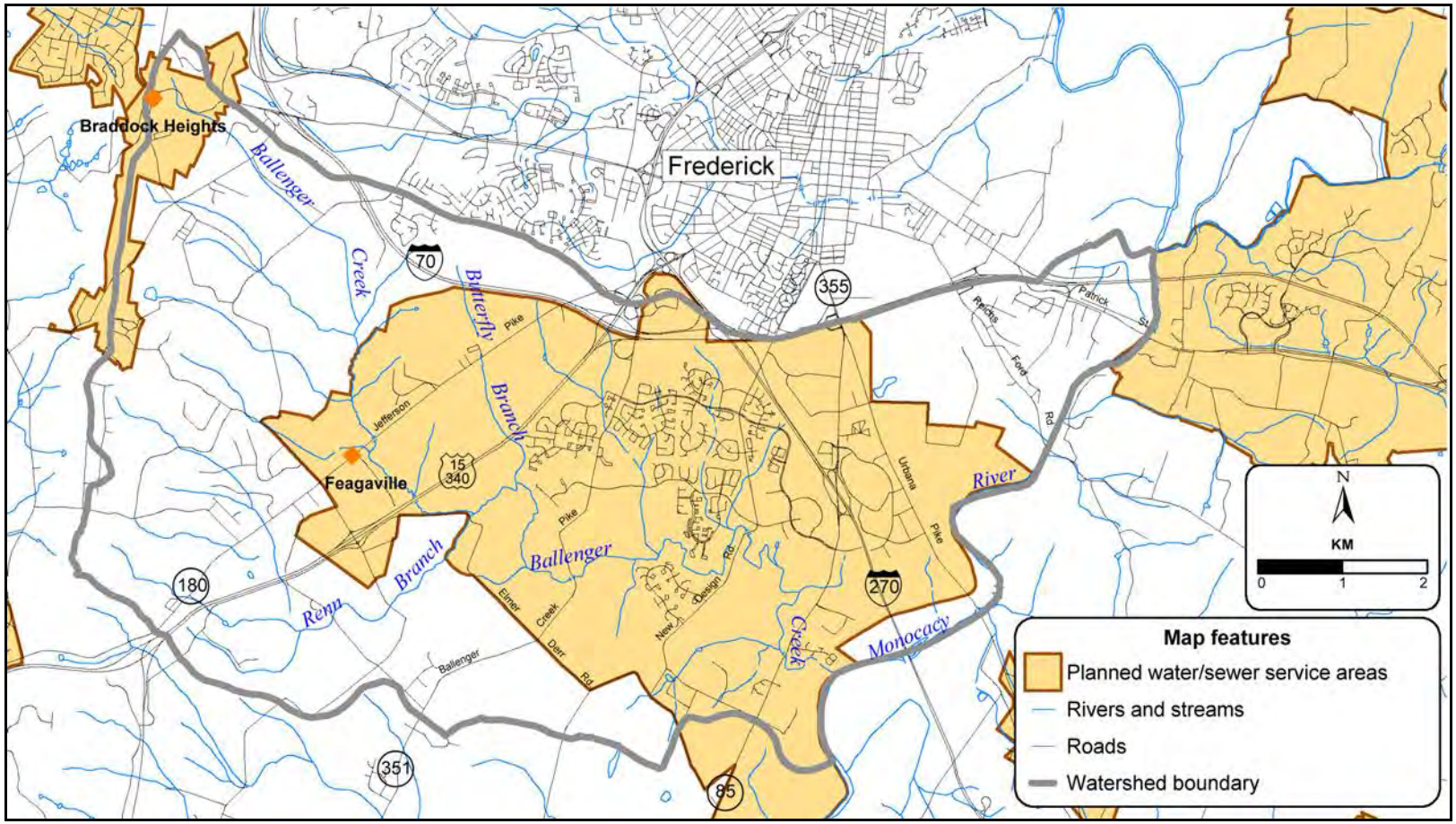

Figure 4-3. Twenty-year planned water and sewer service areas within Ballenger Creek watershed

Currently, numerous road improvement projects, such as road widening, overpass replacement, and upgrading exit ramps, are underway along the I-70 and I-270 corridors.

A rail line cuts northeastward from Point of Rocks, across the eastern third of the watershed to the City of Frederick. This rail line is being upgraded to support MARC commuter trains. One station will be located just north of the watershed at East Street. A second station, Monocacy Station, will be located in the Riverview Plaza on Urbana Pike, and is in the Ballenger Creek watershed. The Monocacy Station will provide parking for 800 cars. Three trains are scheduled to operate on this line and are expected to enter service in late 2001 (State of Maryland 2000).

Where the CSX railroad line, major highways, and other roadways pass through the Ballenger Creek watershed, there is potential for detrimental effects to water quality. Cars, trucks, and trains can leave behind residues of oil and grease, as well as metals from tire wear, and exhaust emissions. Through rainfall and runoff, this build up of pollutants and road salts can, over time, pose a threat to nearby streams. There is also some risk of small leaks or catastrophic spills from truck and railroad transport of bulk or hazardous materials.

4.7 Inventory of Pollution Sources

Given the size of the watershed and the amount of development contained within, it was impractical to conduct an exhaustive inventory of pollution sources. Therefore, this inventory of possible pollution sources was compiled using ancillary data to serve as an example of the types of pollution likely to be found within the Ballenger Creek watershed. The purpose of this inventory is to aid in characterizing stormwater impacts and other contributors to water quality degradation. Both point and nonpoint sources were identified in this assessment, including stormwater management facilities, permitted discharges, nonpoint source pollution from development and agriculture, and other potential sources of contaminants.

4.7.1 Stormwater Management Facilities

The County's stormwater database was used to identify and describe the existing stormwater management facilities within the Ballenger Creek watershed. A review of the database revealed comments indicating that certain entries were not considered BMPs or outfalls; therefore, these entries were omitted, leaving the final count at 114 stormwater management facilities in Ballenger Creek (Table 4-12; Figure 2-3).

Of the facilities within the database, the most commonly found are extended detention (34 facilities). There are 23 infiltration trenches, 17 detention basins, and 12 oil and grit separators. Seven of the facilities did not have a type listed in the database. The remaining 21 facilities were split among 14 different types of facilities, with no more than three facilities of each type. Three facilities were listed as being a combination of multiple types.

Table 4-12. Stormwater management facilities in Ballenger Creek watershed

ID	Structure Number	Structure Name	Practice Type
1	54A	Copperfield, Sec. 2 Infiltration Trenches	IFT
5	22B	Omega Center, Lot 8A - PGC Scientifics	EDD
63	5	Braddock Heights Village Center, SWM Site	DTN
70	50	Kings Kingdom - ED Pond	IFB, DTN
73	124	Stadler Nursery - ED Basin	EDW
78	82	Jefferson Pike Warehouse Center	Not listed
81	53	Stuart Mechanic, Pond #1 - Condos	EDD
82	28	Ballenger Creek Meadows, SWM Pond	RTN
84	38A	Farmbrook SWM Basin	DTN
93	26A	Crestwood Village, SWM Pond #1	DTN
95	102	Parkway Church of God, ED Basin	DTN
96	23	Frederick Villas - Detention Pond	DTN
97	1	Stonebridge Regional Shallow Marsh Pond	EDW/SHM
99	37	Foxcroft II - Society Circle	DTN
102	89	Aspen Systems	DRY
105	36	Foxcroft II - The Chase, SWM Pond #1	DTN
107	109	Zinc Development Company (N/F)	Not listed
108	101	McCormick Paints (N/F)	Not listed
111	72	Miscellaneous Metals, Lot 23 Infiltration Trench	Not listed
112	99	Lowes	Not listed
113	86	Evergreen Warehouses	Not listed
115	11	Frederick Industrial Regional Facility	DTN
118	71	Midmost LLC (Was Days Inn)	DTN
119	75	Roy Rogers - Rt. 85	DTN
126	79	Hampton Inn	RTN
131	22	Omega Center, Stormwater Management Pond "A"	EDD
132	22A	Omega Center	DRY
133	22C	Omega Center	VEG
135	76	FSK Lincoln Mercury	IFT
138	88	Saturn of Frederick	DTN
140	65	United Concrete Products	Not listed
142	9A	FSK Mall, Quality Inn (N/F)	INF
143	9B	FSK Mall, Pizza Hut	DRY
159	129	BFI, Inc. (was Eastern Waste Management)	IFT
161	2	Clearview Detention Pond	DTN
242	321	Hannover Regional Facility	SHM/EDW
243	311	Ballenger Crossing, SWM Pond No.1	EDD
245	322	Wal*Mart SWM Pond	EDD
254	327	Robert's Electric Motors, Infiltration Trench	IFT
259	332	Wedgewood Regional SWM Facility	EDW
260	333	Grove Road Business Complex	OTH
265	338	Omega Center, Lot 3, Stormceptor	OGS
269	342	Monocacy Business Center, SWM Pond No. 2	EDD
272	345	Stuart Mechanic SWM Pond No. 2	EDD
276	349	Fairfield Inn, Stormceptor	OGS
282	355	Christ UMC SWM Facility	EDD

Table 4-12. (Continued)

ID	Structure Number	Structure Name	Practice Type
339	414	The Peoples Baptist Church ED Pond	EDD
340	415	Frederick Baptist Temple, Pond #1	EDD
341	416	Frederick Baptist Temple - Pond #2	EDD
343	418	D. W. Ogg Equipment Company, Inc.	IFT
347	422	Hannover, Section 3 ED Pond	EDD
349	424	Checkers - Sand Filter	SND
350	425	Emmanuel Alliance Church, Detention Pond	DTN
351	426	Crum Electric Infiltration Trench	IFT
352	427	Miscellaneous Metals, Oil/Grit Separator - Plans only.	OGS
353	428	Miscellaneous Metals, Lot 24	IFT
354	429	Admar Construction, Lot 15	BioRet.
355	431	Eastern Business Center, Lots 44 & 45	IFT
356	432	Miland Associates, Sec. 2, Lot 36	IFT
357	433	Eastern Business Center, Lots 41 & 42	IFT
358	434	Frederick Mini Storage - Infiltration Trench	IFT
359	435	Princeton Court Apartments at Foxcroft	DTN
360	436	Glass & Mirror Service	IFT
361	437	Chevy Chase FSB - Pond #1	EDD
362	438	Chevy Chase FSB - Pond #2	EDD
363	439	Chevy Chase FSB - Basin B""	EDD
364	440	Chevy Chase Bank FSB - Pond C""	EDD
365	441	Chevy Chase FSB - Pond A""	EDD
366	442	Standard Federal Auxiliary Parking	OGS
367	443	Westview Retention Pond	RTN
368	444	Patapsco Designs, Inc.	OGS
369	445	NAPA Products, Inc.	IFT
370	446	Southern States - Evergreen Point	IFT
371	447	Bob Evans Restaurant	IFT
372	448	Sam's Club - Pace Warehouse	EDD
373	449	Tate Chrysler/Plymouth/Jeep/Eagle	IFT
374	450	FSK Mall Regional SWM Facility	EDD
375	451	I-270 Technology Park Pond @ FSK Mall	DTN
377	453	I-270 Tech Park, Lot 5C, SWM Basin #1 - Crisplant USA, Inc.	EDD
378	454	I-270 Tech Park, Lot 5C, SWM Basin #2 - Crisplant USA, Inc.	EDD
379	455	I-270 Technology Park, Lot 4	DTN
380	456	Pizza Hut, Rt. 85 - Moyer Plaza	UNG
403	479	Cracker Barrel - SWM Pond "A"	EDD
404	480	Cracker Barrel - SWM Basin B""	EDD
415	493	Renn Branch Estates	DTN
421	499	Dudrow Industrial Park, Pond #2	EDD
422	500	Wedgewood Business Park, Lot 45 - WQ Pond #1	EDD
423	501	Wedgewood Business Park, Lot 45 - WQ Pond #2	EDD
424	502	Kingsbrook Crossing Shopping Center - Stormceptor STR 10	OGS
425	503	Kingsbrook Crossing Shopping Center - Stormceptor STR. 61	OGS
426	504	Kingsbrook Crossing Shopping Center - STR. 14	OGS

Table 4-12. (Continued)

ID	Structure Number	Structure Name	Practice Type
431	509	Bowman's Plains Regional SWM Facility	EDD
432	510	Bowman's Plains, Lot 10	IFT
433	511	Bowman's Plains, Lot 3	VEG
437	515	Washington Valve and Fitting	IFT
440	518	Lowes Pro Yard	EDD
441	519	McCormick Paints	OGS
442	520	McKinney Industrial Park, Lot 11	IFT & OGS
443	521	McKinney Industrial Park, Lot 12	IFT
444	522	McKinney Industrial Park, Lot 13	IFT
445	523	McKinney Industrial Park, Lot 20	OGS
446	524	Aspen Systems, Inc.	EDD
447	525	Omega Center, Stormwater Management Pond "B"	EDD
448	526	Omega Center, Lot 6	OGS
449	527	Frederick Veterinary Center	IFT
475	553	Riverview Plaza - SWM Pond #1	EDD
476	554	Riverview Plaza - SWM Pond #2	EDD
483	561	Admar Construction, Lot 15	IFT
484	562	Circuit City Store #3628	EDD
512	590	355 Auto Sales	IFT
514	593	Amoco - Snax at Md. Rt. 85	EDSD
515	592	I-270 Technology Park, Lot 13	EDSD
523	602	Children's World Learning Center	EDD
529	608	Rt. 85 Exxon - Buckeystown Pike	OGS

Practice Type		Practice Type	
BioRet.	Bio Retention	IFT	Infiltration Trench
DRY	Dry Pond	INF	Infiltration
DTN	Detention Basin	OGS	Oil & Grit Separator
EDD	Extended Detention	OTH	Other
EDSD	Extended Detention Dry	RTN	Retention
EDW	Extended Detention Wet	SND	Sand Filter
SHM	Shallow Marsh	UNG	Underground Detention
IFB	Infiltration Basin	VEG	Vegetation

Appropriate enforcement action was taken by the County when illicit discharges were found during the recent inspection of all facilities within the County (Frederick County 2000).

4.7.2 Individual Permitted Discharges

A review of the USEPA's Permit Compliance System (PCS) on-line database of NPDES permits, as well as a database of NPDES point source discharges obtained from MDE, identified 18 facilities with discharges to water in the Ballenger Creek watershed (USEPA 2000; Robert Daniel, MDE, Personal communication, July 11, 2000). These NPDES-permitted facilities and

their purposes are listed in Table 4-13 and their locations are shown in Figure 2-3. Note that several of these properties also have stormwater management facilities listed in Table 4-12.

Table 4-13. NPDES-permitted point source discharges within Ballenger Creek watershed

Facility	Facility ID	NPDES ID	Type of Operation	Effluent Parameters
Concord Trailer Park MD Route 180 Jefferson Pike Jefferson, MD 21701	MD0000545905	MD0023060	Surface Municipal Discharge, permit expired 4/30/00.	dissolved oxygen, biological oxygen demand, pH, total suspended solids, flow, fecal coliform
Springview Mobile Estates, Inc MD Route 180 Jefferson Pike Jefferson, MD 21701	MDD985414168	MD0022870	Surface Municipal Discharge	dissolved oxygen, biological oxygen demand, pH, total suspended solids, flow, total residual chlorine, fecal coliform
New Life Foursquare Church 5913 Jefferson Pike Frederick, MD	MDD985395755	MD0057100	Surface Municipal Discharge, permit expired 1/31/2000	dissolved oxygen, biological oxygen demand, pH, total suspended solids, flow, fecal coliform
Superior Concrete Plant 5823 Urbana Pike Frederick, MD	MD0000753616	MDG842695	General Permit; Ready-mix concrete	pH, total suspended solids, flow, total petroleum hydrocarbons
Dyna Corp. - TOYS-R-US 7121 English Muffin Way Buckeystown, MD 21701	95MM9803	MDG499803	General Permits; mineral mining	Not available
United Concrete Products, Division of Phoenix Inc. 5703 Urbana Pike Frederick, MD 21701	95MM2671	MDG492671	General Permits; mineral mining	Not available
Exxon Service Station 5516 Buckeystown Pike Frederick, MD 21701	MDD985384379	MDG915987	Groundwater Industrial Discharge; groundwater treatment system	benzene, ethyl benzene, toluene, xylene, flow
Dan's Auto Body Shop 5909 Enterprise Court Frederick, MD 21701	95DP2708	Not listed	Groundwater Industrial Discharge	Not available
Tamko Roofing Products, Inc. 4500 Tamko Drive Frederick, MD 21701	97DP2862	Not listed	Groundwater Industrial Discharge	Not available
Genstar Stone Products South St. Frederick, MD 21701	MDD069383222	MD0052914	Rock quarry	pH, total suspended solids, settleable solids, flow

Table 4-13. (Continued)				
Facility	**Facility ID**	**NPDES ID**	**Type of Operation**	**Effluent Parameters**
SHA - Frederick Shop 5111 Buckeystown Pike Frederick, MD 21701	97SW1343	Not listed	General Industrial Stormwater	Not available
Richard F. Kline, Inc. 7800 Grove Road Frederick, MD 21704	97SW1066	Not listed	General Industrial Stormwater	Not available
D.M. Bowman, Inc. - Frederick 6816 English Muffin Way Frederick, MD 21703	97SW0726	Not listed	General Industrial Stormwater	Not available
United Parcel Service 6766 English Muffin Way Frederick, MD 21701	97SW0850	Not listed	General Industrial Stormwater	Not available
Solarex 630 Solarex Court Frederick, MD 21703	97SW1199	Not listed	General Industrial Stormwater	Not available
Medimmune Manufacturing 636 Research Drive Frederick, MD 21703	97SW1217	Not listed	General Industrial Stormwater	Not available
Bestfoods Baking Company 7110 English Muffin Way Frederick, MD 21704	97SW098	Not listed	General Industrial Stormwater	Not available
McCormick Paint Works Company - Frederick 7202 McKinney Circle Frederick, MD 21701	97SW1067	Not listed	General Industrial Stormwater	Not available

Permits are designed to monitor and constrain the discharge of pollutants and while most facilities remain in compliance, others may periodically exceed their discharge limitations, either through negligence or limitations in the best available technology that the Clean Water Act requires them to use. In any case, some level of pollutants are discharged into surface waters and these levels may or may not be detrimental to aquatic ecosystems or human health. A review of the types of permits issued and their effluent parameters indicates that permitted discharges have the potential to influence Ballenger Creek by introducing suspended and dissolved sediments, reducing DO, and changing the pH. A few facilities could potentially introduce organic chemicals or petroleum hydrocarbons. Although it is possible for these permitted discharges to impact water quality, there was no evidence that this was the case.

4.7.3 Nonpoint Pollution from Development

Much of the residential and commercial development south of Frederick is relatively recent and stormwater management facilities designed to address nonpoint pollution have been integrated into these areas. However, for these stormwater management facilities to remain effective, they must actively be monitored and maintained. As new technologies and strategies for addressing

stormwater issues in karst areas become available, efforts should be undertaken to upgrade existing facilities to increase their effectiveness and protect groundwater and surface water resources.

Areas of older development are located in various locations within the watershed and typically, these predate modern stormwater management regulations and were built without controls. A number of older residential properties were observed among the farmland in the western watershed and stormwater controls were not observed in these areas. In addition, several older commercial and industrial properties in the eastern watershed were also observed without controls.

4.7.4 Nonpoint Pollution from Agriculture

As previously mentioned, a large portion of the western watershed is used for agricultural purposes. This type of land use creates specific stresses on a watershed. Unrestricted livestock access to the stream and narrow riparian buffers were both observed along Ballenger Creek and its tributaries. The exclusion of livestock from the stream can allow riparian vegetation to recover and, combined with efforts to increase the number and width of riparian buffers, can help protect streams in rural areas from sediment, nutrient, and erosion problems.

4.7.5 Potential Sources of Contaminants

The USEPA maintains several databases accessible via the Internet that contain information on facilities that have been impacted by the improper use, storage, and/or disposal of hazardous and toxic materials. An on-line review of the USEPA's Toxic Releases Inventory (TRI) and the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) databases revealed that two facilities in Ballenger Creek watershed were listed in the TRI database. The TRI listed the McCormick Paint Works Co. as having fugitive/non-point and stack/point emission of ethylene glycol in 1996 and the Solarex facility as having stack/point emissions of hydrochloric acid and sulfuric acid in 1994. While these emissions may affect ambient air quality, they are not expected to directly affect water quality within Ballenger Creek. In addition, no major contaminated sites are known by the USEPA to exist within the watershed area.

Frederick County staff also reported two chemical releases within the Ballenger Creek watershed in 2000. The McCormick Paint works had a spill involving 30,000 gallons of latex paint, which was successfully contained, and cleaned up to the County's satisfaction. Less than one gallon of paint was reported to have reached Ballenger Creek. The second release took place at the Country Meadows Retirement Community construction site when a contractor was super-chlorinating newly installed water lines. During a routine site visit, a County Inspector observed spent disinfectant being discharged on-site. The Inspector halted this activity and ordered the contractor to store this liquid in a tank truck for subsequent off-site disposal. This material was also cleaned up to the County's satisfaction (Rick Masser, Frederick County DPW, Office of Technical Support, personal communication).

In rural areas such as the western portion of Ballenger Creek watershed, sewage from individual residential properties is frequently handled through the use of on-site septic tanks and leach fields. As these systems get older, they sometimes fail for a number of reasons, including a lack of proper maintenance. Their failure can lead to the introduction of insufficiently treated sewage into nearby surface and sub-surface waters. However, no obvious signs of these problems were noted in the watershed.

4.8 Zoning and Population Projections

Zoning and population projections were made to characterize and predict future environmental conditions, particularly in relation to stream water quality and stormwater management. Zoning, demographic, and land use data were used to assess levels of development in the watershed. Twenty-year projections of future land use were used to assess future vulnerability of the watershed to further degradation and declining water quality.

As foreseen in Regional Plans, much of the planned or proposed new development in the watershed will occur within growth boundaries located in the central portion of the watershed as well as in the vicinity of Braddock Heights (FCDPZ 1991, 1992). These areas have all been designated as 20-year planned water and sewer service areas. The County's Adequate Public Facilities Ordinance (APFO) states that preliminary plan or site plan approval for new development is contingent upon evidence that adequate schools, roadway facilities, and water and sewer facilities exist or will be provided by the County or the developer. Adequate water and sewer capabilities must be available before development can be approved.

Consistent with this approach, Frederick County has designated specific Municipal and Unincorporated Growth Areas where the County and private developers have committed a significant amount of funds for school, road, water, sewerage, and other capital improvements. Encouraging full development within Growth Areas at densities that support the provision of public services will serve to protect unique agricultural, environmental, and historic resources elsewhere. The Ballenger Creek Growth Area is centered on the Ballenger Creek watershed. While growth outside of targeted areas is expected to be more limited, a review of recent subdivisions and other proposed projects shows that low density development is likely to occur in other parts of the watershed.

4.8.1 Existing Land Use

Statewide land use data from 1997, developed by the MOP, show the watershed to be dominated by agriculture (about 59 percent of watershed area) with smaller amounts of residential and commercial/industrial/office development (16 and 9 percent, respectively), and forest/brush vegetation (13 percent)(Figure 4-4, Table 4-14). High resolution aerial photographs from April 2000 were inspected to identify areas that have undergone substantial land use change since 1997. Several new residential, office park, and commercial developments have been constructed

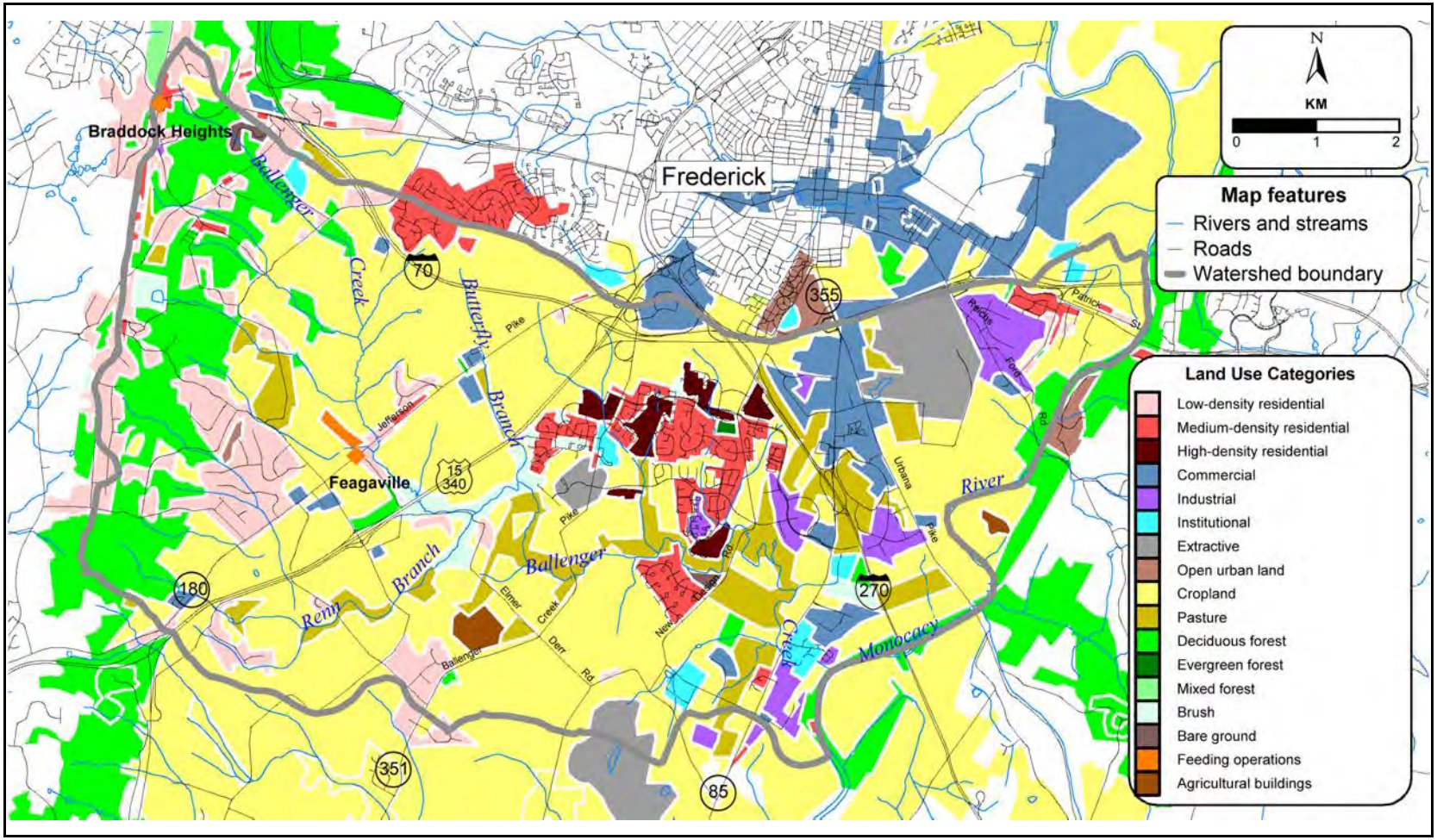

Figure 4-4. Current (1997) land use within Ballenger Creek watershed (MOP 1997)

Table 4-14. Estimated existing land use (2000) in the Ballenger Creek watershed		
Land Use Class	**Acres**	**Percent**
Low density residential	1,299.7	8.7
Medium density residential	802.3	5.4
High density residential	219.7	1.5
Commercial	656.9	4.4
Industrial	448.1	3.0
Institutional	190.2	1.3
Extractive	528.1	3.5
Open urban land	19.8	0.1
Total urban	**4,164.7**	**27.8**
Cropland	7,422.6	49.6
Pasture	1,264.5	8.5
Feeding operations	24.5	0.2
Agricultural building	62.7	0.4
Total agriculture	**8,774.3**	**58.7**
Deciduous forest	1,700.8	11.4
Evergreen forest	9.9	0.1
Mixed forest	1.0	0.0
Brush	262.8	1.8
Total forest/vegetation	**1,974.5**	**13.2**
Bare ground	41.4	0.3
Total other	**41.4**	**0.3**
Total area	**14,954.8**	**100.0**

in the central portion of the watershed; therefore, the percentages listed here may slightly underestimate the extent of human uses at present.

Zoning designations in the watershed were compiled from the most recent Frederick and Adamstown Regional Plans (FCDPZ 1991, 1992). Zoning information along the northern boundary was provided by the City of Frederick (1995). Information was digitized from these two sources to depict zoning classifications for the watershed (Figure 4-5).

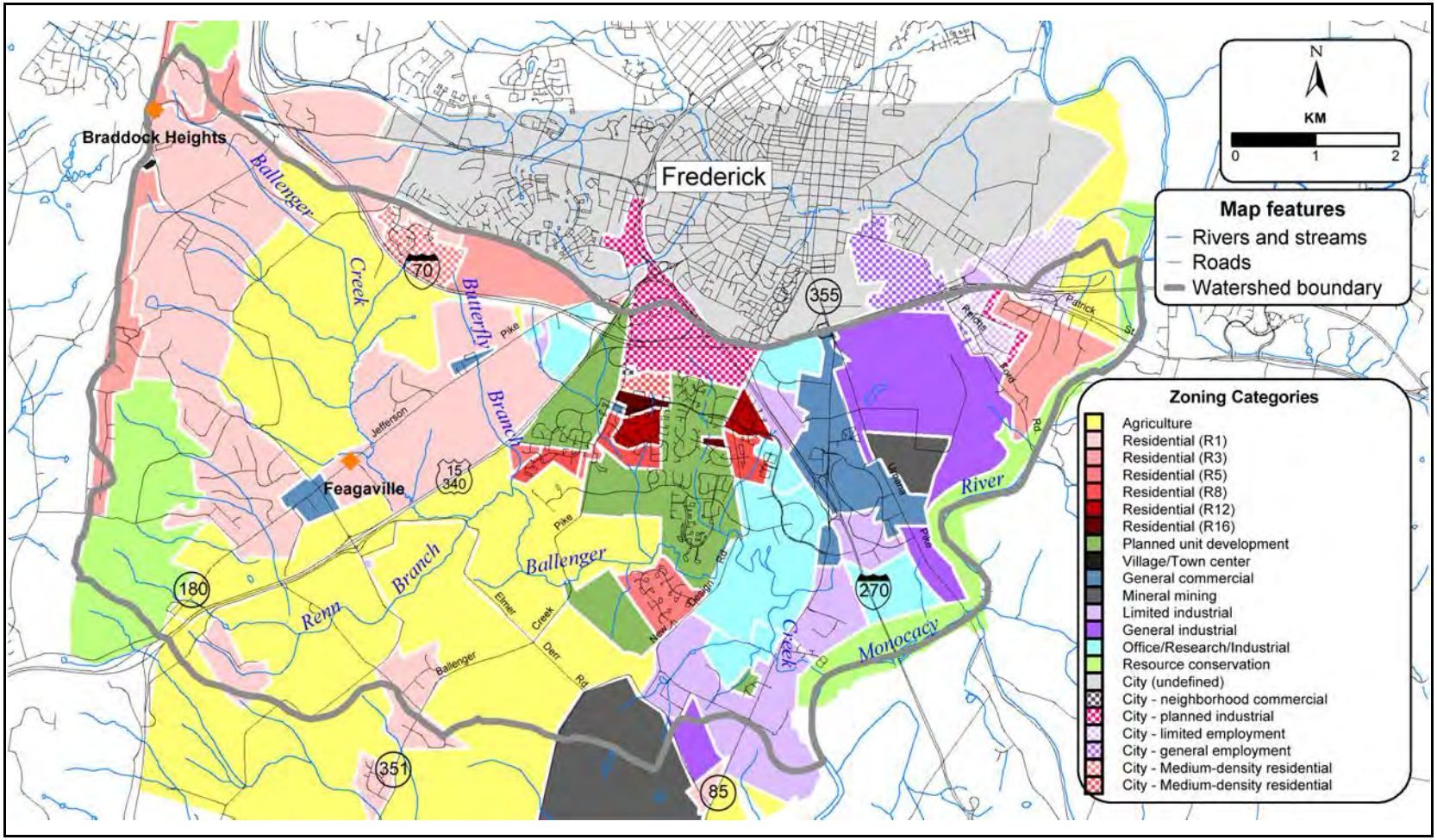

Figure 4-5. Current Frederick County zoning (2000) within Ballenger Creek watershed

4.8.2 Existing and Future Population

As of January 2000, Frederick County had a population of 199,369 representing an increase of 49,161 individuals (33 percent) since the 1990 census. By the year 2020, the County's population is projected to reach 281,710, an increase of 82,341 (41 percent) above its current level (all figures from FCDPZ 2000). Accompanying this growing population is a substantial increase in new housing and commercial/industrial construction. Countywide statistics estimate a total cost of new construction for 1999 of $437 million, a 13 percent increase over the previous year. More than 17,300 additional housing units in 79 major residential projects are in the County's development project pipeline (FCDPZ 2000), while commercial and industrial development also continue apace.

Projected population trends within Ballenger Creek watershed are shown in Table 4-15. An estimated 17,761 people resided in the watershed in 2000, up 23 percent from 1995. According to these predictions, population is expected to steadily increase over the next 20 years (Figure 4-6). By 2020, the watershed's population is expected to reach 30,865, more than double the 1995 level. In 1995, there were 5,176 households in Ballenger Creek watershed. By 2020, the projected number of households is 11,601, again more than doubling the 1995 value. Population density (number of people per square mile) is expected to increase from 618 in 1995 to 1,319 in 2020.

Table 4-15 . Projected population, number of households, and employment in Ballenger Creek watershed, 1995-2020

	1995	**2000**	**2005**	**2010**	**2015**	**2020**	**Increase 1995-2020**
Population	14,458	17,761	21,319	23,963	27,248	30,865	113%
Number of Households	5,176	6,432	7,815	8,873	10,172	11,601	124%
Population Density (people/sq. mile)	618	759	911	1,024	1,164	1,319	113%
Employment	12,828	21,020	24,787	29,686	33,627	37,016	189%

In addition to residential development, substantial commercial and industrial growth is occurring in the watershed, as demonstrated in recent employment trends. Approximately 21,020 persons were employed in the watershed in 2000, an increase of 64 percent from the 1995 level.

Employment is projected to continue to increase (Figure 4-6), reaching more than 37,000 in 2020.

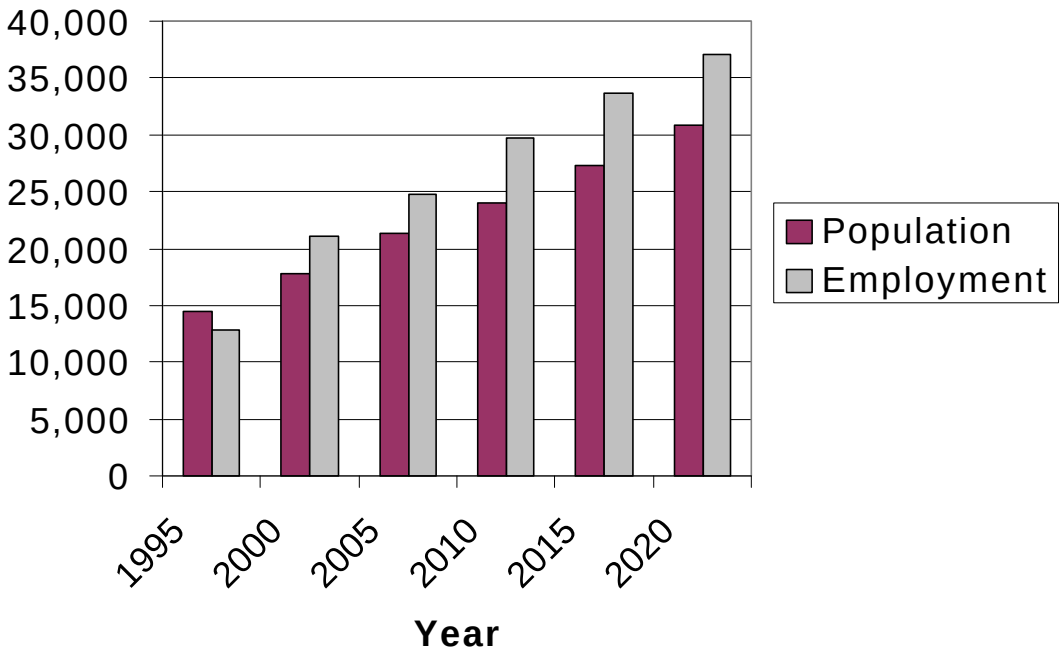

Figure 4-6. Current and projected population and employment within Ballenger Creek watershed, 1995-2020

Note that projecting population at this localized level is inherently an uncertain exercise. Future growth in areas like Ballenger Creek that face strong development pressure is a function of land use policies, land prices, and individual landowner actions. The decision by a single landowner to sell his property, and the subsequent approval of a new, large residential subdivision, could suddenly and significantly increase the population of Ballenger Creek watershed. Similarly, development of remaining lands zoned for office/research and commercial uses is expected to increase employment; however, the precise timing of such buildout is unknown.

4.8.3 Future Land Use

Figure 4-7 shows the predicted spatial pattern of the projected future land use in the Ballenger Creek watershed for the year 2020. Table 4-16 presents a breakdown of future land use (acres) by type of use. Because of the inherent uncertainty in projecting future land uses, classifications are more general than those used in characterizing current land use (Figure 4-4).

Projections indicate a substantial increase in human activities within the watershed. If the watershed is "built out" according to the zoned categories, by 2020 the watershed will be about 62 percent urban, up dramatically from its current level of about 25 percent. Residential uses are projected to reach about 36 percent, more than doubling the current land area used for residential purposes. Commercial, industrial, and other development are projected to reach 26 percent. Agriculture is

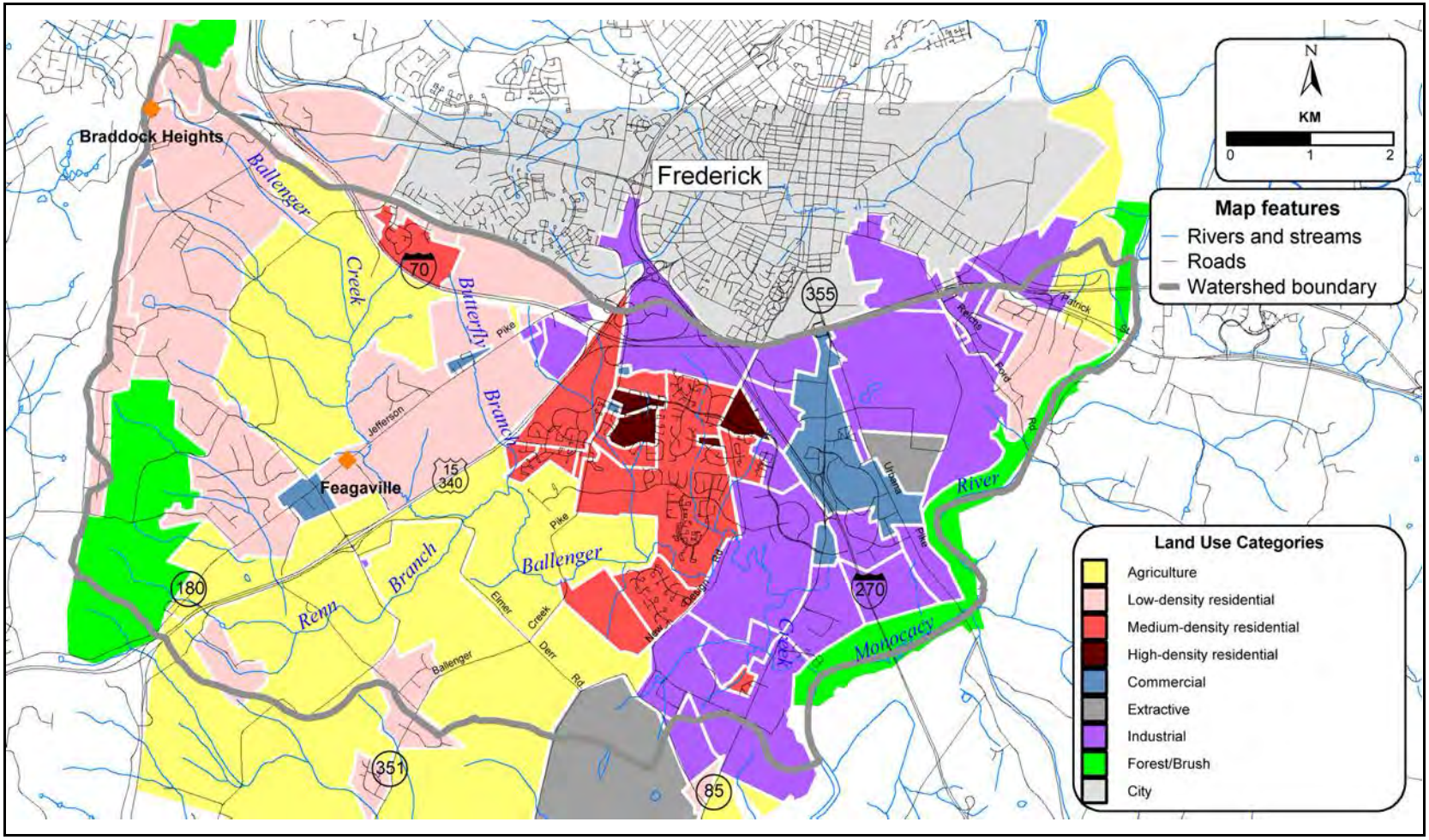

Figure 4-7. Projected future (2020) land use within Ballenger Creek watershed

expected to decrease from 59 percent to 30 percent, while forest cover is projected to drop from 13 percent to about 8 percent.

Table 4-16. Estimated future land use (2020) in the Ballenger Creek watershed

Land Use Class	Acres	Percent
Residential	5,331.4	36.1
Commercial/Industrial/Extractive	3,880.3	26.2
Total urban	**9,211.7**	**62.3**
Total agriculture	**4,442.3**	**30.0**
Total forest/vegetation	**1,131.8**	**7.7**

As planned, most new commercial/industrial development will occur in the eastern third of the watershed, in the subwatersheds drained by Quarry Branch and an unnamed tributary that joins Ballenger Creek just upstream of Buckeystown Pike. Much of this area overlays the band of limestone karst geology that cuts through the watershed (Figure 3-2). Future residential development in the central and upper watershed has the potential to affect Pike, Butterfly and Renn Branches as well as the mainstem of Ballenger Creek. The potential combined impact of both types of development may significantly degrade water quality and stream habitat, if stormwater management issues are not properly addressed.

4.9 Estimates of Impervious Surface in the Watershed

To predict stormwater impacts to stream water quality that may result from increased urbanization, it is valuable to examine the expected increase in impervious surface cover of the Ballenger Creek watershed. Currently, an estimated 16 percent of the watershed is impervious surface (e.g., rooftops, pavement, sidewalk, etc.). Figure 4-8 shows a generalized view of the current impervious surface coverage in the watershed. By 2020, our estimates show the watershed will have changed to include approximately 30 percent impervious surface.

The degree of imperviousness within Ballenger Creek watershed, 16 percent, has exceeded the 10 percent imperviousness threshold at which adverse effects are often reported. Ballenger Creek watershed's degree of imperviousness places it within the 10-25 percent impervious surface range at which habitat and water quality degradation are commonly noted. Without proper management, watersheds with greater than 25-30 percent impervious surface are vulnerable to severe impacts, including erosion, channel instability, severe habitat degradation, and decreasing biological integrity (CWP 1998). Our future projections indicate Ballenger Creek is likely to reach this higher level of imperviousness in the next 20 years.

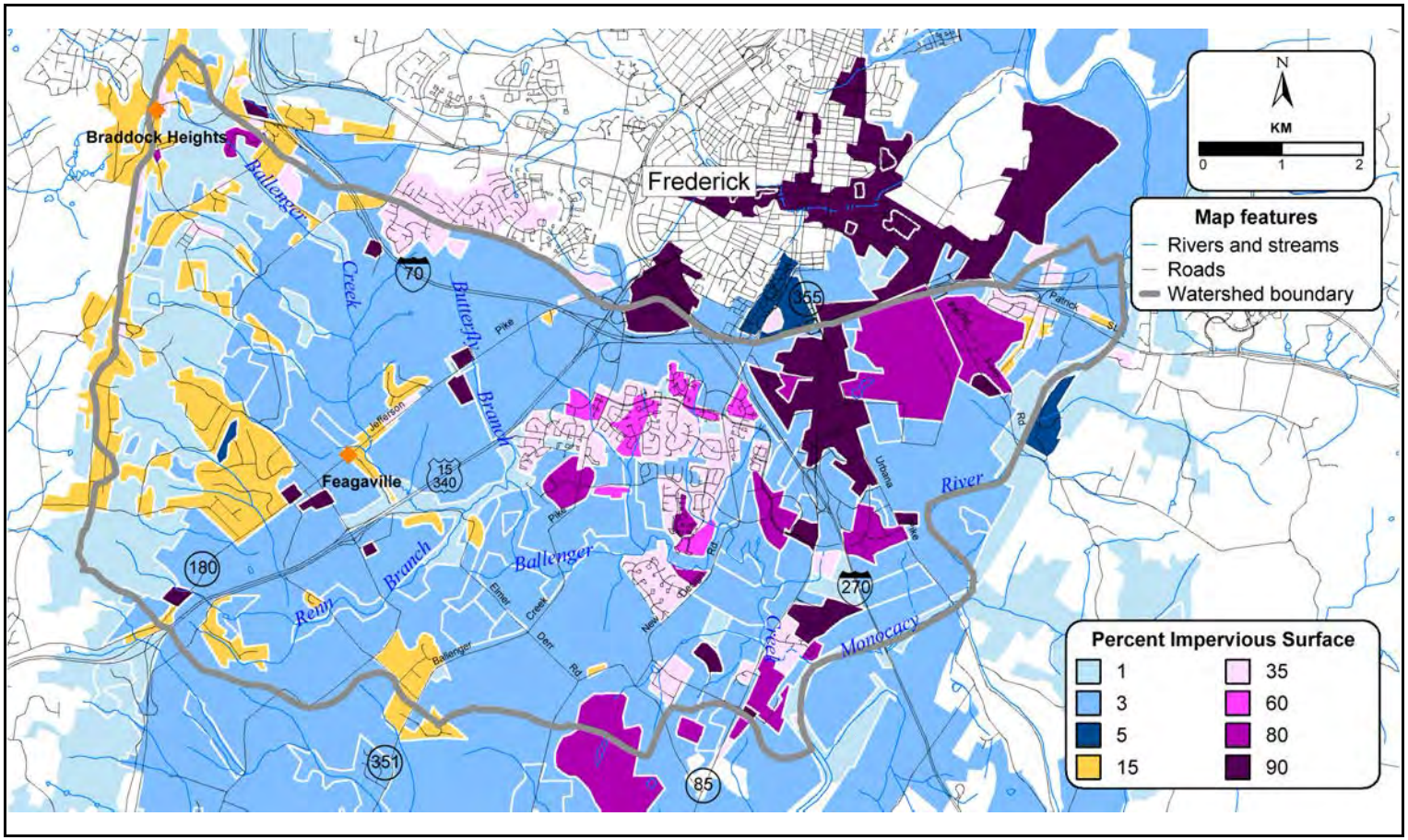

Figure 4-8. Generalized view of current impervious surface coverage within Ballenger Creek watershed

Furthermore, certain areas of the watershed (e.g., the corridors along I-270, I-70, MD 85, and MD 355) are likely to incur even greater amounts of impervious surface as more intensive development is targeted to these areas. Clearly, wise application of stormwater management measures will be needed throughout the watershed to prevent stream degradation in light of the expected increases in impervious surface.

5.0 ASSESSMENT OF WATER QUALITY PROBLEMS

The focus of this watershed assessment is to assess existing conditions in the Ballenger Creek watershed, identify water quality problems, and describe opportunities to improve water quality. The assessment of current conditions presented in Section 4 indicates a wide range of potential stressors, including both urban and agricultural land use activities. In addition, projections of future development and estimates of future impervious surface highlight the need to consider potential future impacts.

Within the last 10-15 years, development around the City of Frederick has expanded southward, replacing rural, agricultural, and undeveloped lands in the north-central and eastern portions of Ballenger Creek watershed. Projections of future development predict that urban land use, currently at approximately 25 percent, will expand rapidly to about 62 percent over the next 20 years. Impervious surface in the watershed is currently at a level where stream impacts are typically observed, and an increase brought about by additional development is likely to place additional stress on Ballenger Creek's water quality, biological integrity, and physical habitat.

Common stresses associated with urbanization include the loss of natural vegetation throughout the watershed and particularly the loss of riparian vegetation, which supports many important stream processes. Riparian vegetation stabilizes streambanks and reduces the inputs of nutrients, sediment, and other pollutants. Riparian vegetation also provides shade and contributes to shoreline and stream habitat quality by supplying rootwads and other woody debris that serve as cover for amphibians, reptiles, mammals, fish, and invertebrates. Other effects of urbanization can include more variable stream flows, increased erosion from runoff, habitat degradation caused by channel instability, increased nonpoint source pollutant loading, elevated air and water temperatures, and losses of biological diversity.

A list of water quality problems in Ballenger Creek watershed was developed by integrating information gleaned from the environmental assessment, visual inspection for potential watershed stressors, and other analyses compiled for this report. The objective was to identify problems and their likely causes as a basis for identifying opportunities to improve water quality.

Problems affecting water quality in Ballenger Creek and its tributaries are predominantly those arising from both urban and agricultural nonpoint sources. General problem types evident in Ballenger Creek and its tributaries include alterations of natural flow regimes (i.e., rapid conveyance of stormwater into stream channels), sediment deposition, and physical habitat degradation. In many cases, problems are minor, particularly where the presence of extensive forest buffer or existing stormwater management facilities provide some protection from the impacts of nearby land uses. More severe impacts were apparent at particular locations, especially in the lower sections of Ballenger Creek where karstic features re-route surface runoff and streamflows underground, create instabilities in existing BMPs, and otherwise increase the complexity of SWM issues. Taken individually, many of the activities in the watershed likely

have little detrimental effect; however, the cumulative effect of these activities throughout the watershed can be of greater concern.

Water quality problems within Ballenger Creek loosely fall into ten groups centered around the following issues: karst, hydrologic modification, livestock access to stream, cropland runoff, failing septic systems, new construction, future development, industrial/commercial development, existing structures, and stream restoration.

5.1 Ranking of Water Quality Problems

In order to prioritize the water quality problems, specific criteria were developed to assess and rank problems identified. For each problem, scores of 1 to 5 were assigned for the following factors:

- Extent: the spatial extent of the problem, ranging from local (1) to widespread (5)
- Severity: the degree to which the problem is a detriment to stream quality, ranging from mild (1) to most severe (5)
- Potential for environmental restoration benefit: this factor answers the questions "Would action likely bring about improvement in the condition of the environmental resource?" and "Overall, would restoration action likely be successful and cost-effective at this site?" Answers were scaled from little potential restoration benefit (1) to great potential benefit (5).

An average of the extent, severity, and restoration potential scores was then calculated to produce an overall water quality problem rating (1-5). Problems with an overall rating score of 3.0 or higher were then selected as priority issues because they present the greatest opportunity for improving water quality.

A summary of specific problems under each of the general types, along with rankings, is given in Table 5-1.

5.2 Opportunities to Improve Water Quality

In the last several years, Frederick County has expended considerable resources and effort to expand its NPDES stormwater management programs. These efforts have resulted in strong facility inspection, GIS and database management, permit review, stormwater sampling, and watershed assessment components. The County is also currently updating its stormwater management ordinance to reflect recent changes in State requirements.

In order to increase the effectiveness of the County's SWM management programs, an adaptive management process is being followed, with refinements continuously considered and

implemented. As such, a number of additional opportunities are recommended that would enable the County to better address SWM issues and improve water quality (Table 5-1). These opportunities include site-specific activities as well as general programmatic refinements that could apply to many areas and thus address cumulative effects throughout the Ballenger Creek watershed.

Many of the programmatic approaches recommended in the watershed assessment for Lower Bush Creek watershed (Roth et al. 1999a) are applicable to the problems noted here. As funding and staff resources allow, implementation of these approaches, especially those pertaining to education/outreach and agricultural issues, will bring about County-wide improvements and therefore help conditions in Ballenger Creek.

Several opportunities recommend Division of Public Work (DPW) coordination with other agencies. Managing stormwater at the county level is a complex task and involves a number of County agencies. While stormwater management is not the primary mission of these agencies, it is an issue that land use planners, road managers, development review staff, and conservation district staff deal with frequently. Staff from multiple agencies are often dealing with similar problems or working on related tasks, however, coordination is often informal at best. Organization of a more formal coordination committee between County agencies could help avoid duplication of efforts, share resources and knowledge, and provide more effective and consistent management of stormwater. Also, working with MDE and the City of Frederick is recommended, to address issues that fall outside the County's jurisdication.

The north-central and eastern portions of Ballenger Creek watershed contain relatively intense development. Much of the newer residential and commercial development appears to conform to current stormwater management standards; however, the presence of karst in the Frederick Valley presents special circumstances that may not be adequately addressed by existing facilities. As the collective knowledge base for stormwater management advances, new techniques may be available for addressing management issues in karst areas that were not available at the time many of these facilities were constructed. Therefore, retrofit opportunities may be available in the future.

Even with strict adherence to current stormwater control practices and implementation of BMPs for erosion and sediment control, it will be difficult to prevent any diminishment of the current level of stream water quality and habitat integrity in the watershed, especially given the projected level of development within the watershed. For example, most construction sites within Frederick County meet current erosion and sediment control requirements, however not all sediment is contained given the limits of existing technology. Therefore, the County may want to find ways to improve the efficiency of site controls in order to better retain topsoil and protect water resources. Given that no SWM practices are 100 percent effective in reducing runoff, sediment, and erosion, some degree of stream degradation is also likely to occur, as indicated by the amount of impervious surfaces within the watershed. However, without such stormwater control measures, far greater degradation would likely result.

Table 5-1. Assessment of water quality problems in Ballenger Creek watershed. Shading indicates problems with the greatest opportunity for improving water quality.

Problem ID	Location	Stream Affected	Description of Problem	Extent of Problem	Severity of Problem	Potential for Environmental Restoration Benefit	Overall Rating	Opportunities to Improve Stream Water Quality
Karst								
KA1	Portions of eastern third of watershed underlain by Frederick Limestone formation	Mainstem Ballenger Creek and tributaries in eastern third of watershed	Sinkholes, disappearing streams, and unlined SWM facilities can introduce stormwater and other pollution sources to groundwater	5	4	4	4.3	Develop karst ordinance with overlay zones, implement demonstration projects (structural and/or non-structural BMPs) to protect groundwater and improve stormwater management in karst areas
Hydrologic modifications								
HM1	Various locations watershed-wide	Entire watershed	Sediment discharged directly into stream channel at road crossings	5	4	3	4.0	Continue coordination with Highway Dept. to develop a road maintenance program to collect cinders, use less salt (as in the County's current initiative), create turnouts into vegetated filter strips, and use street sweepers and clean out storm drains in more urban areas
HM2	Channelization, W. of intersection of Renn and Elmer Derr Roads.	Unnamed tributary to Renn Branch	Straightened stream channel with possible headcutting and downstream sediment deposition	1	3	4	2.7	Monitor stream conditions to determine if channelization has caused detrimental effects
HM3	Culverts beneath Corporate Drive at Pike Branch	Pike Branch	Heavy coating of sediment and standing water in outlet aprons	1	2	5	2.7	Possible opportunity for SWM retrofit involving a sediment trap or vegetated filter
HM4	Concrete lined channels, particularly in areas of older development	North-central region of the watershed	Artificial substrate increases flashiness of flow	2	3	1	2.0	Suggest that property owners/home owners associations retrofit the lined channels during the next major maintenance effort
Livestock access to stream								
LA1	Western half of watershed	Mainstem Ballenger Creek, Renn Branch, Butterfly Branch, and several headwater tributaries to mainstem	Unrestricted livestock access to stream	3	4	5	4.0	NRCS or SCD conservation specialists can help farmers limit livestock access to streams with streambank fencing, and develop alternate watering and stream crossing facilities. Develop process for improved coordination with NRCS and SCD whereby DPW would notify them of problem sites or other concerns, as necessary, and follow up to confirm how problems have been addressed

Table 5-1. (Continued)

Problem ID	Location	Stream Affected	Description of Problem	Extent of Problem	Severity of Problem	Potential for Environmental Restoration Benefit	Overall Rating	Opportunities to Improve Stream Water Quality
Cropland runoff								
CR1	Western half of watershed	Mainstem Ballenger Creek, Renn Branch, Butterfly Branch, and several headwater tributaries to mainstem	General agricultural impacts arising from agriculture - sediment, excess fertilizers, narrow/absent riparian buffers	3	3	4	3.3	NRCS or SCD conservation specialists can help farmers implement current agricultural BMPs to manage nutrients, prevent soil erosion, trap sediment, and plant riparian buffers. Develop process for coordination and report specific problems to NRCS or SCD (see LA1 above)
Failing septic systems								
FS1	Watershed-wide in older development	Entire watershed	Older houses may have failing septic systems that could affect water quality	2	2	1	1.7	Determine extent of problem. Develop educational materials for residential property owners and provide technical assistance for upgrades and maintenance. Additional efforts could include monitoring for fecal coliform, and conducting dye studies of suspect systems
New construction								
NC1	MARC Frederick Extension, MD 355	Unnamed Tributary to Monocacy River, Monocacy River, & Ballenger Creek Watershed	Large expanses of bare earth near Monocacy Station site, altered site hydrology, few erosion and sediment (E&S) controls observed	3	4	5	4.0	Falls under MDE jurisdiction; no opportunities for DPW have been identified
NC2	Various locations watershed-wide	Entire watershed	Inadequate coordination on E&S problems	3	3	4	3.3	Although E&S falls outside of DPW jurisdiction, DPW inspectors do, on occasion note E&S problems. Develop process for coordination and report specific problems to SCD (see LA1 above)
NC3	Along I-70 corridor	Tributaries in northern part of watershed	Example: New development evident in headwaters of Butterfly Branch. Although located within jurisdiction of City of Frederick, activities may affect water quality downstream	2	2	1	1.7	Coordinate management efforts in this area with City of Frederick

Table 5-1. (Continued)

Problem ID	Location	Stream Affected	Description of Problem	Extent of Problem	Severity of Problem	Potential for Environmental Restoration Benefit	Overall Rating	Opportunities to Improve Stream Water Quality
Future development								
FD1	Watershed-wide	Entire watershed	Regional growth associated with City of Frederick and MARC commuter line will increase population and development within the watershed	5	4	3	4.0	Continue to enforce planning and construction requirements for SWM controls, with the goal of not altering flows or pollutant loads from predevelopment conditions. Minimize short-term construction impacts. Identify locations for new structural BMPs in western half of watershed as new developments are proposed
Industrial/Commercial development								
IC1	Automobile scrapyard and truck repair facility, Reichs Ford Road	Unnamed Tributary to Monocacy River	Inadequate stormwater controls in area of older Industrial/Commercial development	2	3	4	3.0	Review area in greater detail to identify retrofit opportunities or work with facility owners (private landowner and City of Frederick) to improve housekeeping practices
IC2	Quarrying operations and related facilities, MD 355 & Reichs Ford Road	Quarry Branch, Unnamed tributary to Monocacy River	Dust, discharge of pumped groundwater, disruption of hydrologic regimes of receiving waters	3	4	1	2.7	MDE has been notified of dust issues. Other activities are regulated under mining discharge permit. Little opportunity for further action.
IC3	Frederick Municipal Airport	Monocacy River	Materials may wash from airport into the watershed, depending on site grading and storm drain system	1	2	3	2.0	Contact facility manager to determine if airport drains into the watershed, discuss typical stormwater pollutants from airports, and determine if housekeeping practices are adequate. Coordinate with City of Frederick, which has jurisdiction over the airport

Table 5-1. (Continued)

Problem ID	Location	Stream Affected	Description of Problem	Extent of Problem	Severity of Problem	Potential for Environmental Restoration Benefit	Overall Rating	Opportunities to Improve Stream Water Quality
Existing structures								
ES1	Riverview Plaza; MD 355	Monocacy River	Poorly vegetated banks, trash, turbid water, sediment deposition, adjacent construction of MARC station and tracks may disrupt functioning of dry pond	2	3	5	3.3	Contact MDE and request that they increase inspection and enforcement measures at the MARC construction project because it is impacting an adjacent structure under DPW jurisdiction. DPW to inspect adjacent structure and if necessary notify with facility manager to improve maintenance efforts. Take opportunity to educate facility manager about the need and importance of the BMP and its continued upkeep
ES2	Wedgewood Regional SWM Facility, Wedgewood Boulevard	Unnamed tributary entering Ballenger Creek just upstream of MD 85	Accumulated sediment in forebay, trash and debris below outlet, blown out swale entering basin	2	3	5	3.3	Prior to conversion of this sediment basin to SWM pond, and while bond is still being held by the County, inspect structure and if necessary, notify facility manager to improve maintenance efforts. Take opportunity to educate facility manager about the need and importance of the BMP and its continued upkeep
ES3	Frederick Industrial Regional Facility, Industrial Drive	Arundel Branch	Erosional scars and animal burrows noted in berm, damaged inlet structures	2	2	5	3.0	Inspect structure and if necessary notify facility manager to improve maintenance efforts. Take opportunity to educate facility manager about the need and importance of the BMP and its continued upkeep

Table 5-1. (Continued)

Problem ID	Location	Stream Affected	Description of Problem	Extent of Problem	Severity of Problem	Potential for Environmental Restoration Benefit	Overall Rating	Opportunities to Improve Stream Water Quality
Stream Restoration								
SR1	Ballenger Creek behind Ballenger Creek Elementary School	Ballenger Creek	Severely eroded and undercut banks, and large debris blockages immediately downstream from active livestock pasture. Several sewer line crossings have been hardened with concrete	3	5	5	4.3	Restore impacted stream channel, correct and minimize further erosion-related problems, and coordinate environmental educational opportunities with Board of Education. This site is located on publicly owned land which would significantly reduce project costs and complexity; requires coordination with Board of Education
SR2	Confluence of King and Arundel Branches with Ballenger Creek, immediately upstream of New Design Road	Mainstem Ballenger Creek, King Branch, Arundel Branch	Severe bank erosion, lateral channel migration, and grade adjustment due to destabilized channel, downstream disturbances from excess sediment	2	5	5	4.0	Correct major stream channel erosion impacts, design to reduce additional high flow degradation
SR3	Ballenger Creek at Ballenger Creek Park	Ballenger Creek	Severe bank erosion, lateral channel migration, and grade adjustment. Downstream sediment deposition	3	4	5	4.0	Restore impacted stream channel, including erosional problems. Implement joint agency effort to improve a public use area, coordinate with the Ballenger Creek Trail Project, conduct environmental education, and improve stream water quality and aesthetics
SR4	Ballenger Creek Park to the mouth of Ballenger Creek	Ballenger Creek	Limited or absent forested riparian buffer along the mainstem	2	3	5	3.3	Collaborate with Ballenger Creek trail effort and the state-wide Stream Releaf program to restore or enhance the forested riparian buffer
SR5	Various locations watershed-wide	Entire watershed	Loss of forested land	3	2	4	3.0	When off-site mitigation is being considered under Frederick County's Forest Resource Ordinance, plantings may be targeted in riparian areas to restore forested stream buffers

6.0 WATERSHED WATER QUALITY PLAN

This watershed water quality plan integrates the results of the entire watershed assessment and provides recommendations for water quality improvements that focus largely on preventative measures. The Plan includes both programmatic actions intended to encourage the design of appropriate SWM facilities, as well as site-specific recommendations. To be most effective, actions should be taken at both scales to protect Ballenger Creek from the impacts of existing land use and future development. In particular, the watershed's underlying limestone and karst features present specific challenges to designing SWM facilities because hydrologic characteristics, site conditions, and potential stormwater contaminants vary greatly.

6.1 Integration of Watershed Assessment Results

The Ballenger Creek watershed is characterized by rolling topography of the Western Division of the Piedmont Physiographic Province, with an area of limestone beneath the eastern third of the watershed exhibiting karstic features. Agriculture is the dominant land use within the watershed; however, the north-central and eastern third of the watershed is heavily developed with residential subdivisions, as well as commercial/industrial corridors along main roads. Given the long history of human habitation and agricultural land use in the region, streams are far from pristine; however, much of Ballenger Creek and its tributaries appear to be in moderately good condition at present. The stream supports a variety of fish and invertebrate biota, including several sportfish species. Remaining forest and wetland areas support good biological diversity. Potential pollutant sources are most likely to stem from nonpoint sources; currently development, especially in karst areas, is expected to pose the most significant threat to water quality, while agricultural sources also affect the creek and its tributaries.

Development pressures are strong in Frederick County, and in order to protect natural resources, growth has been targeted to selected areas of the County in an effort to minimize overall environmental impacts. Ballenger Creek has been designated as a Growth Area, and projections indicate that by 2020 the watershed will be approximately 62 percent urban, up dramatically from its current level of about 25 percent. A major challenge in managing the Ballenger Creek watershed is to minimize environmental impacts within the designated Growth Area, while also preserving the natural character of other sensitive resource areas.

An assessment and ranking of water quality problems shows that reducing impacts of current and future development, as well as those from agriculture, are key issues within the watershed. The identification of these issues provides an opportunity to develop measures to improve existing water quality in Ballenger Creek, as well as pro-actively address future issues.

6.2 Recommended Actions to Improve Water Quality

From a list of water quality problems and potential opportunities to improve water quality in Ballenger Creek, the most promising opportunities (shaded problems in Table 5-1) were selected

as part of this watershed plan. Further implementation depends upon cost, available funding, feasibility, and the likelihood of success in improving or sustaining stream habitat and water quality. Recommended actions (including both programmatic and site-specific opportunities) address the primary threats to water quality, as identified in the watershed assessment. These include stormwater runoff from existing development, stormwater management issues in karst areas, livestock access to streams, agricultural runoff, and future construction and development.

6.2.1 Programmatic Opportunities

The benefits of programmatic refinements to Frederick County's SWM activities are expected to be particularly important because they address water quality impacts across the County and not just in Ballenger Creek watershed. For example, refinements to address the karst issues in Ballenger Creek would also help other karst areas in the County that have yet to be assessed, thereby bringing improvements to these areas earlier than otherwise would occur through the current watershed assessment schedule. The County-wide focus of these approaches would also help build public and institutional support for SWM programs.

It is also recognized that the County's opportunities for action at a particular site may be limited, especially with regard to existing SWM structures. However, programmatic changes can shape the way stormwater is managed in the future, in particular, through better site designs, construction of new BMPs, and maintenance of existing SWM facilities. For instance, developers can be encouraged (or required) to use low-impact development approaches, while the process of completing a permit application can be used to promote proper management strategies.

The following programmatic approaches are recommended:

> **County NPDES management committee:** The formation of an interagency NPDES Management Committee, as Baltimore County has done, would help coordinate and disseminate information between representatives from involved County agencies. The group would formalize the interaction between Frederick County's Division of Public Works (i.e., Development Review and Highways and Transportation), Division of Planning, and other agencies, allowing agency staff to work together to address stormwater management activities. Building upon existing programs will also facilitate more cost-effective solutions.
>
> SCHEDULE: Initiate assessment of feasibility by December 2001
>
> PRELIMINARY COST ESTIMATE: $5,000

Karst: Limestone karst underlies much of Ballenger Creek watershed, particularly the eastern and central portions where current residential, commercial, and industrial developments are concentrated and where future development is likely to occur. Because standard BMPs used generally may not function properly in karst terrain, specialized approaches are needed to address unique issues involving water quantity and quality, as well as structural integrity and public safety problems.

Degradation of groundwater quality is also a key concern in karst areas, particularly with stormwater runoff from roads, large parking lots, and other commercial/industrial areas. As shown in highway and other studies, fractures, sinkholes, and sinking streams provide little filtration of surface water; therefore, sub-surface flows can transport surface contamination to groundwater resources as they are rapidly recharged. The effects of this contamination on groundwater may also persist over long periods. Therefore, Office of Development Review staff should be knowledgeable about hydrogeology and karst issues in order to provide adequate review of submitted plans. This may require extra training or additions to staff.

A programmatic strategy for addressing stormwater issues in karst areas could include:

! Development of a Karst Ordinance to supplement Frederick County's stormwater ordinance. The karst ordinance could require lined structures or the diversion of stormwater away from known sinkholes to prevent groundwater contamination. Other locales have successfully implemented karst ordinances that require a multi-phased geotechnical study by permit applicants that includes an on-site evaluation of karst features and site hydrology. Applications are reviewed by the permitting agency (or their geotechnical consultant) to identify potential problems early in the process. Elements include review of existing data, aerial photo interpretation, geological site reconnaissance (collecting site-specific data), agency review/comment following karst BMP guidelines, and a construction inspection. Results and recommendations become part of the site plan and plan approval process. The Town of Walkersville, Maryland, has a karst ordinance that may serve as a local example.

SCHEDULE: Draft by Spring 2002

PRELIMINARY
COST ESTIMATE: $20,000

! Development of a karst overlay zone to identify areas where special stormwater management procedures, such as those in a Karst Ordinance, are required.

SCHEDULE: - Obtain and evaluate Maryland Geologic Survey karst maps, which are scheduled for completion in mid-2001, by FY03
- Propose overlay zone by FY04

PRELIMINARY COST ESTIMATE: $10,000

Coordination procedures: Stormwater management in neighboring jurisdictions, as well as those in the domain of the agricultural community, can affect Frederick County's watersheds. Therefore, the County should contact staff from the City of Frederick, neighboring counties, Natural Resource Conservation Service (NRCS), and local Soil Conservation District (SCD) to develop an improved process to coordinate regional activities, relay concerns about specific locations (e.g., using a phased approach to limit exposed soils at active construction sites or identifying sites where livestock have access to stream), and follow-up to see how SWM concerns have been addressed.

SCHEDULE: Initiate contact by March 2001

PRELIMINARY COST ESTIMATE: $4,000

Roads: Continue current initiatives with the County's Department of Highways and Transportation to develop a road maintenance program that reduces the amount of sediment, gravel, de-icing agents, and other materials that are washed directly from road right-of-ways into the County's streams. Also contact Maryland Department of Transportation to discuss how their projects and roads in Frederick County affect stormwater. (Note: additional recommendations may result from the road maintenance evaluation required under the County's NPDES stormwater permit, to be conducted in 2001.)

SCHEDULE: As needed

PRELIMINARY COST ESTIMATE: $4,000

Combined program activities: In conjunction with capital improvement projects (e.g., stream restoration and structural BMPs), multiple program activities such as educational/outreach activities and street sweeping/drain clean-out efforts can be combined to address stormwater management issues in older areas of development. The intent of this concerted effort would be to increase the success and long-term stability of restoration efforts, while also capitalizing on the opportunity for public education and involvement. It is worth noting that Baltimore County, Maryland uses this combination of approaches in areas that do not have adequate controls.

SCHEDULE: Proposal by December 2001

PRELIMINARY
COST ESTIMATE: During 2001: $5,000
Future: $10,000

Forest resources: Forests are a valuable resource in the County and when off-site mitigation is being considered under the County's Forest Resource Ordinance, plantings to replace lost trees may be targeted in riparian areas to restore forested stream buffers. Efforts to replant riparian forests can also be combined with a state-wide Stream ReLeaf program to restore or enhance forested stream buffers in the Chesapeake Bay watershed.

SCHEDULE: As needed

PRELIMINARY
COST ESTIMATE: Nominal

6.2.2 Site-Specific Opportunities

A number of opportunities to improve water quality were identified at various locations in the watershed and site-specific approaches were developed to address these issues. These opportunities have been grouped into two categories; BMPs and stream restoration. A third category contains recommendations for further study, where insufficient information was available to fully assess impacts or develop recommendations.

6.2.2.1 Best Management Practices

The following actions associated with BMPs are recommended in the Ballenger Creek watershed:

Demonstration project: Construct a structural BMP demonstration project to research karst issues related to stormwater management. An important objective of this project would be to prevent groundwater incursion by contaminant-laden runoff, and then facilitate the incorporation of these findings into the design and maintenance of future BMPs in the County.

SCHEDULE: Initiate design and land acquisition in FY06

PRELIMINARY
COST ESTIMATE: $500,000

Re-inspections: Problems were noted at three existing SWM structures during the watershed assessment (Table 5-1, Problem IDs ES1, ES2, and ES3) and efforts should be undertaken by the County to re-inspect these facilities, taking advantage of this opportunity to educate facility managers about the need and importance of the BMP and its continued upkeep.

SCHEDULE: Inspect by February 2001

PRELIMINARY
COST ESTIMATE: Nominal

6.2.2.2 Stream Corridor Restoration

Flooding, excessive erosion and deposition, and poor physical habitat are common problems associated with destabilized stream channels. Stream restoration is a valuable tool that can help return these streams to a more natural condition, and thereby prevent additional degradation of water quality, habitat, and biological resources. However, a number of major considerations must be addressed in order to achieve success, as discussed below.

Unmodified stream channels are the product of a dynamic equilibrium between erosional and depositional processes. This equilibrium fluctuates over time and, typically, stream channels are able to recover after disturbance events such as flood pulses or temporary influxes of excess sediment. However, changes in the underlying variables can force the equilibrium to re-establish itself (and the stream) differently. For example, development within a watershed typically results in a flashier streamflow regime as increased imperviousness causes stormwater to be conveyed more rapidly to stream channels. The channel may respond to flashier flows with geomorphic changes, evident in destabilized banks and altered channel structure. The new flow regime can be incorporated into stable restoration designs, recognizing that the resulting stream system may be quite different than that which existed prior to major disturbances.

New methods for rehabilitation of channelized rivers have emerged over the last few decades. These successful methods are based on emulating the natural form and processes that take place in an undisturbed, meandering channel (Brookes 1985, 1987; Newbury and Gaboury 1993). Advantages of rehabilitating stream systems via this approach include: increasing channel stability, because pools and riffles help dissipate energy; reducing disturbance to biotic systems through the maintenance of habitat diversity; and the improvement of many intangible benefits which arise from greater visual, aesthetic, and recreational potential (Brookes 1987; Keller 1975).

Rehabilitation projects attempt to re-create selected processes that shape natural systems, although often the results of these projects only approximate natural systems (NRC 1992). Fluvial ecosystems are very complex, and their reconstruction is often based on considerations of stream hydraulics. This approach is centered on the observation that organisms live where there is suitable habitat, and suitable habitat is formed by diversity in the stream's hydraulic conditions (Petts 1995). Under this approach, developing variability in hydraulic conditions will lead to increased morphological (habitat) diversity, and ultimately, to increased biotic diversity. The variable nature of fluvial systems also necessitates that channel improvement plans be tailored to a particular site (Brookes 1985).

The natural linkages that exist between upland, riparian, and aquatic ecosystems must also be maintained for these ecosystems to function as they should. Therefore, restoration of riparian vegetation is fundamental to the success of stream rehabilitation projects (Kauffman et al. 1993, Brookes 1987). Kauffman et al.(1993) suggest that 100-foot (30 meter) forested buffers be preserved along both sides of rehabilitated streams.

While the success of any restoration project depends on a number of natural and human variables that must be accounted for in the planning, design, and construction phases, the following phased approach may be used to help avoid, minimize, or mitigate many of the obstacles facing projects. Brookes (1990) recommended a project framework consisting of seven phases: 1) establish detailed project objectives, 2) perform a feasibility/planning study, 3) develop project design and engineering plans, 4) implement project construction, 5) conduct post-construction clean-up, 6) perform on-going maintenance, and 7) perform post-project monitoring. The monitoring phase is critical to evaluating the success of the project as well as contributing to the overall knowledge base on rehabilitation of stream ecosystems (Brookes 1990, 1995; Toth et al.1995; NRC 1992; Kondolf 1995; Kauffman et al. 1993). Kondolf (1995) also suggests that each project be considered an experiment in which findings may be used to improve subsequent projects.

As such, restoration is proposed for the following stream reaches:

Ballenger Creek at Ballenger Creek Elementary School: Severely eroded and undercut banks were observed immediately downstream of an active livestock pasture. This site is located on publicly owned property and would provide unique educational opportunities for school students and the community.

SCHEDULE: - Initiate design study July 2001
- Initiate construction July 2002

PRELIMINARY
COST ESTIMATE: Design: $18,000
Construction: $80,000

Ballenger Creek at Ballenger Creek Park: Significant bank erosion, lateral channel migration, and grade adjustment were observed at this location. This site is located on publicly owned property and would provide unique educational opportunities for the community, especially if coordinated with the Ballenger Creek Trail Project.

SCHEDULE: - Initiate design study July 2001
- Initiate construction July 2002

PRELIMINARY
COST ESTIMATE: Design: $60,000
Construction: $250,000

Ballenger Creek Park to the mouth of Ballenger Creek: The County may be able to collaborate with the Ballenger Creek Trail Project and the state-wide ReLeaf program to restore lost or enhance existing riparian buffer along a large portion of the stream.

SCHEDULE: As needed

PRELIMINARY
COST ESTIMATE: $5,000

Ballenger Creek just upstream of New Design Road: Significant bank erosion, lateral channel migration, and downcutting were observed at the confluence of King and Arundel Branches.

SCHEDULE: Feasibility to be determined; approach private landowners by FY06

PRELIMINARY
COST ESTIMATE: $20,000

6.2.2.3 Further Investigations at Specific Sites

Insufficient information was available to fully assess impacts associated with the following issues, therefore further study is recommended.

Stormwater impacts to groundwater in karst areas: To assess stormwater impacts to groundwater in karst areas, the County could evaluate surface and groundwater quality in the vicinity of existing SWM facilities within the karst area. This study should determine whether retrofits are needed to improve water quality, especially in areas where groundwater is still being used as a source of drinking water. A groundwater survey could rely, partially, upon data collected from existing domestic wells to reduce costs.

SCHEDULE: Design study by FY04

PRELIMINARY
COST ESTIMATE: $50,000-$100,000

Scrapyard and truck repair facility: These facilities located on Reichs Ford Road could pose serious threats to water quality if contaminants are washed off-site and into nearby streams. The area should be reviewed in greater detail to identify retrofit opportunities. In addition, facility managers, which include a private landowner and the City of Frederick, should be contacted to discuss methods for improving housekeeping practices.

SCHEDULE: Identify opportunities by May 2001

PRELIMINARY
COST ESTIMATE: $5,000

6.3 Monitoring to Evaluate Effectiveness of Water Quality Improvements

Outlined here are proposed procedures to monitor and evaluate the effectiveness of water quality improvements as a result of project implementation. As set forth in the Long-Term Monitoring Plan (Southerland et al. 1999), water quality, physical habitat, and biological conditions should be monitored periodically. We recommend that conditions at the six Ballenger Creek watershed monitoring stations (BALL-01 to BALL-06) be reevaluated every two years, using the procedures described in the Long-Term Monitoring Plan. Assessing these stations every other year will more effectively distribute the County's resources and save on monitoring costs, while still providing sufficient information to track changes in watershed conditions. Results from this assessment should be documented in a separate study report as well as summarized in the County's NPDES Annual Report.

In addition to stream monitoring data, we recommend that supplemental visual inspections and photographic documentation of specific site locations be conducted at least every two years to monitor effectiveness of management actions. Because natural variability may make it difficult to detect trends in stream monitoring data until a long-term data set is amassed, visual inspection results will help demonstrate whether management actions are beginning to achieve the desired benefit, or whether additional corrective measures are needed. Findings from each round of supplemental visual inspections should be documented in a study report which discusses trends and also presents recommendations necessary to address major problems identified during the survey.

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