APPENDIX B

MODELING REPORT:
CAMERON RUN WATERSHED PLAN

Prepared for

Fairfax County
Stormwater Planning Division
Department of Public Works
and Environmental Services

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1.0 SWMM-RUNOFF MODEL DEVELOPMENT

1.1 INTRODUCTION

This section documents the procedures used to develop the SWMM-RUNOFF model of the Cameron Run watershed. The SWMM-RUNOFF model simulates the watershed runoff produced by rainfall. Groundwater routines included in the model are used to simulate stream baseflow. The SWMM-RUNOFF model is also used to simulate nonpoint washoff by storm runoff as well as baseflow water quality. SWMM-RUNOFF model simulations produce time histories of flow and pollutant loads. These data files are transferred to SWMM-TRANSPORT model(s) to simulate instream water quality impacts. Ultimately, SWMM-TRANSPORT and HEC-RAS are applied to simulate conditions in the streams in response to the simulated flows and loads calculated by SWMM-RUNOFF.

The procedures used to delineate the subbasin (catchment) boundaries and to develop data on the subbasins for input to the models are described in the following sections. These procedures are based on the guidelines and recommendations contained in CDM's Technical Memorandum No. 3 – Stormwater Model and GIS Interface Guidelines (TM3) (CDM 2003).

As a result of the stormwater control regulations that have been in place in Fairfax County over the years, there are hundreds of stormwater control facilities (primarily wet ponds and dry ponds) throughout the Cameron Run study area. For a watershed planning study, it is not feasible to collect design information and simulate each of these stormwater facilities individually. For this reason, the selected approach is to model a composite stormwater control for each subbasin to approximate the effects of multiple facilities on stormwater quantity and quality.

As described in TM3 (CDM 2003) Fairfax County assigned portions of the watershed areas in the county to one of the following subarea categories based on the type of stormwater controls (these parcel areas were provided to Versar as GIS files):

A. Parcels developed after 1972 are assumed to be served by stormwater detention control facilities that control the peak flows from the upstream developed area.

B. Parcels that were developed after 1993 are assumed to have peak flow control and water quality stormwater control facilities.

C. Parcels developed prior to 1972 are assumed to have no stormwater controls.

Portions of the cities of Falls Church, Alexandria, and Arlington are included in the Cameron Run watershed. Stormwater facilities data for these cities are not available. The SWMM-RUNOFF model set up assumes that these areas have no stormwater controls.

1.2 SUBBASIN DELINEATION

To simulate runoff, the watershed is subdivided into subbasins ranging from 100 to 300 acres. The first step in the model setup was the subbasin delineation. Fairfax County Stormwater Planning Division provided digital elevation data in DEM format with a grid size of 30 feet by 30 feet. A DEM format consists of a uniform grid of elevation data that covers the watershed. The data were obtained by processing data for a detailed elevation model including elevation points and breaklines developed as part of the County topographic mapping project. Portions of the watershed outside of Fairfax County were delineated using DEM data from the cities of Falls Church, Alexandria, and Arlington.

Generalized procedures are available to develop subbasin boundaries from digital elevation data in DEM format. These procedures require that the DEM data be further processed before the subbasins can be defined. Much of this processing was performed by the County as described below. The County had preprocessed these data to “burn” in the major stream network using the Fairfax Hydrograph Dataset Stream layer. The County had also used generic routines to identify and “fill” low spots within the grid. Generic flow-direction and flow-accumulation grids were also generated. The flow-direction grid defines the direction in which flow will leave the grid cell based on the elevation in the grid cell and elevations of surrounding grid cells. The flow-accumulation grid identifies the number of grid cells located upstream from each grid cell.

ArcView Version 3 (PrePRO) scripts were obtained from Dodson & Associates, Inc. These tools were used to develop the subbasin boundaries. The PrePRO tools define subbasin areas located above outlet points. Initially, automated tools were used to develop watershed outlet points for the subbasins. The outlet point locations were edited and additional points were added to represent the locations of Fairview Lake, Lake Barcroft, and the USGS gaging station on Cameron Run in Alexandria, VA. The automatically generated subbasins were compared with the GIS layer of stormwater facilities (STORMNET) provided by the County. This GIS layer provides an accurate mapping of stormwater facilities, including stormwater pipes, in the Cameron Run watershed. The subbasin boundaries were examined for situations where the constructed storm drainage network caused the subbasin boundaries to be significantly different from that generated from the DEM data; no significant adjustments were needed based on this analysis.

The delineation processes resulted in 155 subbasins. The total area in the final watershed is 44.39 square miles of which an area of 33.9 square miles is upstream of the USGS gage and is included in the model. The subbasins range from 99 to 289 acres and average 183.3 acres; subbasins are grouped by the major tributaries into subwatersheds (e.g., Tripps Run). The final subbasin boundaries are shown in Figure 1-1. A GIS layer will be provided to the County with the drainage boundaries including data such as area in acres, slope, and width (this includes subbasins in portions of Alexandria, Falls Church, and Arlington).

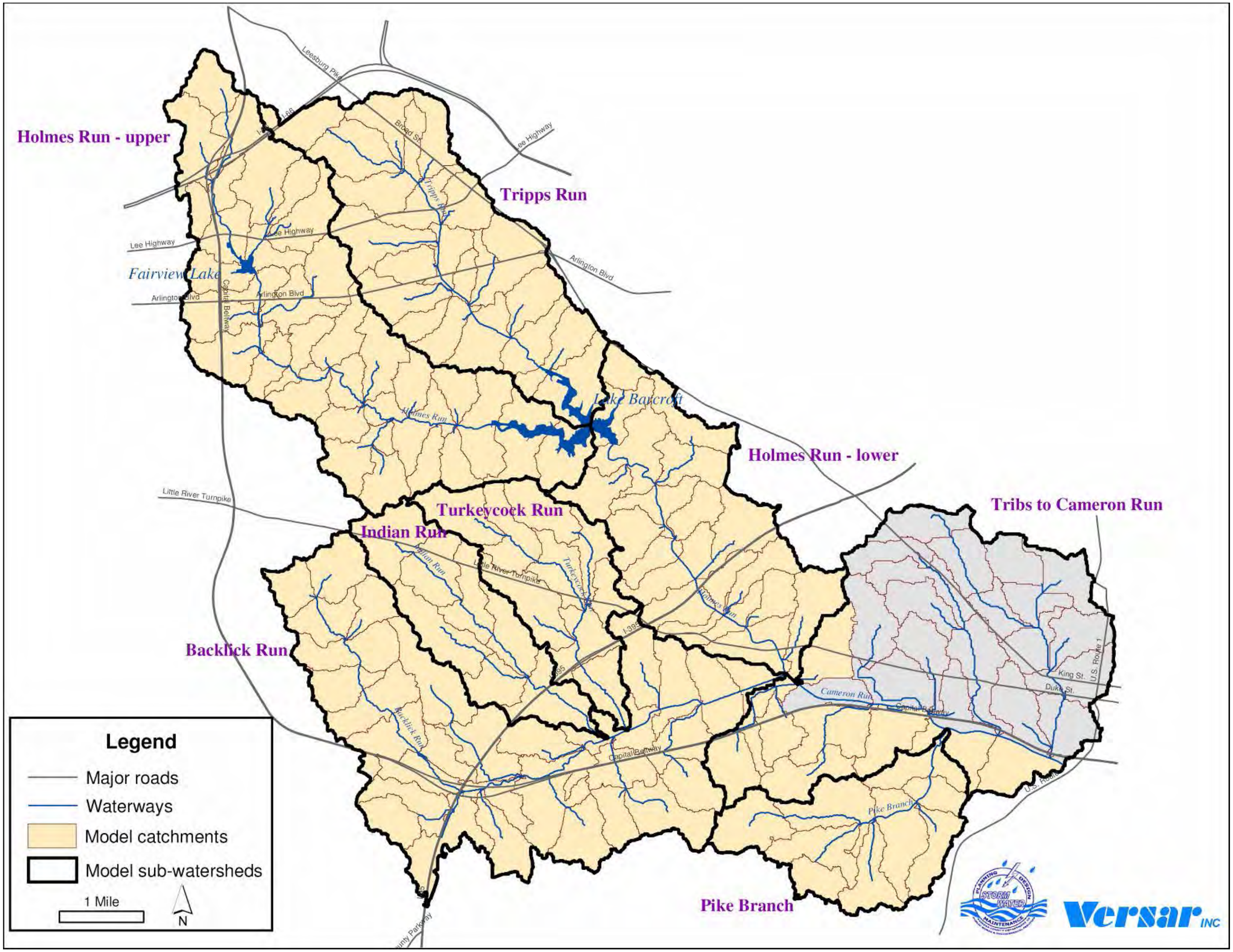

Figure 1-1. Cameron Run subwatershed and subbasin delineation

1.3 SUBBASIN IDENTIFIERS

Subbasin identifiers were generated based on recommendations in the TM3. The identifiers include three parts:

- A two-character watershed name. CA for subbasins in the Cameron Run watershed.
- A two-character subwatershed or stream tributary identifier. These are the stream names developed for the Stream Physical Assessment Study. Named streams in the Cameron Run watershed are identified below:
  - BA (Backlick Run)
  - CA (Cameron Run)
  - CW (Cow Branch)
  - HO (Hooff Run)
  - HR (Holmes Run)
  - IR (Indian Run)
  - PK (Pike Branch)
  - PR (Poplar Run)
  - TA (Taylor Run)
  - TR (Tripps Run)
  - TK (Turkeycock Run)
- A four-digit subbasin identifier. The subbasins within a named tributary are numbered sequentially generally starting at the bottom of the tributary and proceeding upstream.

As an example, CAPK0001 is one of the subbasins in the Pike Branch subwatershed.

The SWMM-RUNOFF and TRANSPORT models limit the maximum number of characters in a subbasin ID to 10. As discussed further in Section 2.2, additional identifiers are required to distinguish portions of the watershed that have peak shaving and water quality control best management practices. Therefore, a shortened version of the subbasin identifiers was used for input to the models. The shortened identifier was created from the long identifier by eliminating the leading two characters in the basin identifier portion of the name. All of the subbasins in the Cameron Run watershed start with CA.

Using these procedures, the long subbasin name CAPK0001 is shortened to PK0001 for input to the SWMM-RUNOFF model. The leading zeros in the four-digit subbasin identifier are eliminated in the name to identify junctions in the SWMM-TRANSPORT models.

Each subbasin is subdivided by the three stormwater control subarea types based on the year that the parcel was developed and the corresponding types of stormwater controls that were required (A, B, or C). These identifiers are appended to the shortened subbasin name in the SWMM input file. For example, subareas in PK0001 are named as PK0001A, PK0001B, PK0001C and to represent the separately simulated subbasin subareas as needed (however, not all subbasins have stormwater controls).

1.4 PHYSICAL SUBBASIN PARAMETERS

The SWMM-RUNOFF model uses a kinematic wave methodology to simulate runoff from the subbasin which requires the input of the following parameters:

- Subbasin Width
- Subbasin Slope

Width was calculated using SWMMTools. SWMMTools is an ArcView extension that allows users of SWMM to visualize a SWMM model in conjunction with existing GIS data. The tool permits viewing of model input and output summary data within ArcView. Two scripts work with a stormwater subbasin theme to facilitate subbasin parameterization. One estimates RUNOFF subbasin widths.

Subbasin width is a measure of the length of the main drainage channel in a subbasin and the level of aggregation of the prototype drainage network. The algorithm used computes the subbasin width as a user-specified factor times the longer of the height or width of the subbasin polygon. This approach is loosely based upon a methodology in the SWMM manual (James et al. 2003), which suggested an initial subbasin width of 1.7 times the length of the main drainage channel. As ArcView only computes the axis lengths of a polygon along the X- and Y- axes, the polygon extent does not necessarily correspond with the length of the principal axis; however, the method yields a reasonable value for a typical model, and is intended as an initial estimate rather than a fixed specification. The suggested value of 1.7 was the factor used to run the script for this project. Values between 1 and 2 can be used in the calculation.

Slope was calculated using the Profile Extractor ArcView extension and a path-length weighted calculation referenced in the SWMM user manual (James et al. 2003). The procedure starts with determination of the line of maximum depression through the subbasin. The stream layer was used as the primary source for this. Subbasins were then divided into equal increments drawn perpendicularly, through the line of maximum depression, with the number of increments increasing based on the complexity of the subbasins. The Profile Extractor tool was then used to derive the change in elevation along each line by extracting a cross-section profile from the filled DEM. The sum of these values was used to compute a weighted slope in feet per foot for each subbasin.

The physical subbasin parameters were computed for each of the subbasins. The same slope is used for each of the three subareas (A, B, and C) that represent the type of stormwater control. The subbasin width is adjusted proportionally to the area of the subareas such that the flow length for the subareas equals the length computed for the entire subbasin.

1.5 SOIL INFILTRATION PARAMETERS

The Fairfax County soil GIS layers were investigated for use in developing infiltration parameters for input to the models. Approximately twenty-five percent of soils in Fairfax County is not mapped. The missing areas are currently being surveyed by the Natural Resources Conservation Service (NRCS) of the United States Department of Agriculture. The majority of the Cameron Run watershed is located in the unmapped area of the County. Also, the soils for the areas of the included cities of Falls Church, Alexandria, and Arlington are not included in the County soil map layer. Regional data available from the NRCS in the State Soil Geographic Database (STATSGO) was used in lieu of County soil information and in the cities of Falls Church, Alexandria, and Arlington.

The STATSGO data were intersected with the subbasin boundary layer to determine the acres of each type of soil in each subbasin. Data tables provided in STATSGO soils information include the hydrologic soil group (A, B, C, or D). These were used to develop the subbasin area in each of the four hydrologic soil groups. These data were applied to Table 4-2 in TM3 to develop area-weighted Horton soil parameters WLMAX, WLMIN, and DECAY for input to the SWMM-RUNOFF model according to the procedure listed in TM3. The hydrologic soil group indicates the ability of the soil to infiltrate water. Soils in hydrologic soil group A (A soils) will typically be sandy soils with a high infiltration rate and lower runoff rates. D soils will be clay soils with low infiltration rates and high runoff rates. Soil type can have significant effects on the annual runoff volumes and the peak runoff rates.

Since the STATSGO soils data do not vary greatly within a particular subbasin, the weighted soil infiltration parameters computed for the entire subbasin are applied to the individual subareas (A, B, and C) for onsite stormwater facilities.

1.6 IMPERVIOUS AREA ESTIMATES

1.6.1 Introduction

Impervious area includes manmade facilities such as roads, parking lots, buildings, driveways, and sidewalks that do not allow rainfall to infiltrate into the soil. Besides reducing infiltration, impervious area produces faster runoff flow rates compared to pervious areas such as woodlands and grassy areas. For the SWMM-RUNOFF model impervious areas are subdivided into two categories:

1. **Directly Connected Impervious Area (DCIA) –** Impervious areas where the runoff either directly enters a stream or enters a stormwater drain or swale that discharges the flows to a stream or drainage way. The key is that the runoff does not have the opportunity to infiltrate into the soils before entering the drainage system. These areas are modeled separately from the pervious area in the SWMM-RUNOFF model.

2. **Not Directly Connected Impervious Area (NDCIA) –** Impervious areas where the runoff discharges to a pervious area that allows the runoff to infiltrate. An example is a single-family home where the downspouts discharge to a large lawn area. The net effect of NDCIA is to reduce the surface area through which water can infiltrate; infiltration parameters for the pervious area are adjusted to account for NDCIA.

Impervious area is a good indicator of the density of development within various portions of the watershed and the potential for this development to impact the stream hydrology and habitat.

The procedures described in the following sections allow the percent impervious area estimates to be accurate for each of the three categories – detention, detention and water quality controls, and no controls. This required processing the data at the parcel level.

Impervious area estimates were developed for existing and future land use conditions. Section 1.6.3 describes the development of future land use conditions. Existing land use impervious area estimates are described below.

Existing Land Use: This represents land use conditions in the 1997 to 2001 time frame. The fact that data were obtained from various sources results in this range in years. The GIS data on which impervious area is based were derived from 1997 planimetric layers, while current land use is based on 2003 Fairfax County Department of Tax Administration parcel-level data. Existing land cover for the cities of Falls Church, Alexandria, and Arlington was based on data from the National Land Cover Database developed by the Multi-Resolution Land Characteristics (MRLC) Consortium. The MRLC Consortium is a partnership of federal agencies (www.mrlc.gov), consisting of the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA) Forest Service (USFS), the National Park Service (NPS), the

U.S. Fish and Wildlife Service (FWS), the Bureau of Land Management (BLM) and the USDA Natural Resources Conservation Service (NRCS). One of the primary goals of the project is to generate a current, consistent, seamless, and accurate National Land cover Database (NLCD), circa 2001, for the United States at medium spatial resolution. A summary of the percent existing land use within each subwatershed is shown in Table 1-1 and illustrated in Figure 1-2.

1.6.2 Current Conditions

1.6.2.1 Fairfax County Portions of the Watershed

Impervious area estimates for existing conditions were derived from GIS layers depicting impervious areas that were developed by Fairfax County from aerial photography taken in 1997:

- Buildings – This polygon coverage includes building footprints. Buildings are classified by building type – commercial, industrial, public, multi-family residential, single-family residential, and other. Building impervious areas are classified into DCIA and NDCIA based on recommend values in Table 4-3 of TM3.

- Major Transportation (Transmaj) – This polygon coverage includes the footprint of roads and highways. Paved roads and bridges were assumed 100% DCIA; medians and unpaved roads were assumed 50% DCIA.

- Minor Transportation (Transmin) – This polygon coverage includes parking lots for commercial and industrial areas as well as parking lots for multi-family residential development (condominiums and town houses). Paved parking lots were assumed 100% DCIA; unpaved parking lots were assumed 50% DCIA.

- Sidewalks – This line coverage includes the edge of sidewalks. The total length is multiplied by the half-sidewalk width (assumed to be 2 feet) to compute the sidewalk area. It is assumed that sidewalks are 85% DCIA.

The above layers include all impervious areas except for single-family residential driveways. These were accounted for by adding 1,000 square feet of impervious area for each single-family residential building.

The existing percent impervious was computed at the parcel control level. The County existing land use layer was processed in the following way prior to this work:

- The existing land use layer includes “holes” that primarily include roads, highways, highway interchanges, etc. The parcel layer was modified to have these holes filled in with a polygon which was assigned to a “Transportation” land use. It is assumed that 100% of this area is DCIA.

Table 1-1. Cameron Run subwatershed land use percentages - current conditions

Subwatershed	Area (acres)	Open Space	Multi-family Common Area	Low Density Residential	Medium Density Residential	High Density Residential	Low Intensity Commercial	High Intensity Commercial	Industrial	Trans-portation	Open Water #
Tripps Run	3704	16.0	1.7	18.7	37.9	2.8	5.6	1.6	0.4	14.3	1.1
Holmes Run-Upper	5400	9.7	3.5	12.2	33.3	4.8	13.2	1.1	0.7	19.9	1.7
Holmes Run-Lower	3201	23.0	1.0	22.3	34.0	5.4	4.4	1.6	0.7	6.7	0.9
Indian Run	1586	8.2	4.1	30.8	17.8	3.7	13.2	3.2	0.9	18.0	0.0
Turkeycock Run	1725	21.4	7.2	23.0	15.9	9.5	4.5	2.9	1.4	14.4	0.0
Backlick Run	5659	10.8	3.4	11.7	29.5	5.1	7.7	2.9	10.7	18.1	0.0
Tribs to Cameron Run*	1708	16.8	6.1	12.8	28.2	5.8	8.1	0.9	3.9	17.5	0.0
Pike Branch	1814	7.6	6.7	7.8	44.4	7.3	8.5	1.7	1.4	14.6	0.0
Weighted Average		13.7	3.6	16.0	31.5	5.1	8.4	1.9	3.3	15.9	0.6

* includes area in Alexandria upstream of USGS gage on Cameron Run
# includes Lake Barcroft and Fairview Lake only

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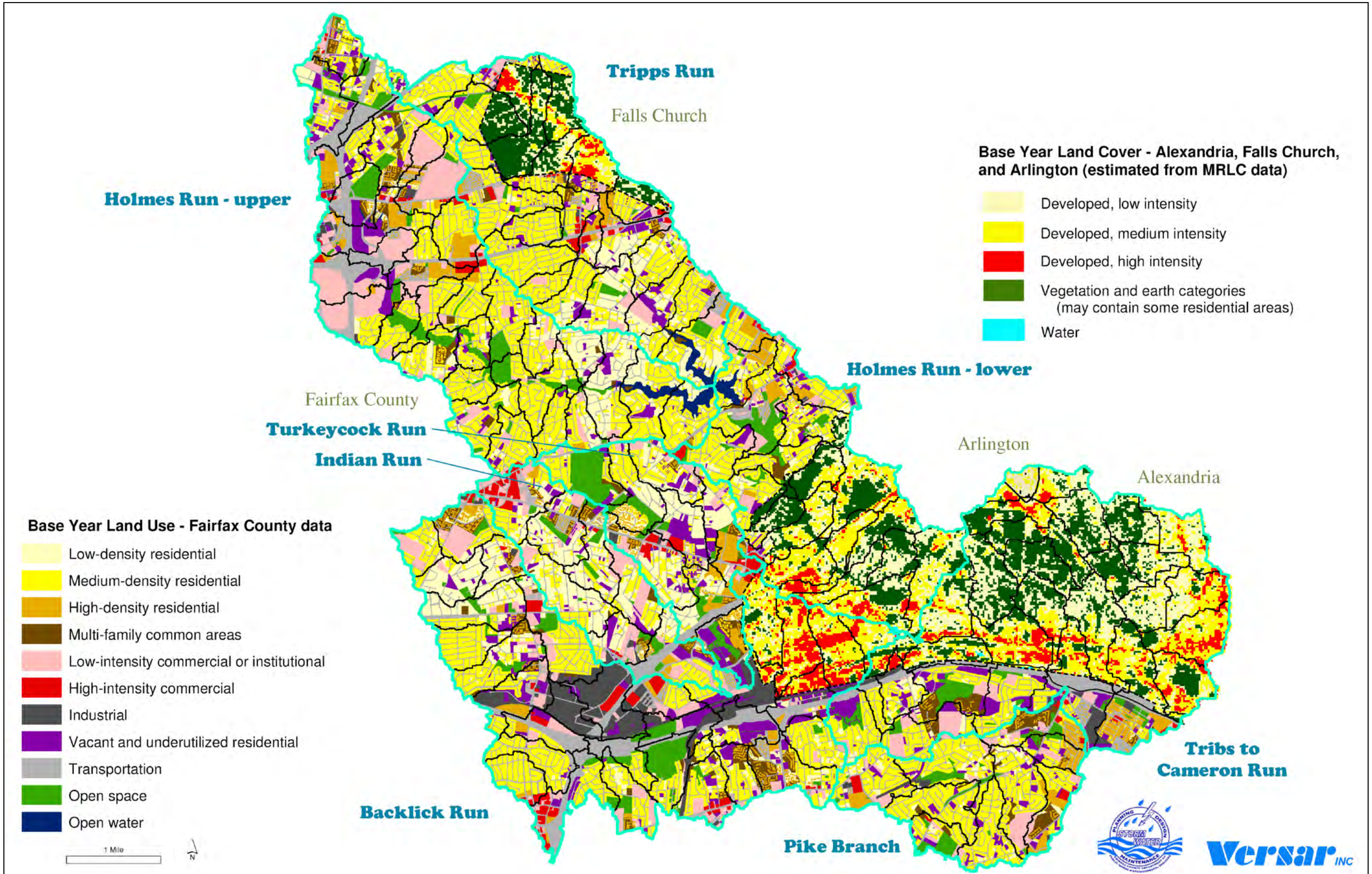

Figure 1-2. Current land use in Cameron Run watershed

- Unknown, other and missing landuse is not accurately defined in the existing landuse file. This results in areas that essentially have a defined landuse being classified as none. Using recent aerial photography, the existing and future land use codes for these areas were changed to the appropriate land use.

- Initial calculations of imperviousness in the parcel areas with detention and water quality controls (DBMP) were lower than expected. A sampling of 5 subbasins indicates that land use in these parcels showed they have been developed, based on 2003 aerial photography, while imperviousness was based on 1997 aerial photography. To correct for development which occurred during the intervening years, all the DBMP parcel areas were identified which contained few or no impervious layers within them. For these parcels only, imperviousness was calculated based on land use categories. A description of the processing steps used to develop land-use-based imperviousness for areas within the Cameron Run watershed is included in Section 1.6.3.1. These revised DBMP parcels were added to those that already had impervious layers within them, creating a revised impervious percentage for each subbasin for the DBMP category.

- The Cameron Run watershed has two major water bodies, Fairview Lake and Lake Barcroft. These two water bodies were incorporated into the landuse layer as open water.

GIS processing was performed to develop the percent impervious for each stormwater control parcel, including the Transportation areas, and to associate parcels with the appropriate subbasin. Codes developed for each parcel that assign them to one of three classes of stormwater controls based on the date of development were used to subdivide the percent impervious to these three subareas within each subbasin.

1.6.2.2 The Cities of Falls Church, Alexandria, and Arlington Portions of the Watershed

The following procedures were used to estimate the existing impervious areas for the cities of Alexandria, Falls Church, and Arlington portions of the Cameron Run watershed. The cities do not have comparable GIS impervious layers available for analysis; therefore, the GIS layers provided by Fairfax County were used. A weighted average DCIA for each land use type in Fairfax County was calculated. These values were then applied to the equivalent land cover in the areas of the watershed in the cities of Falls Church, Alexandria, and Arlington. No stormwater control data were available for the cities of Falls Church, Alexandria, and Arlington; these areas were defined as not having any stormwater controls.

1.6.2.3 Summary of Existing Percent Impervious Area

Existing total percent impervious was computed for each subbasin. The directly connected impervious area (DCIA) percentage for the subareas of the subbasin that have A) detention only, B) detention and BMP coverage, and C) have no detention or water quality BMPs were also computed for input to the SWMM-RUNOFF models.

1.6.3 Future Conditions

Future impervious area estimates were developed to evaluate the impact of future development on the streams in the Cameron Run watershed. Impervious area estimates were derived for a "buildout" land use condition where the land in the watershed is developed in accordance with the recommended land use in Fairfax County's Comprehensive Plan. While it is recognized that the land use plans are subject to revisions, it would not be possible to estimate potential future changes at this time. A summary of the percent future land use within each subwatershed is shown in Table 1-2 and future land use is illustrated in Figure 1-3; changes from present to future are listed in Table 1-3.

The following generalized land use categories derived from land use designations in the County's Comprehensive Plan are used in these analyses:

- OS – Open Space
- MFC – Multi-family Common Areas – Common areas within High Density Residential areas
- LDR – Low Density Residential – Single-family detached with 0.5-2 acres per residence.
- MDR – Medium Density Residential – Single-family detached less than 0.5 acres per residence and multi-family less than 8 dwelling units per acre.
- HDR – High Density Residential – All residential less than 0.125 acres per residence.
- LIC – Low Intensity Commercial/Institutional
- HIC – High Intensity Commercial/Institutional
- IND – Industrial
- OW – Open Water
- TRA – Transportation

Table 1-2. Cameron Run subwatershed land use percentages - future conditions

Subwatershed	Area (acres)	Open Space	Multi-family Common Area	Low Density Residential	Medium Density Residential	High Density Residential	Low Intensity Commercial	High Intensity Commercial	Industrial	Trans-portation	Open Water #
Tripps Run	3704	13.2	1.2	18.0	41.0	2.9	5.6	2.4	0.4	14.3	1.1
Holmes Run-Upper	5400	7.1	2.4	11.7	37.2	4.8	12.5	1.4	1.4	19.9	1.7
Holmes Run-Lower	3201	20.5	0.8	22.0	36.8	5.6	4.4	1.8	0.6	6.7	0.9
Indian Run	1586	4.0	2.8	32.5	20.6	3.7	11.8	4.7	1.9	18.0	0.0
Turkeycock Run	1725	8.8	4.4	27.5	23.2	9.6	7.6	3.2	1.4	14.4	0.0
Backlick Run	5659	6.4	2.6	11.9	31.5	5.2	7.7	3.3	13.1	18.1	0.0
Tribs to Cameron Run*	1708	7.8	4.0	11.0	39.2	6.0	9.5	1.0	3.9	17.5	0.0
Pike Branch	1814	4.2	5.2	5.4	51.0	7.4	9.0	1.8	1.4	14.6	0.0
Weighted Average		9.3	2.6	15.9	35.5	5.3	8.5	2.4	4.0	15.9	0.6

* includes area in Alexandria upstream of USGS gage on Cameron Run
# includes Lake Barcroft and Fairview Lake only

Table 1-3. Cameron Run subwatershed land use percentages - change from current percentage to future percentage

Subwatershed	Area (acres)	Open Space	Multi-family Common Area	Low Density Residential	Medium Density Residential	High Density Residential	Low Intensity Commercial	High Intensity Commercial	Industrial	Trans-portation	Open Water #
Tripps Run	3704	-17.3	-28.0	-3.6	8.2	3.8	0.4	45.5	-16.8	0.0	0.0
Holmes Run-Upper	5400	-27.1	-31.4	-4.7	11.6	1.4	-5.2	27.6	121.1	0.0	0.0
Holmes Run-Lower	3201	-11.2	-22.2	-1.5	8.1	3.7	1.7	11.2	-9.4	-0.1	0.0
Indian Run	1586	-51.7	-30.3	5.2	15.8	0.0	-10.8	45.8	109.2	0.0	0.0
Turkeycock Run	1725	-59.0	-38.6	19.8	46.1	1.6	69.9	9.1	-0.2	0.0	0.0
Backlick Run	5659	-40.7	-21.8	1.8	6.7	2.4	0.2	14.2	22.3	0.0	0.0
Tribs to Cameron Run*	1708	-53.7	-34.0	-14.2	39.0	5.1	17.8	20.6	0.0	-0.1	0.0
Pike Branch	1814	-44.3	-22.3	-31.1	14.8	1.5	5.2	7.6	0.0	0.0	0.0
Weighted Average		-31.7	-28.8	-0.7	12.9	2.4	1.5	22.0	23.3	0.0	0.0

* includes area in Alexandria upstream of USGS gage on Cameron Run
# includes Lake Barcroft and Fairview Lake only

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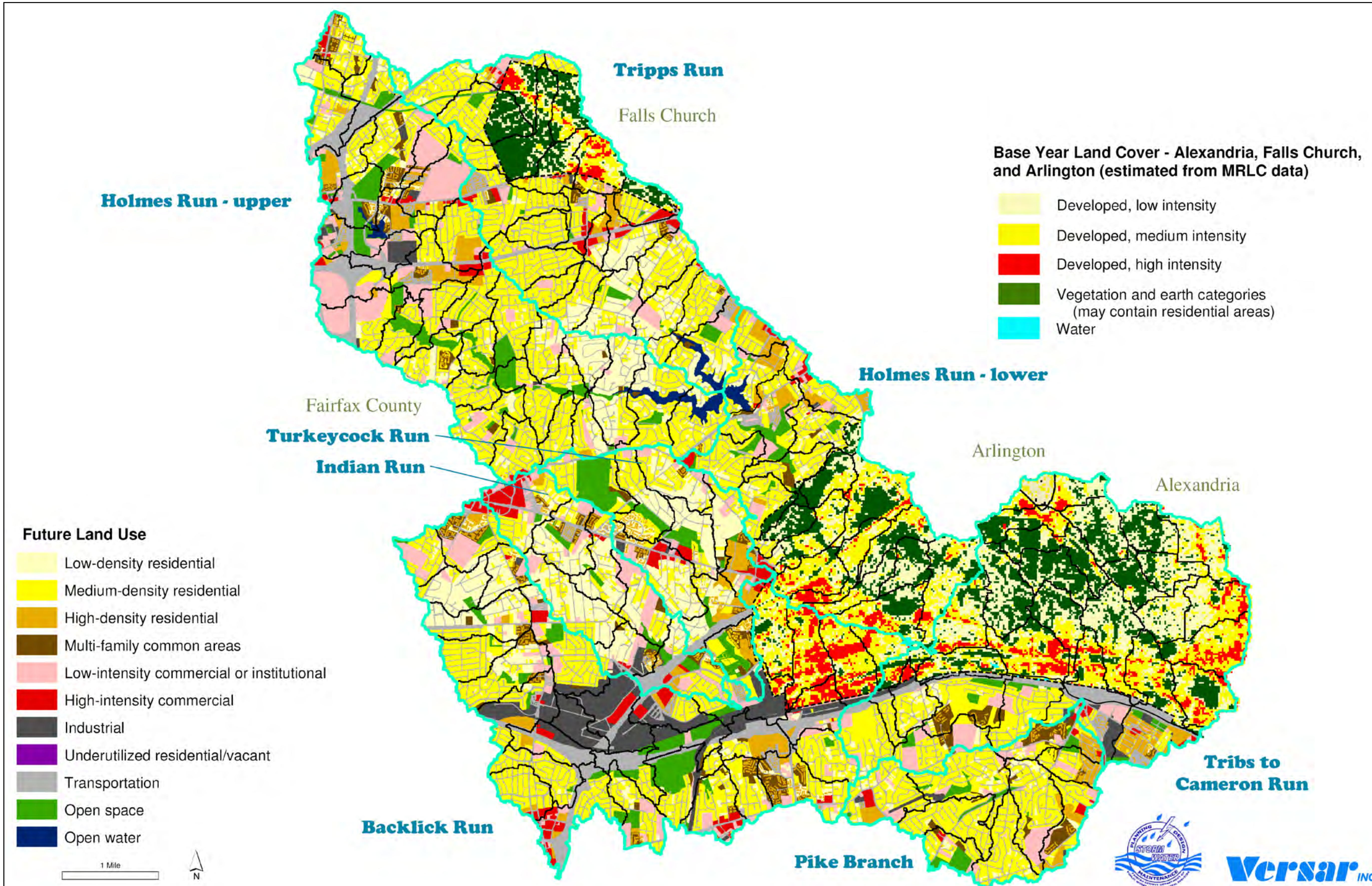

Figure 1-3. Projected future land use in Cameron Run watershed

1.6.3.1 Fairfax County Portions of the Watershed

Residential Land Use

The procedures used to develop future land use impervious areas assume that existing residential parcels that are currently developed at or near the density allowed by the planned land use will remain unchanged.

New residential development will occur in vacant parcels planned for residential development. Future impervious area estimates assume that these are developed at the density allowed in the existing land use plan.

The future impervious area estimates also assume that redevelopment will occur in parcels where the existing density is less than the density allowed by the land use designation. These procedures account for infill development. For example, a one-acre parcel with a single house in an area where the planned land use is four residents per acres is assumed to be redeveloped at the higher density.

Fairfax County previously performed an analysis that compares the existing and planned density and identifies underutilized parcels. Underutilized parcels were assumed to be developed as defined by the planned land use code. The underutilized parcels provided by the County apply only to residential areas.

The County has GIS layers that summarize parcels that are vacant based on the existing land use codes. The County also has an 'underutilized' layer that defines parcels where the existing land use is significantly less than the zoned or planned land use for residential areas of the County. The procedures for estimating DCIA and NDCIA for future buildout land use conditions assume that development within the vacant and underutilized parcels will be removed and the parcels will be developed to the densities described by the planned land use or zoning classification, whichever is greater. The impervious area for existing parcels that are not expected to undergo development as well as streets, highways, and water will remain unchanged.

To calculate future buildout impervious area estimates for non-residential land uses, these areas were assigned their future land use. Areas identified as having a lower density land use in the future were assigned their current land use. This step assures that future land use areas will not decrease in density. The existing impervious estimates do not account for the replacement of smaller homes with larger homes on the same lot ("mansionization").

Impervious Area Assignments

The impervious area to be assigned to the various land use categories was developed by sampling the estimated existing impervious area for developed parcels in the Fairfax County portions of the Cameron Run watershed. The existing impervious area was estimated by parcel as described in Section 1.6.2. These data were analyzed to estimate the typical impervious area for each land use category based on representative conditions for developed areas in the Fairfax County portion of the Cameron Run watershed. The estimates include allowances for roads associated with the development. These estimates of the average impervious area for each land use are summarized in Table 1-4.

1.6.3.2 Cities of Falls Church, Alexandria, and Arlington Portions of the Watershed

Future land use data for the cities of Falls Church, Alexandria, and Arlington are not readily available for inclusion in this watershed plan. Existing current impervious area previously calculated was also used as future buildout impervious area as discussed in Section 1.6.2.

1.6.4 Summary and Discussion of Impervious Area Estimates

Figures 1-4 and 1-5 show the existing and buildout impervious area for each subbasin. Figure 1-6 illustrates the increase in impervious area between existing and buildout land use conditions. GIS layers with these results will be delivered to the County upon project completion. Tables 1-5, 1-6, and 1-7 summarize existing and future impervious area for the entire watershed broken down by subwatershed and showing the amount of parcel-controlled areas. Tables 1-8 and 1-9 summarize future impervious area by subwatershed for the parcel-controlled areas including the projects proposed as listed in Chapter 6 of the main report.

1.6.5 Other SWMM-RUNOFF Input Parameters

The RUNOFF model requires other input parameters for computing runoff from directly connected pervious and impervious areas. Pervious area roughness coefficients were determined for each subwatershed area based on the proportion of land use types and the values listed in Table 4-8 of TM3. The initial values of these coefficients are as follows:

Parameter	Value
Impervious Area Manning’s Roughness	0.015
Pervious Area Manning’s Roughness	0.25-0.35
Impervious Area Depression Storage (Inches)	0.10
Pervious Area Depression Storage (Inches)	0.20

Table 1-4. Cameron Run subwatershed directly connected impervious area percentages by land use type

Subwatershed	Area (acres)	Open Space	Multi-family Common Areas	Low Density Residential	Medium Density Residential	High Density Residential	Low Intensity Commercial	High Intensity Commercial	Industrial	Trans-portation	Open Water #
Tripps Run	3704	7.3	12.1	8.2	18.3	39.7	31.8	80.2	45.8	100.0	100.0
Holmes Run-Upper	5399	3.8	12.9	9.0	16.3	37.5	21.8	83.9	45.0	100.0	100.0
Holmes Run-Lower	3201	2.4	5.6	10.1	16.8	37.8	33.9	85.0	32.1	100.0	100.0
Indian Run	1585	6.4	13.8	9.8	15.3	33.1	37.8	87.0	51.3	100.0	-
Turkeycock Run	1725	3.1	7.0	11.9	15.6	32.8	33.8	85.6	48.3	100.0	-
Backlick Run	5657	5.4	19.0	9.3	16.9	41.2	35.2	80.7	37.8	100.0	-
Tribs to Cameron Run*	1708	4.7	6.9	7.9	16.7	36.0	18.3	85.4	29.3	100.0	-
Pike Branch	1814	4.9	5.9	8.0	16.2	30.9	15.9	77.7	10.7	100.0	-
Weighted Average		4.5	11.4	9.4	16.8	36.5	27.5	82.6	37.2	100.0	100.0

* includes area in Alexandria upstream of USGS gage on Cameron Run
# includes Lake Barcroft and Fairview Lake only

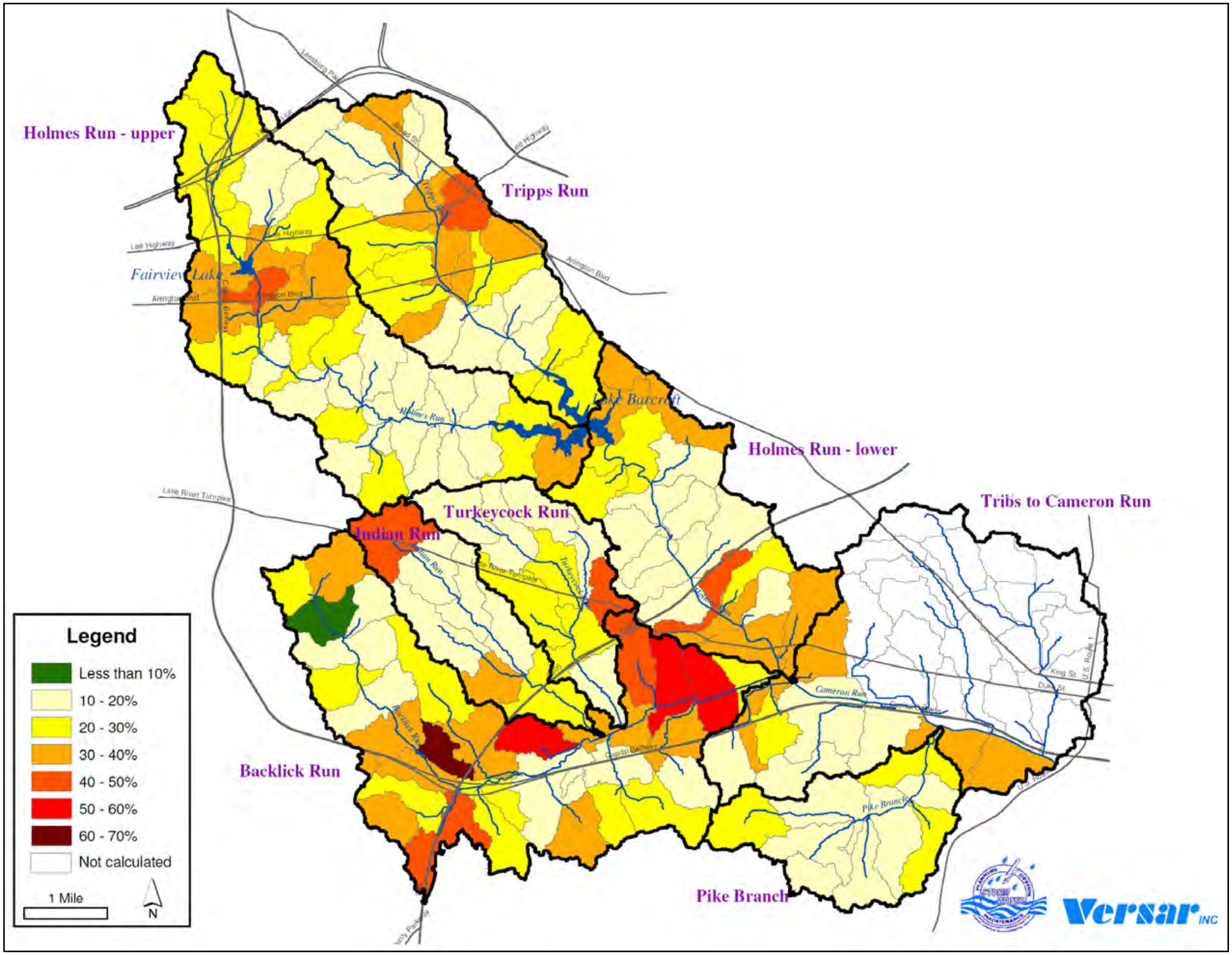

Figure 1-4. Existing impervious area within Cameron Run watershed

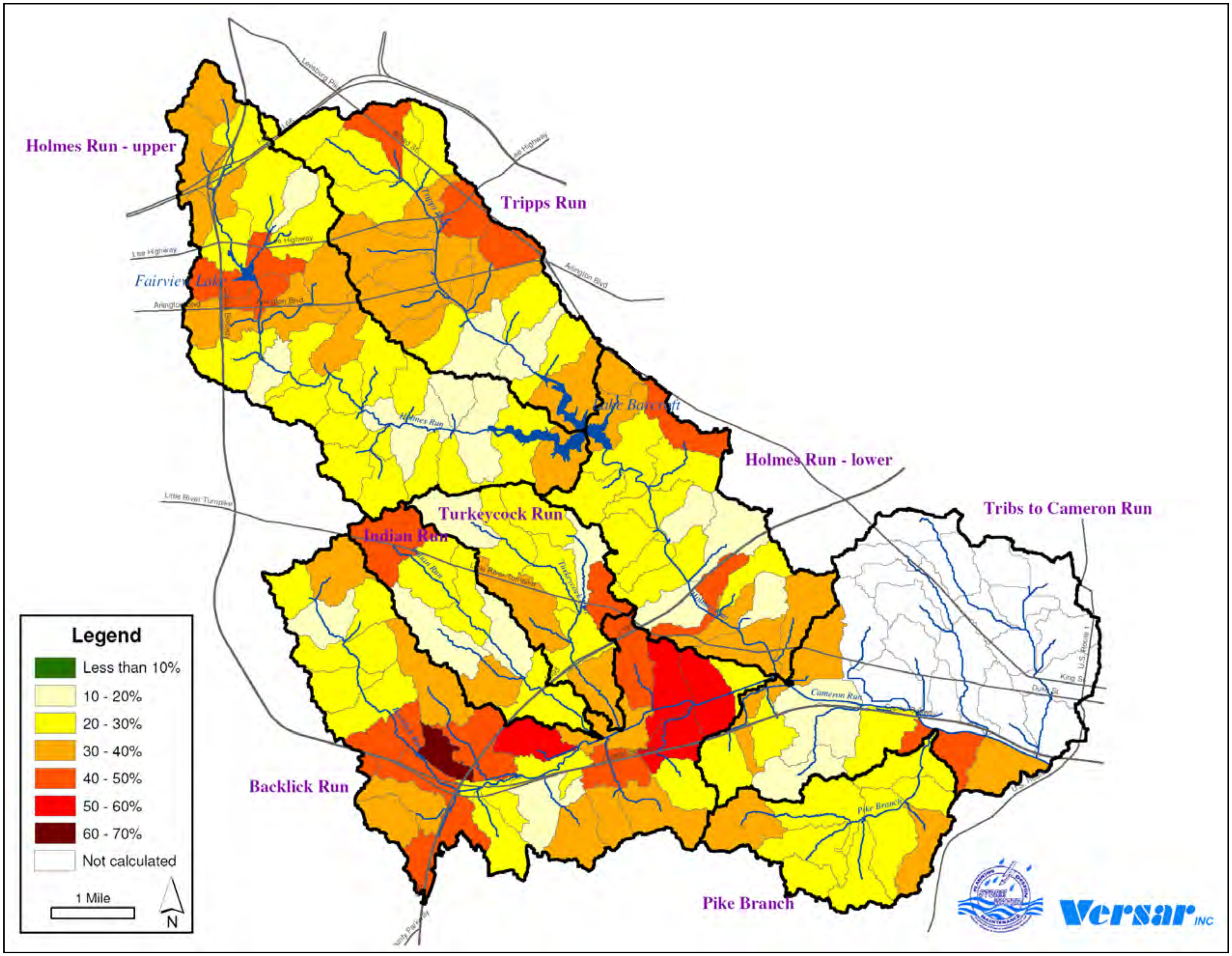

Figure 1-5. Projected future impervious area within Cameron Run watershed

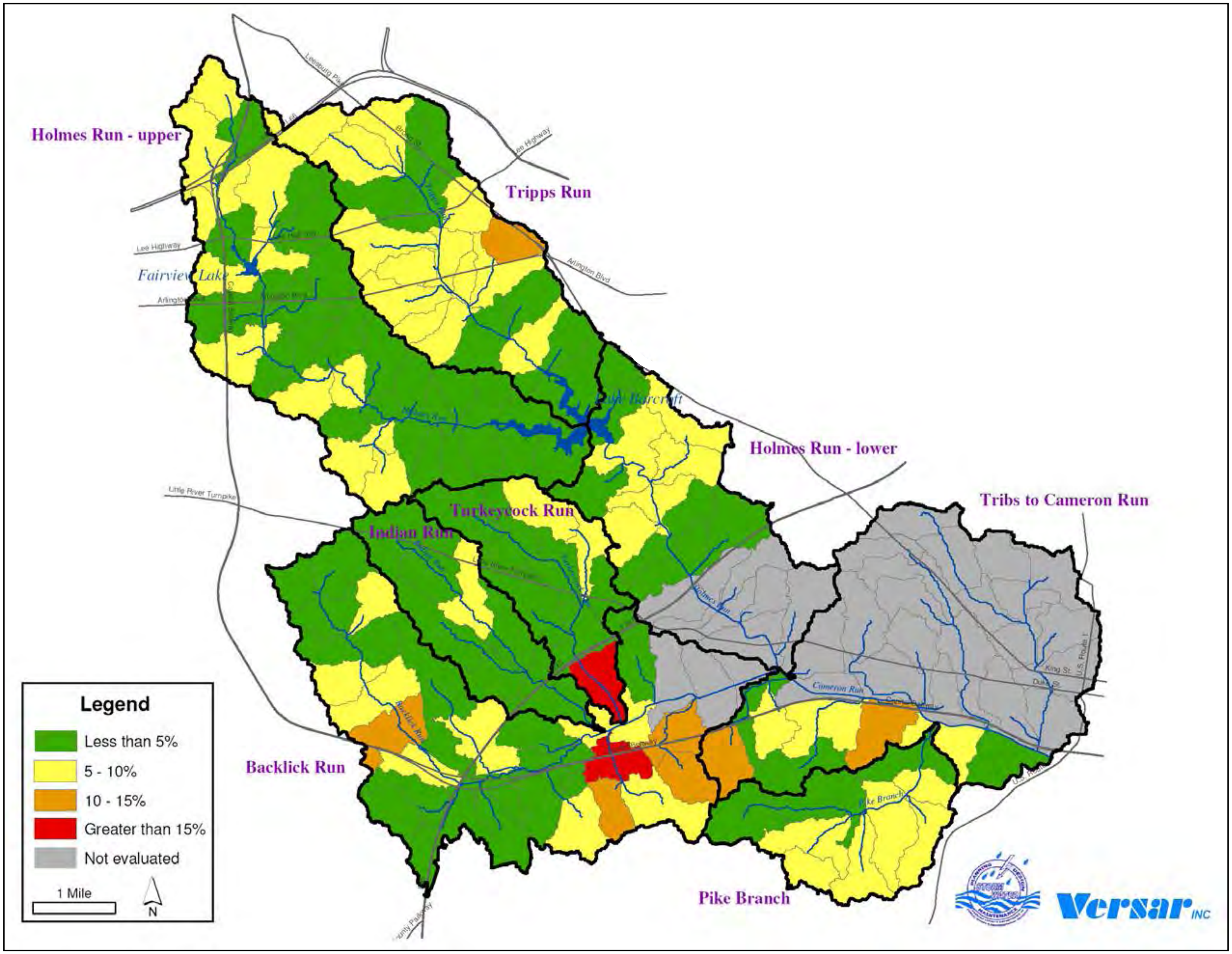

Figure 1-6. Net increase in imperviousness under future land use conditions within Cameron Run watershed

Table 1-5. Impervious area estimates for major subwatersheds in Cameron Run (BMPs evaluated only in Fairfax County) - current conditions

Subwatershed	Area (acres)	Overall Subwatershed Imperviousness (%)	Detention-controlled Area Imperviousness (%)	Detention- and Water Quality Controlled Area Imperviousness (%)	Uncontrolled Area Imperviousness (%)	Area with Detention Controls (% of area)	Area with Water Quality Control (% of area)	Total with Controls (% area)	Total with No Control (% area)
Tripps Run	3704	25.0	20.9	25.2	25.1	2.7	0.6	3.3	96.7
Holmes Run-Upper	5399	24.5	24.7	34.5	24.1	9.3	2.8	12.1	87.9
Holmes Run-Lower	3201	25.2	20.3	32.7	25.2	3.1	0.8	3.9	96.2
Indian Run	1585	25.2	47.6	37.9	23.0	7.4	2.7	10.0	90.0
Turkeycock Run	1725	21.3	28.8	21.8	19.9	14.9	2.9	17.8	82.2
Backlick Run	5657	30.7	44.0	21.4	29.7	8.3	2.7	11.0	89.1
Tribs to Cameron Run*	1708	23.7	24.0	18.4	23.8	5.8	2.2	8.1	91.9
Pike Branch	1814	20.8	15.7	23.2	21.3	10.1	3.5	13.6	86.4
Weighted Average		25.6	30.3	27.0	25.1	7.4	2.2	9.6	90.5

* Includes Alexandria only upstream of USGS gage on Cameron Run

Table 1-6. Impervious area estimates for major subwatersheds in Cameron Run (BMPs evaluated only in Fairfax County) - future conditions

Subwatershed	Area (acres)	Overall Subwatershed Imperviousness (%)	Detention-controlled Area Imperviousness (%)	Detention- and Water Quality-Controlled Area Imperviousness (%)	Uncontrolled Area Imperviousness (%)	Area with Detention Controls (% of area)	Area with Water Quality Control (% of area)	Total with Controls (% area)	Total with No Control (% area)
Tripps Run	3704	29.8	27.9	27.8	29.9	2.6	4.8	7.4	92.6
Holmes Run-Upper	5399	27.8	29.5	29.0	27.5	9.2	6.8	16.0	84.0
Holmes Run-Lower	3201	27.5	26.8	29.6	27.5	3.1	3.6	6.6	93.4
Indian Run	1585	28.6	54.5	26.4	26.6	7.3	7.9	15.2	84.8
Turkeycock Run	1725	26.3	38.1	20.0	25.1	14.4	13.4	27.8	72.2
Backlick Run	5657	35.9	48.8	40.5	34.2	8.2	7.6	15.8	84.3
Tribs to Cameron Run*	1708	29.5	28.5	31.7	29.3	5.7	10.5	16.2	83.8
Pike Branch	1814	25.5	20.3	26.9	26.0	9.8	9.4	19.2	80.8
Weighted Average		29.8	36.0	30.4	29.2	7.2	7.2	14.5	85.6

* Includes Alexandria only upstream of USGS gage on Cameron Run

Table 1-7. Present to future change in impervious area estimates for major subwatersheds in Cameron Run (BMPs evaluated only in Fairfax County)

Subwatershed	Area (acres)	Overall Subwatershed Imperviousness (%)	Detention-controlled Area Imperviousness (%)	Detention- and Water Quality-Controlled Area Imperviousness (%)	Uncontrolled Area Imperviousness (%)	Area with Detention Controls (% change)	Area with Water Quality Control (% change)	Total Area with Controls (% change)	Total Area with No Control (% change)
Tripps Run	3704	19.1	33.1	10.6	19.2	-1.2	674.3	125.6	-4.2
Holmes Run-Upper	5399	13.5	19.3	-16.1	13.9	-1.1	145.7	32.3	-4.4
Holmes Run-Lower	3201	9.4	32.4	-9.7	8.8	-0.7	326.6	69.0	-2.8
Indian Run	1585	13.3	14.7	-30.4	15.4	-1.1	197.7	51.7	-5.8
Turkeycock Run	1725	23.3	32.3	-8.4	25.9	-3.7	363.2	55.8	-12.1
Backlick Run	5657	16.9	10.8	89.3	15.1	-1.2	182.4	43.9	-5.4
Tribs to Cameron Run*	1708	24.6	18.7	72.4	23.1	-1.4	369.8	101.4	-8.9
Pike Branch	1814	22.5	29.3	15.6	21.9	-2.8	170.2	41.6	-6.5
Weighted Average		16.5	19.0	12.5	16.2	-1.7	229.5	51.4	-5.4

* Includes Alexandria only upstream of USGS gage on Cameron Run

Table 1-8. Impervious area estimates for major subwatersheds in Cameron Run (BMPs evaluated only in Fairfax County) - future with projects (includes new ponds and pond retrofits in Detention and Water Quality controlled area and Low Impact Development (LID) projects)

Subwatershed	**Area (acres)**	**Overall Subwatershed Impervious-ness (%)**	**Detention-controlled Area Impervious-ness (%)**	**Detention and Water Quality-Controlled Area Impervious-ness (%)**	**LID Area Impervious ness (%)**	**Uncontrolled Area Impervious-ness (%)**	**Area with Detention controls (% area)**	**Area with Water Quality Control (% area)**	**Area with LID Control (% area)**	**Total with Controls (% area)**	**Total with No Control (% area)**
Tripps Run	3704	29.8	28.1	28.7	38.0	29.7	2.4	5.9	1.5	9.8	90.2
Holmes Run-Upper	5399	27.7	29.9	29.0	22.3	27.7	8.7	7.9	4.6	21.2	78.6
Holmes Run-Lower	3201	27.5	26.9	29.6	27.7	27.5	3.0	3.5	1.5	8.1	92.0
Indian Run	1585	28.6	54.8	26.3	40.9	25.9	7.2	7.9	4.1	19.2	80.9
Turkeycock Run	1725	26.3	37.7	22.0	40.3	24.3	12.8	15.0	3.9	31.7	68.3
Backlick Run	5657	35.9	48.9	37.4	26.9	34.7	7.7	10.9	2.7	21.4	78.7
Tribs to Cameron Run*	1708	29.6	28.7	29.9	22.3	29.6	5.7	12.7	2.2	20.6	80.0
Pike Branch	1814	25.5	21.1	27.0	20.0	26.1	8.3	9.3	3.8	21.4	78.6
Weighted Average		29.8	36.4	30.3	27.8	29.2	6.8	8.6	3.0	18.4	81.6

* Includes Alexandria only upstream of USGS gage on Cameron Run

Table 1-9. Future to future with projects change in impervious area estimates for major subwatersheds in Cameron Run (BMPs evaluated only in Fairfax County)

Subwatershed	Area (acres)	Area with Detention Controls (% change)	Area with Water Quality Control (% change)	Total Area with Controls (% change)	Total area with No Control (% change)
Tripps Run	3704	-7%	24%	33%	-3%
Holmes Run-Upper	5399	-6%	17%	32%	-6%
Holmes Run-Lower	3201	0%	0%	22%	-2%
Indian Run	1585	-1%	-1%	26%	-5%
Turkeycock Run	1725	-11%	12%	14%	-5%
Backlick Run	5657	-5%	43%	35%	-7%
Tribs to Cameron Run*	1708	-1%	21%	27%	-5%
Pike Branch	1814	-15%	-1%	11%	-3%
Weighted Average		-7%	20%	27%	-5%

* Includes Alexandria only upstream of USGS gage on Cameron Run

1.7 SIMULATION OF PEAK SHAVING AND WATER QUALITY CONTROLS

Procedures for simulating peak shaving and water quality controls are described in TM3– Stormwater Model and GIS Interface Guidelines (CDM 2003). These procedures were used to simulate facilities in the Cameron Run watershed. The reader is referred to Section 5.3 of TM3 for additional information on these procedures for using the TRANSPORT storage unit method for simulating onsite detention facilities. The application of these procedures to the Cameron Run watershed Plan is described in this section.

Fairfax County Stormwater Management Division developed procedures for assigning individual parcels to the type of stormwater controls based on the year that the parcel was developed:

A. Parcels that are developed after 1972 that may be assumed to be served stormwater detention control facilities that control the peak flow from the upstream developed area. These were identified as DET in the layers provided by the County.

B. Parcels that were developed after 1994 are assumed to have peak flow control and water quality stormwater control facilities. These were identified as DBMP in the GIS layers provided by the County.

C. Parcels that were developed prior to 1972 are assumed to have no stormwater controls. These were excluded or identified as NONE in the GIS layer files provided by the County.

Figure 1-7 presents the percentage of the subbasins with both peak flow and water quality stormwater controls.

Parameters used for the simulation of surface runoff water quality include:

QFACT(1):	See Table 1-10. Values by Pollutant and Land Use (lb/acre)
QFACT(2):	0.15
RCOEFF:	4.6 per inch
WASHPO:	1.0

1.8 GROUNDWATER ROUTINE DATA INPUTS

The SWMM-RUNOFF model was used to simulate groundwater effects on stream baseflows and variations from year to year. SWMM-RUNOFF includes groundwater simulation routines that allow the simulation of percolation of infiltrated rainfall through the unsaturated soil zone, storage in the shallow groundwater zone, and release of groundwater to the stream system. Parameters were set uniformly over the study area to simulate observed base flow recession curves at the flow gage located on Cameron Run in Alexandria. The parameter values listed in Table 1-11 were used for the initial model setup for all subbasins to simulate baseflow with SWMM-RUNOFF; these values were based on CDM's SWMM model guidelines (CDM 2005).

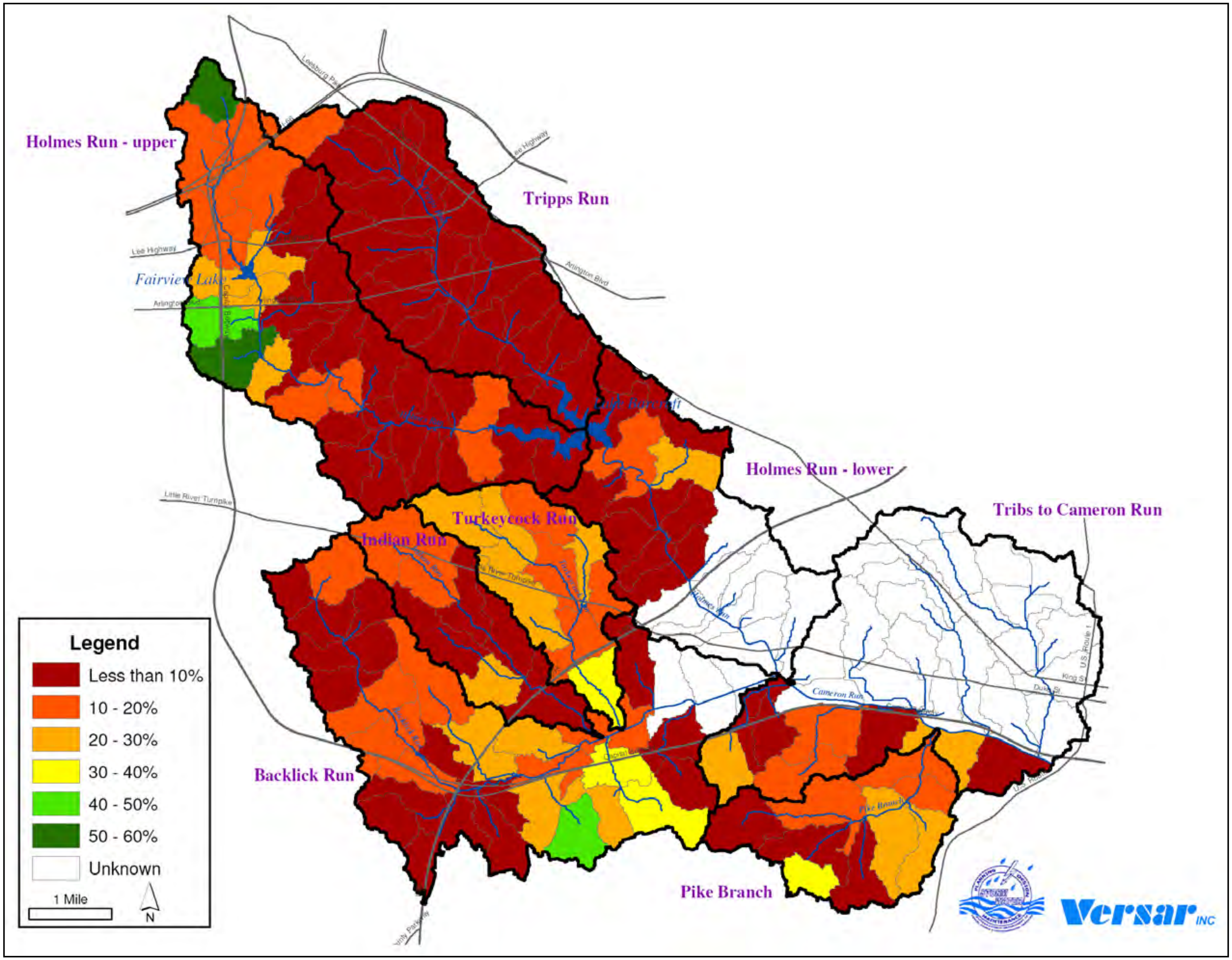

Figure 1-7. Cameron Run subbasin BMP coverage

TABLE 1-10. QFACT(1) VALUES BY POLLUTANT AND LAND USE (LB/ACRE; FROM LIMNO-TECH, 2004, AS REVISED IN CDM, 2005)

Land Use	BOD	COD	TSS	TDS	DP	TP	TKN	TN	TCD	TCU	TPB	TZN
Open Space	0.4	3.1	2	5.2	0.005	0.0075	0.04	0.055	0.000011	0.0003	0.00009	0.0016
Estate Residential	0.6	3.2	1.7	2.3	0.028	0.04	0.23	0.3	0.000025	0.0003	0.00009	0.0016
Low Density Residential	1.2	6.7	3.6	4.8	0.035	0.05	0.26	0.35	0.000026	0.0006	0.0002	0.0034
Medium Density Residential	2.4	13.5	7.3	9.7	0.039	0.55	0.32	0.425	0.00003	0.0011	0.0004	0.0068
High Density Residential	4.5	36.5	12.8	21.2	0.046	0.065	0.36	0.55	0.00004	0.0096	0.0008	0.0197
Low Intensity Commercial	2.7	16.2	16.7	16.6	0.042	0.06	0.36	0.55	0.000025	0.0074	0.00049	0.0369
Industrial	5.5	21.5	17.7	23.6	0.045	0.065	0.3	0.65	0.000011	0.0075	0.00155	0.0476
High Intensity Commercial	5.6	21.5	20.7	21	0.043	0.065	0.3	0.65	0.000024	0.0048	0.00143	0.0297
Transportation	5.6	21.5	20.7	21	0.045	0.065	0.3	0.65	0.000024	0.0048	0.00143	0.0297
Water	0.4	3.1	2	5.2	0.005	0.0075	0.04	0.055	0.00005	0.0006	0.00032	0.0025

TABLE 1-11. GROUNDWATER PARAMETER VALUES		
Parameter	**Description**	**Value**
BELEV	Elevation of bottom of aquifer (feet)	0
GRELEV	Elevation of ground surface (feet)	20
STG	Elevation of initial water table stage (feet)	5
BC	Elevation of channel bottom or threshold stage for groundwater flow (feet)	5
TW	Average elevation of water in channel over run (feet)	5
A1	Groundwater flow coefficient (in/hr-ft^B1)	0.0001
B1	Groundwater flow exponent, dimensionless	32
A2	Coefficient for channel water influence, dimensionless	0
B2	Exponent for channel water influence, dimensionless	1
A3	Coefficient for the cross product between groundwater flow and channel water (in/hr-ft^2)	0
POR	Porosity expressed as a fraction	0.46
WP	Wilting point expressed as a fraction	0.15
FC	Field capacity expressed as a fraction	0.3
HKSAT	Saturated hydraulic conductivity (in/hr)	10
TH1	Initial upper zone moisture expressed as a fraction	0.3
HCO	Hydraulic conductivity vs. moisture content curve-fitting parameter, dimensionless	10
PCO	Average slope of tension versus soil moisture curve (ft/fraction)	15
CET	Fraction of maximum evapotranspiration rate assigned to the upper zone	0.35
DP	Coefficient for unquantified losses (in/hr)	0.002
DET	Maximum depth over which significant lower zone transportation occurs (feet)	14

2.0 SWMM-TRANSPORT MODEL

2.1 INTRODUCTION

The SWMM-TRANSPORT model was used to perform several functions in the models for the Cameron Run watershed. The following section provides a brief overview of the SWMM-TRANSPORT model. A TRANSPORT model was developed for each of the Cameron Run subwatersheds. The functions and data input to this model are summarized below in Sections 2.1.2 and 2.1.3. The development of the model is described in Section 2.2.

2.1.1 Introduction to SWMM-TRANSPORT

The SWMM-TRANSPORT model performs flow and water quality routing through ponds and streams. The conduit and open channel flow routing computations use a kinematic wave approach in which disturbances are allowed to propagate only in the downstream direction. As a result, backwater effects are not modeled and downstream conditions do not affect upstream computations. These assumptions allow a more efficient solution technique compared to more sophisticated hydraulic simulation models such as SWMM-EXTRAN and the Army Corps of Engineers HEC-RAS model. The stream flow routing methodology permits longer time steps which allow the model to be used to simulate flows and water quality for long-duration simulations. The model provides sufficiently accurate routing to evaluate flows, velocities, and stormwater pollution loads in the system. A more detailed hydraulic model such as EXTRAN or HEC-RAS is required to simulate the water surface elevations in the streams. The TRANSPORT model also has other types of elements. As described below, stage-storage-outflow relations defined for storage elements are used to simulate the effects of onsite and regional ponds on flows in the system. The model includes “flow divider” elements that allow pollutant loads to be removed at water quality BMPs.

2.1.2 SWMM-TRANSPORT Model Network

The SWMM-TRANSPORT network developed for the Cameron Run Watershed Plan provides the following functions:

- Routes flows generated in RUNOFF through peak flow shaving and water quality control BMPs

- Routes flows through the major stream system in Fairfax County, and the watershed portions of the cities of Falls Church, Alexandria, and Arlington

- Combines flows from subareas that comprise individual subbasins for input to downstream model segments

The TRANSPORT model network is used in all simulations as an interface between the SWMM-RUNOFF model and the HEC-RAS model. The SWMM-TRANSPORT model network includes the major stream segments modeled in the Fairfax County and the portions of the cities of Falls Church, Alexandria, and Arlington in the study area. This model network includes the same reaches incorporated into the HEC-RAS model and is used to perform flow routing and water quality routing through the stream system. This TRANSPORT model network is used for performing long-duration simulations (e.g., multi-year) of flows and stormwater pollution loads in the streams. The TRANSPORT model network of the Cameron Run watershed streams is a simplified version of the network included in the HEC-RAS model. This TRANSPORT model network does not include nearly the number of stream cross-sections and stream segments. This model network also includes stage-storage relationships for two lakes located within the modeled stream network, Fairview Lake and Lake Barcroft.

The Stormwater Model and GIS Interface Guidelines Technical Memorandum (CDM 2003) summarizes the procedures used to simulate onsite and regional detention facilities. As described in the Technical Memorandum and in Section 2 of this report, each subbasin in the Cameron Run study area is divided into three subareas where required:

A. Parcels developed after 1972 and before 1994 that have peak shaving stormwater controls but no water quality controls.

B. Parcels that were developed after 1994 that have both water quality and peak shaving stormwater controls.

C. Parcels developed before 1972 that have no stormwater controls.

Section 2.2 provides a description of the procedures for developing stage-storage-discharge curves used to simulate the peak shaving stormwater controls from subarea types A and B.

TRANSPORT uses stream cross-section data in a format similar to the HEC-RAS program for natural stream sections. Stream segment length, slope, and Manning's Roughness coefficient are also input to the model. These were derived from the HEC-RAS model; see Section 3.0.

2.2 DEVELOPMENT OF PEAK-SHAVING STORMWATER CONTROLS

There are several hundred onsite detention facilities in the Fairfax County portions of the study area; no data were available for ponds in the Falls Church, Alexandria, or Arlington portions of the watershed. It was not feasible to develop detailed stage-volume-discharge input data to simulate all of these, so they were simulated using a lumped parameter approach.

Peak-shaving storage was simulated as a storage element in the SWMM-TRANSPORT model. The stage-storage-discharge relationships were developed based on the following assumptions:

1. Storage volume and outlet structures are designed to limit the peak flows for existing development to the undeveloped peak flows for the 2-year and 10-year design storms.

2. Ponds in subarea type A (peak-shaving control only) and B (peak-shaving and water quality controls) include extended detention as defined by the County Public Facilities Manual (Fairfax County 2001)

The TRANSPORT storage element input data include a table of depth, surface area, storage volume, and discharge. A SAS program was developed to automate the generation of the stage-storage volume and stage discharge curves. The following steps were used to develop the input data:

1. Simulate peak flows for 2-year and 10-year storms for existing land use conditions. The NRCS Type II 24-hour rainfall distribution was used in these simulations. The 2-year, 24-hour rainfall volume is 3.2 inches; the 10-year, 24-hour rainfall volume is 5.5 inches; and the 100-year, 24-hour rainfall volume is 7.7 inches (NRCS, 2002).

2. Simulate peak flows for 2-year and 10-year storms for a natural undeveloped (forested) condition. This assumes a zero impervious area (DCIA) using the default SWMM runoff parameters as previously described.

3. Compute storage volume required to control the 10-year storm flow for existing development by subtracting the RUNOFF volume for the undeveloped condition from the current condition. The RUNOFF module was used simulate and compute the total volume of the 10-year, 24-hour storm using current impervious conditions for each parcel subarea.

4. Set the storage element surface area to a constant value (e.g., 10,000 square feet) and calculate the depth of the 10-year storage computed in step 3.

5. It is assumed that detention storage facilities are extended dry detention ponds. Compute the extended drawdown volume based on the impervious area and compute the outflow rate to de-water the storage volume over 48 hours. Set this de-watering outflow rate at zero depth and at a depth corresponding to the extended detention volume. Then linearly ramp up outflow from zero to the 2-year predevelopment peak flow over the computed depth for that volume.

6. Ramp linearly up to the 10-year undeveloped peak flow over the constant-area computed depth.

7. Define the storage facility to have a constant outflow equal to the 10-year undeveloped peak flow. Perform a simulation of the 10-year storm for existing development to determine the maximum storage volume required.

8. Set a storage outflow point with the outflow equal to the 10-year undeveloped peak flow and the depth associated with the storage volume determined in step 7 above.

9. Linearly ramp flows up to 3 times the 10-year post-development peak flow over a volume 10% higher than the 10-year developed storage requirement.

This procedure results in a synthetic stage-storage-outflow relationship that effectively simulates the effect of the detention facilities. This approach was applied to all locations where the year of development indicates that detention storage is required in Fairfax County.

Areas indicated for future development were estimated as described in Section 1.6. These areas were re-assigned to subarea type B. The procedure for computing the peak shaving input data for these areas was repeated, assuming that all future development will be fully controlled for both 2- and 10-year peak flow detention and water quality. Thus, a new set of synthetic ponds was developed based on the future impervious area estimates.

Fairview Lake and Lake Barcroft were included in the TRANSPORT model as regional ponds within the stream channel network. Tables 2-1 and 2-2 show the storage-area-depth relationships for these lakes. Fairview Lake is located in Holmes Run Upper subwatershed and is simulated as a storage area between stream segments in that reach. Lake Barcroft is simulated as a storage area with inputs from Holmes Run Upper and from Tripps Run, in addition to several subbasins which drain directly to it.

For subarea B ponds, water quality treatment is simulated in addition to peak flow control. Pollutant removals were simulated using a water quality divider element. Removal efficiencies for each pollutant are listed in Table 2-3.

The purpose of this RUNOFF/TRANSPORT model is to perform long-duration simulations of flows and water quality in the stream segments. The TRANSPORT model uses at least one transport segment between locations where flows from a subbasin enter the modeled stream network or where modeled streams join. Each stream segment was modeled as a trapezoidal cross-section, using the stream length and slope from a subset of the TIN-derived cross-sections in HEC-RAS. Stream cross-sections are numbered consecutively within a subbasin, with the section number indicating its distance in feet from the most downstream portion of each subwatershed or from its connection to the main subwatershed channel for tributary streams. Figure 2-1 illustrates the SWMM RUNOFF and TRANSPORT model network for Cameron Run with each of its subwatershed model components. The RUNOFF and TRANSPORT models are named for the subwatersheds that they represent. SWMM COMBINE elements are used to join tributaries together as shown. Raincode files provide the appropriate rainfall data to each RUNOFF subwatershed model. The final model (including proposed

Table 2-1. Fairview Lake stage discharge-storage values for use in SWMM and HEC-RAS (adapted from HEC1 data file called 1BSN-REV.IH1 from Fairfax County)

Feet Stage	cfs Flow	Acre-ft Storage	ft^3 Storage
310	0	16.1	699138
311	46	18.4	799326
312	131	20.7	899514
313	240	23.0	999702
314	368	25.3	1099890
315	510	27.6	1200078
316	661	30.3	1318213
317	821	33.0	1436347
318	987	35.7	1554482
319	1308	38.4	1672617
320	2181	41.1	1790752
321	3430	51.0	2220166
322	4997	60.8	2649581
323	6840	70.7	3078995
324	8940	80.5	3508410
325	11284	90.4	3937824
326	13594	98.0	4268009
327	16043	105.6	4598194
328	18622	113.1	4928378
330	24131	128.3	5588748

Table 2-2. Lake Barcroft stage-discharge-storage values for use in SWMM and HEC-RAS. Adapted from outflow rating from Table 4 of Lake Barcroft Phosphorus Study by GKY, (GKY 1993), assuming goal to keep lake level constant at 208.5 feet. Surface area and storage from page 3 of the same report, assumed at elevation 208.5, assuming vertical sides within 208-210.5 ft., with a maximum depth of about 50 feet.

Elevation, ft	Flow, cfs	Surface Area, ft^2	Storage, ft^3	Depth, ft
208	1.1	5892750	84173625	53
208.25	1.1	5892750	85646813	53.25
208.33	2.8	5892750	86118233	53.33
208.5	1081	5892750	87120000	53.5
209	4219	5892750	90066375	54
209.5	7956	5892750	93012750	54.6
210	11693	5892750	95959125	55
210.5	18086	5892750	98905500	55.5

projects) includes 379 RUNOFF subbasins, 1071 TRANSPORT elements with 246 storage units, 83 LID elements, and 38 miles of stream segments modeled as trapezoidal channels. Table 2-4 lists the RUNOFF and TRANSPORT model elements for each subwatershed in the Cameron Run watershed SWMM model.

Table 2-3. Percent removal of pollutants for SWMM simulation of extended detention ponds

TN	TP	DP	BOD	COD	TSS	Pb	Cu	Zn	Cd	TDS
30	40	-11#	20	25	80	80	50	50	50	0*

Information sources:

Values from CDM 2005 except as follows:

Pb from: TM3, CDM 2003.

DP from: Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Prepared by Center for Watershed Protection for USEPA Office of Science and Technology.

COD from: Schueler, T.R., 1997. Technical Note 95. Comparative Pollutant Removal Capability of Urban BMPs: A Reanalysis. Watershed Protection Techniques. Vol. 2, No. 4. June 1997.

model cannot simulate pollutant generation, so zero assumed

* No data available, so zero assumed

Table 2-4. SWMM model elements in the Cameron Run watershed model

Subwatershed Name	RUNOFF Subbasins	TRANSPORT Elements	Storage Units	Modeled Stream Length, miles
Holmes Run Upper	85	242	57	23
Tripps Run	54	121	36	8
Lake Barcroft*	18	42	13	5
Backlick Run	88	224	57	15
Indian Run	21	74	14	6
Turkeycock Run	27	80	18	7
Holmes Run Lower	35	121	18	4
Cameron Run Tribs	24	64	15	6
Pike Branch	27	103	18	9
TOTAL	379	1071	246	83

* Separately modeled subbasins draining directly to the lake (from subwatersheds Holmes Run Upper, Tripps Run, and Holmes Run Lower).

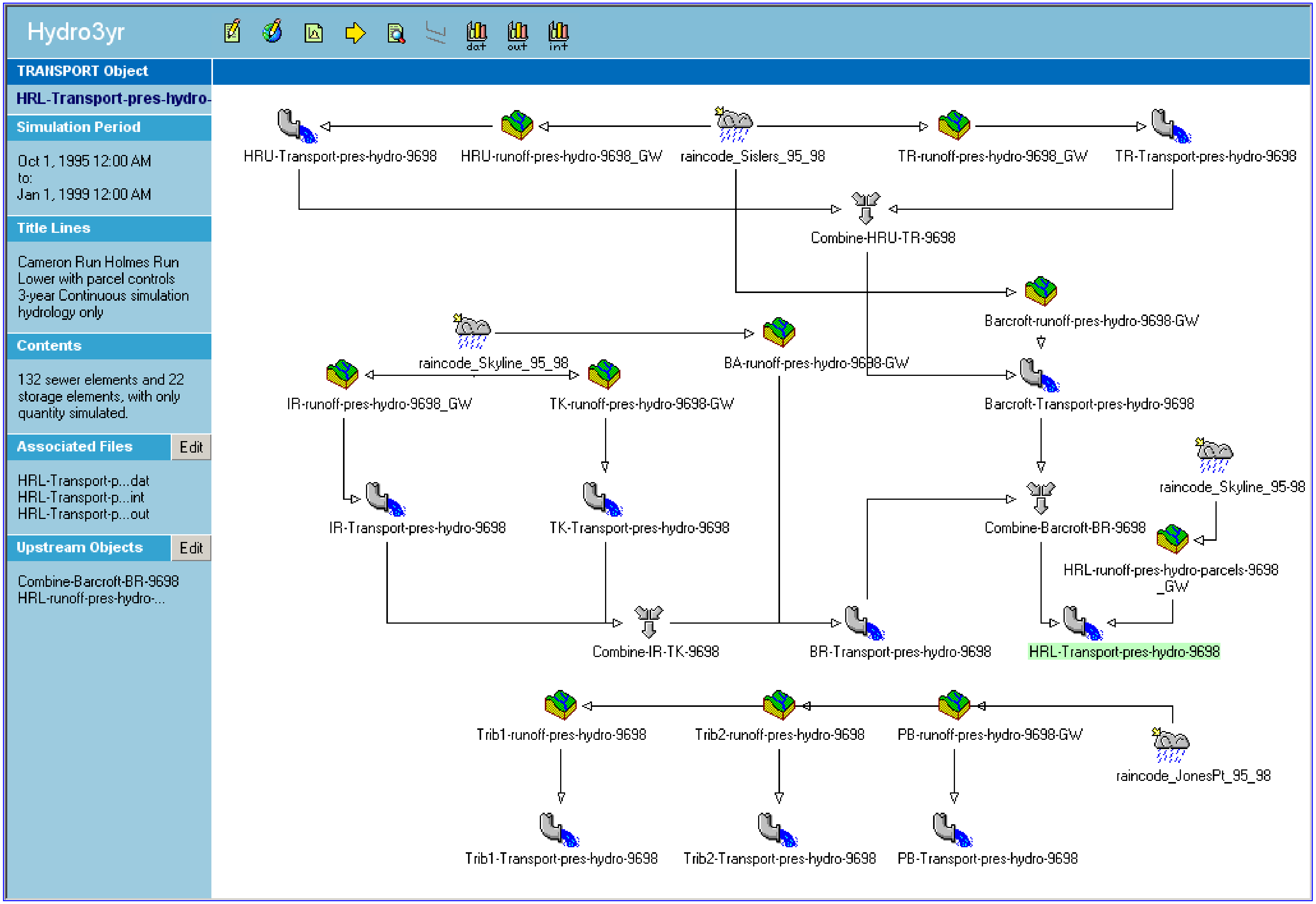

Figure 2-1. Cameron Run watershed SWMM model components as shown in the PCSWMM Object Manager

A second set of SWMM-TRANSPORT models for each subwatershed was developed to provide input to the HEC-RAS model. This model includes the same RUNOFF inputs and storage areas that are included in the overall SWMM hydrology model. Peak flows at cross-sections in the SWMM model downstream of each subbasin were output to provide flows for the HEC-RAS model for single-event simulations of the entire watershed.

2.3 SIMULATION OF TIER-1 PROJECTS IN SWMM

Tier-1 projects consist of four basic types: new stormwater management (SWM) ponds, SWM pond retrofits, low-impact development (LID) projects such as bioretention areas, and stream restoration; the latter were not simulated as detailed designs would be required for this purpose. New SWM ponds are assumed to have both water quality and peak shaving stormwater controls; pond retrofits are assumed to involve conversion of ponds with only peak-shaving benefits into those which also have water quality controls. These facilities are simulated as described in the previous section. Land areas draining to these facilities were digitized in GIS and the imperviousness and landuse fractions for the SWM pond drainages in each subbasin were calculated using the future land use projections as described in the previous section. Similarly, land areas draining to LID facilities in each subbasin which had them were digitized in GIS and the impervious and land use fractions for these drainages were calculated. As described in the Stormwater Model and GIS Interface Guidelines (CDM 2003), the SWMM RUNOFF Model interconnected subbasin method was used to simulate LID controls. This method uses two interconnected subbasins, one representing the land development area controlled by the LID facilities in a subbasin, and one representing the total surface area of the LID facilities in that subbasin. The size of the LID facility was estimated based on the Virginia Stormwater Management Handbook (VACDR 1999) by applying the average of the storage requirement of 0.5-1.0 inch per impervious acre of tributary area, using a maximum ponding depth of 6 inches. The area representing the LID facilities in a subbasin was assumed to be 100% pervious, with pervious depression storage equal to the calculated storage area, up to the maximum ponding depth of 6 inches. RUNOFF flows and pollution loads which do not exceed this available depression storage capacity are removed from the surface runoff, while flows and loads that exceed this capacity overflow untreated to the downstream TRANSPORT channel. Further details of this modeling approach are described in Section 5.5.2 of the Stormwater Model guidelines (TM-3; CDM 2003).

2.4 CONTINUOUS SIMULATION RESULTS

2.4.1 SWMM Hydrology Calibration and Verification

The SWMM-RUNOFF and SWMM-TRANSPORT models were set up to perform a continuous simulation for a three-year calibration period (1996 through 1998). The simulation used 15-minute rainfall recorded at three Fairfax County rainfall gages (Sislers, Skyline, and Jones Point) located in the watershed (Figure 2-2). Each subwatershed was assigned to the closest rain gage for input to the model (Sislers: Holmes Run Upper, Tripps Run; Skyline: Backlick Run, Holmes Run Lower, Indian Run, Turkeycock Run; Jones Point: Cameron Tribs, Pike Branch).

The USGS operates a stream gage on Cameron Run in Alexandria at the Norfolk Southern Railway Bridge. The station is located on the downstream and left side of the bridge. The simulation results were compared with observed flows from the stream gage.

Several iterations were made to calibrate the groundwater parameters to obtain the best fit for baseflows observed during dry weather periods. The best fit was obtained with the following adjusted groundwater parameter values (modified from the default values in Table 1.8): B1=16; A3=.0035; DP=.005. Runoff parameters were also adjusted to obtain the best fit of flow peaks for small, medium, and large storm events; the best fit was obtained with PCTZER=100% (percent of impervious area with zero detention); WSTORE1=0.01 (impervious area depression storage); WSTORE2=0.02 (pervious area depression storage); WLMAX=2.5 (maximum initial infiltration rate); WLMIN=0.03 (minimum infiltration rate).

Figures 2-3 through 2-6 present plots of observed flows and simulated flows for the final calibration, for each of the four quarters of 1996. Figure 2-7 presents the observed and simulated flow-frequency curves for 1996 through 1998.

Flow frequency curves present the fraction of the time that flows are less than or equal to a given flow rate. These results use the parameters and procedures used in the SWMM-RUNOFF and TRANSPORT models as described previously in this report. Tables 2-5 and 2-6 show the results of a statistical comparison of the model simulation results and the gage data for the 3-year calibration period (1996-1998) and for the 3-year verification period (1999-2001). The last quarter of 2001 was not simulated due to missing rainfall data for that period.

The simulation for the portion of the watershed draining to the gage is based on two rainfall gages located within the watershed. The USGS gage reflects the rainfall that fell over the watershed upstream of the gage, including Backlick Run, Holmes Run Lower and Upper, Indian Run, Tripps Run, and Turkeycock Run. Cameron Run (lower mainstem) Tributaries and Pike Branch drain below this gage. Rainfall from the three gages in or near the watershed are quite variable, with the greatest seasonal variability in April through June and lowest variability in October through December. Table 2-7 shows rainfall variability among these three gages and the gage at National Airport to the east of the watershed. An example of rainfall variability in one particular storm is shown in Figure 2-8, which shows a range of total event rainfall of 0.14 to 3.79 inches for an 8-hour event.

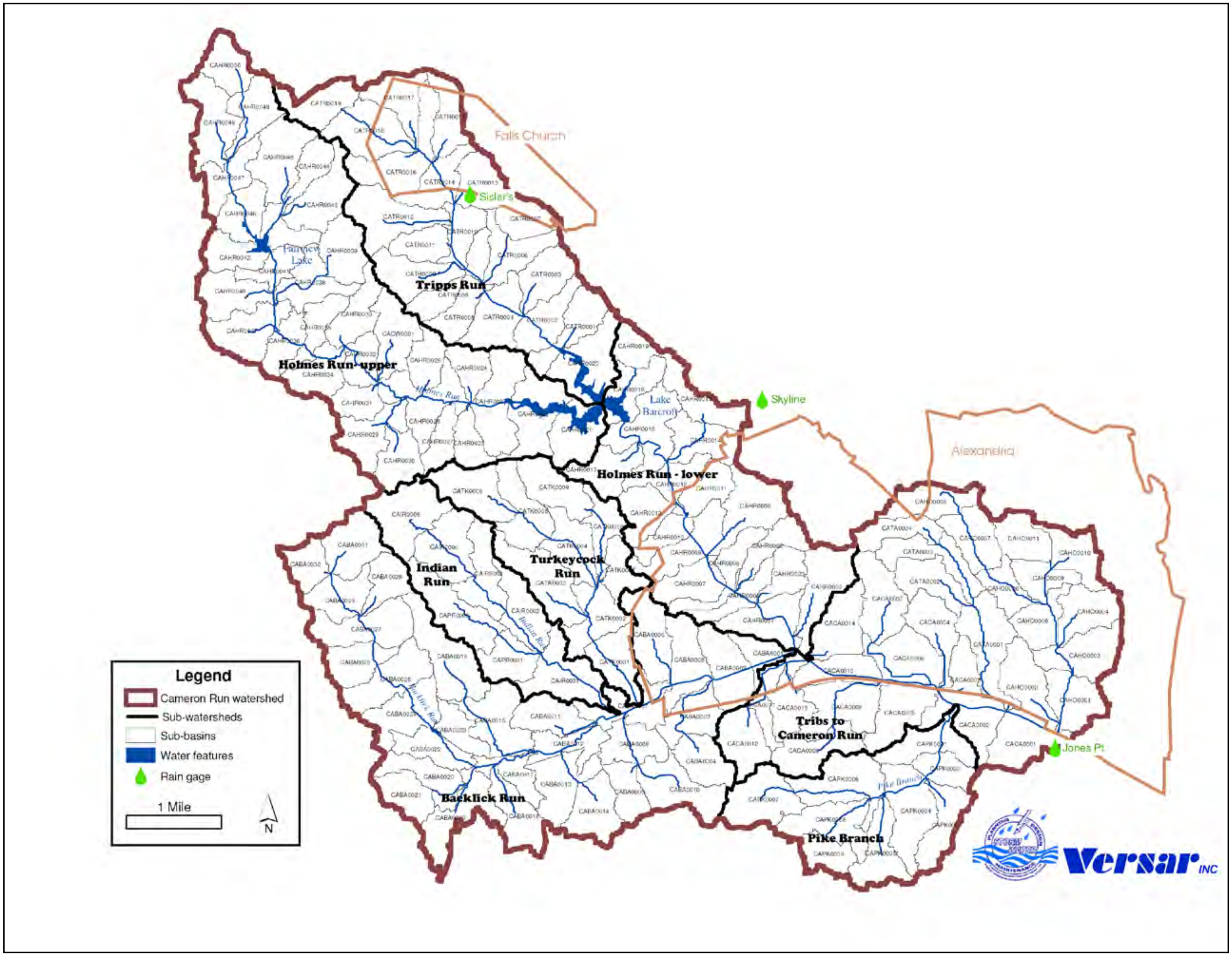

Figure 2-2. Cameron Run watershed showing subwatersheds, subbasins, and rain gages

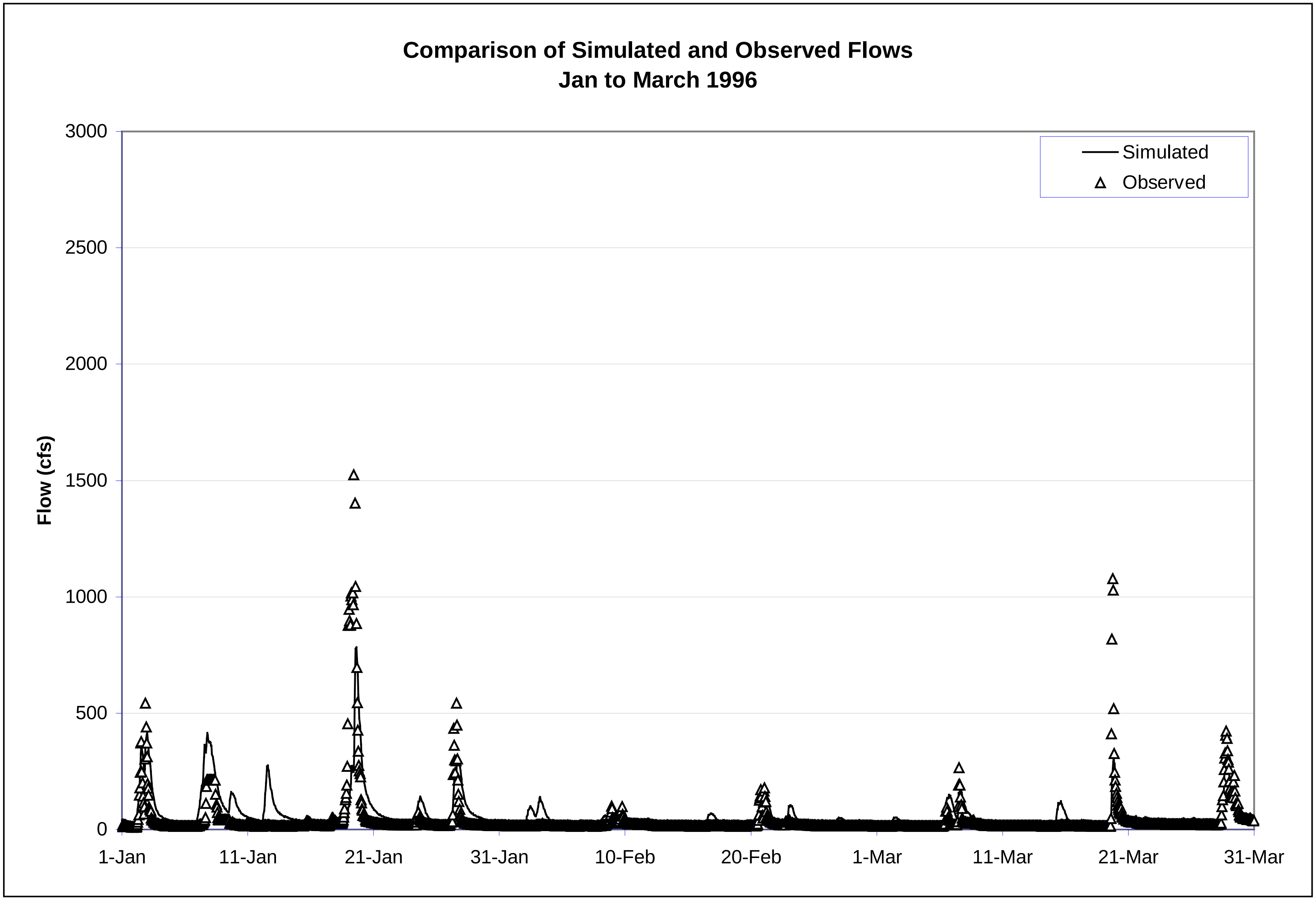

Figure 2-3. Comparison of simulated and observed flows January to March 1996

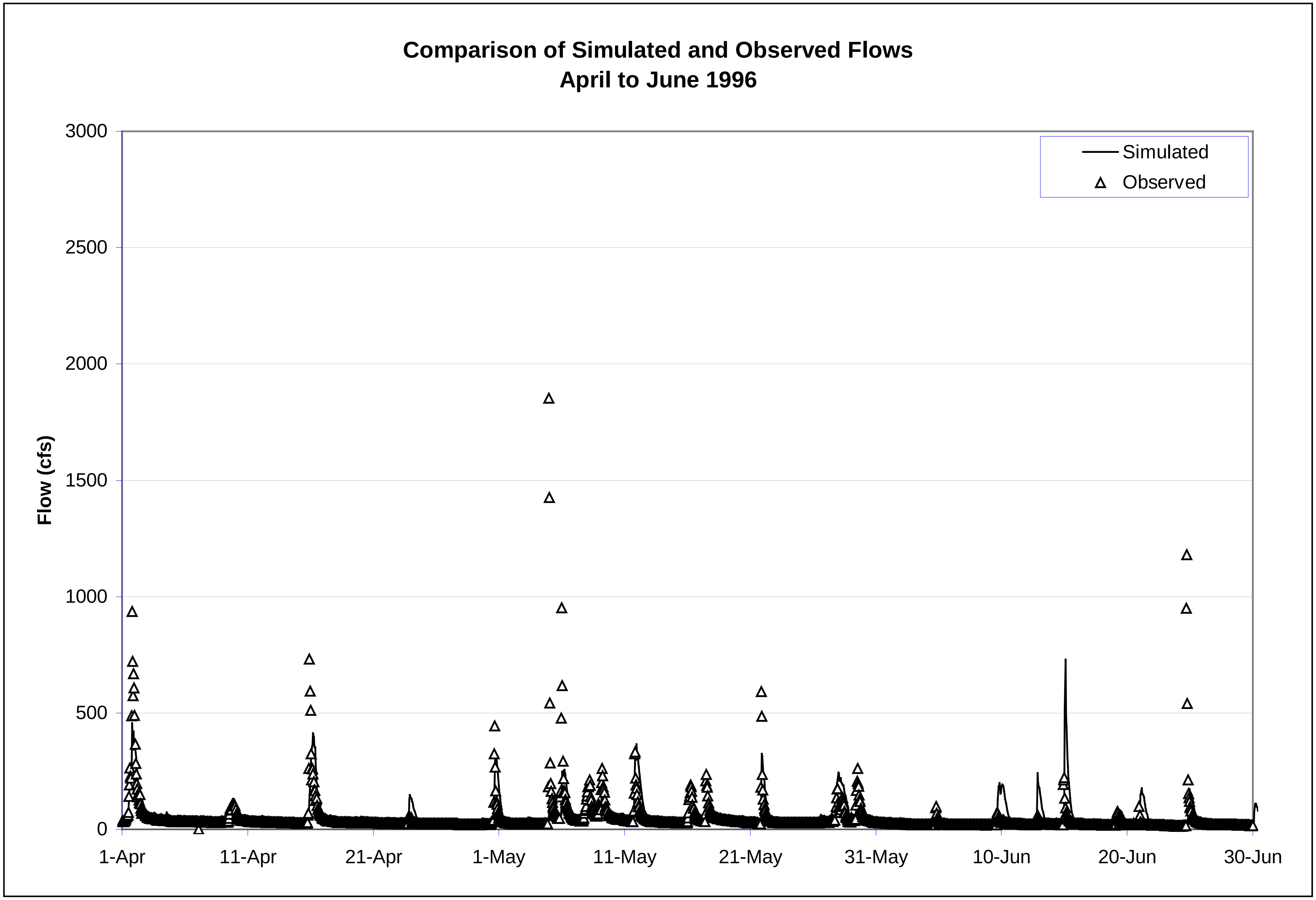

Figure 2-4. Comparison of simulated and observed flows April to June 1996

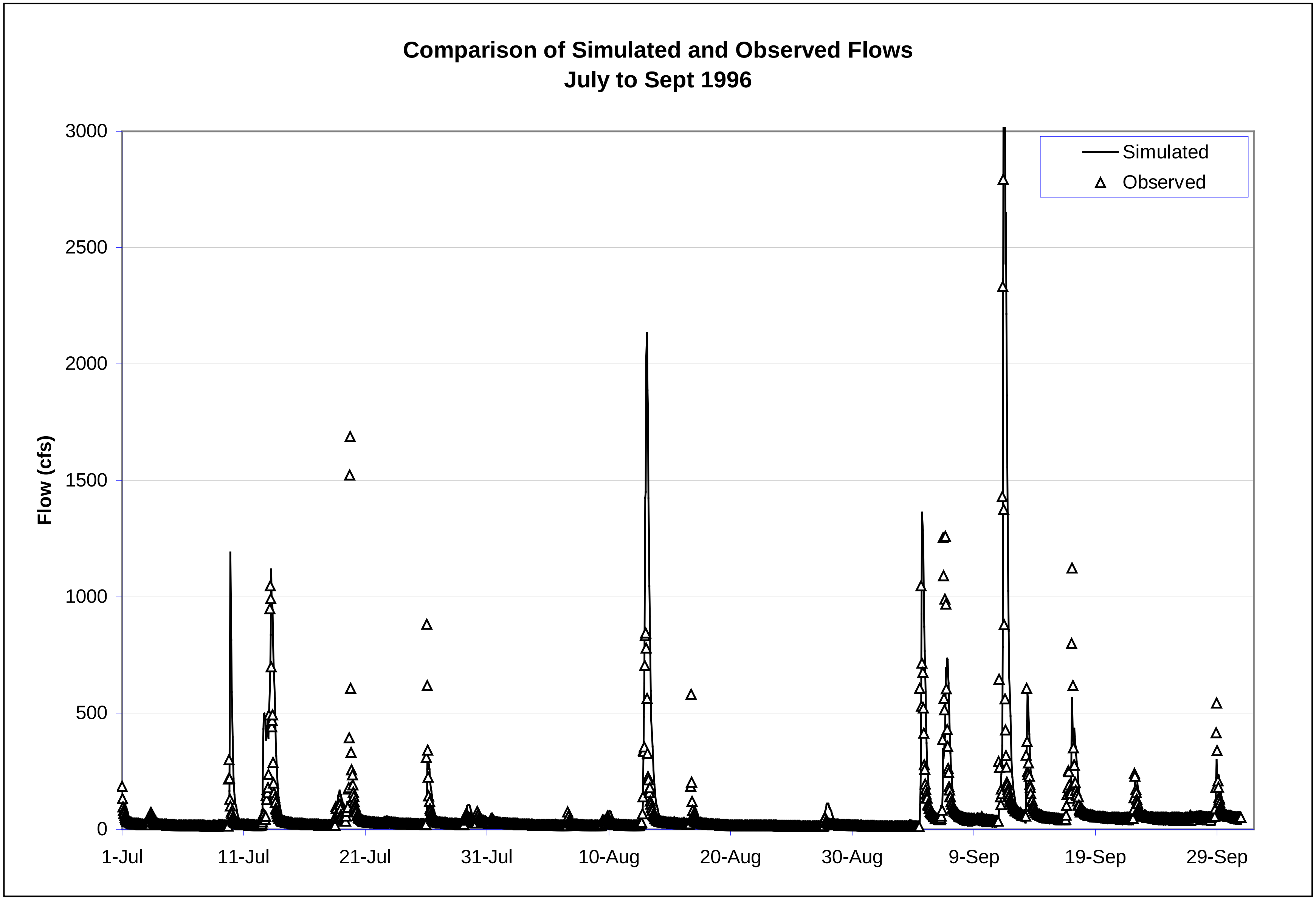

Figure 2-5. Comparison of simulated and observed flows July to September 1996

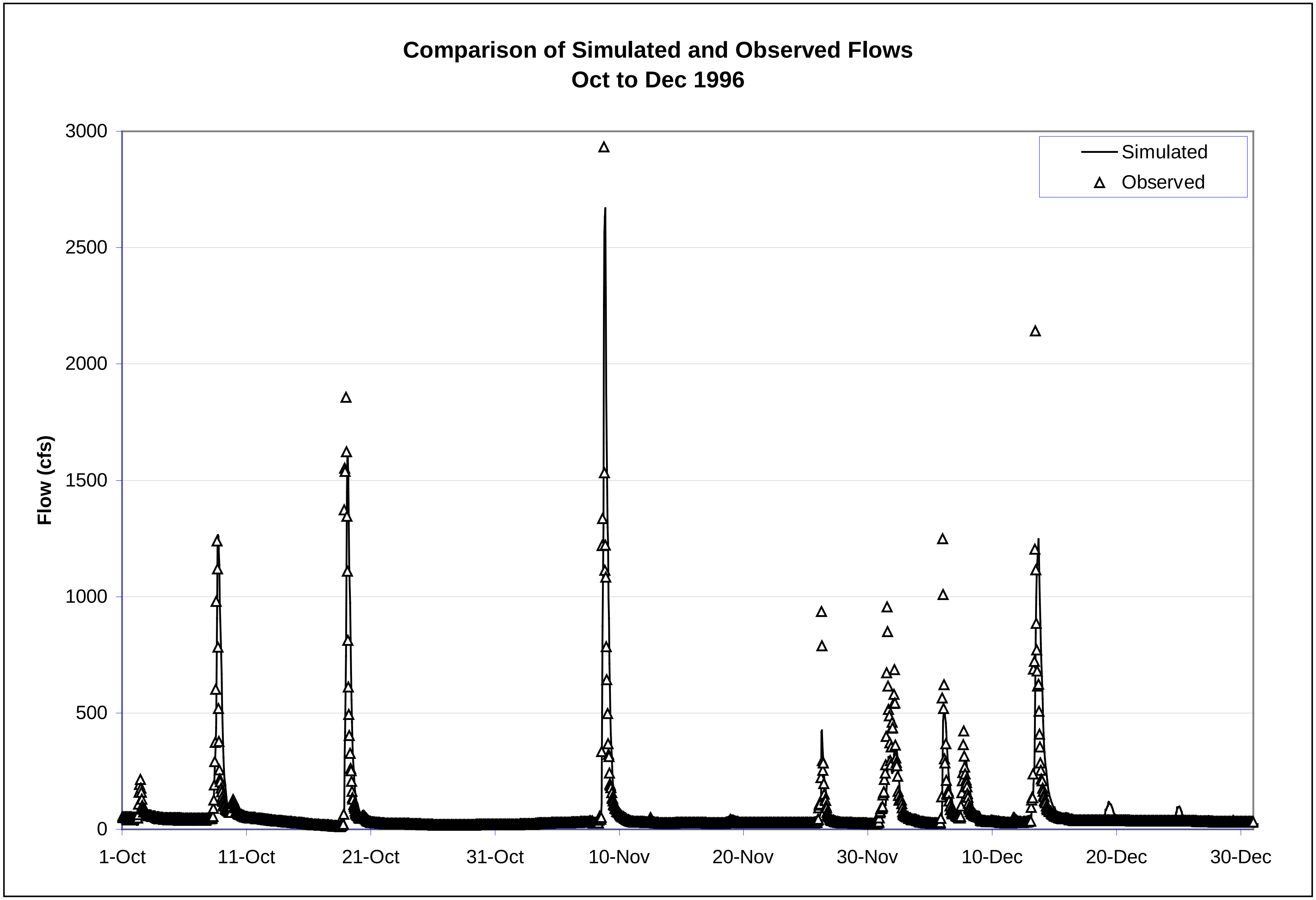

Figure 2-6. Comparison of simulated and observed flows October to December 1996

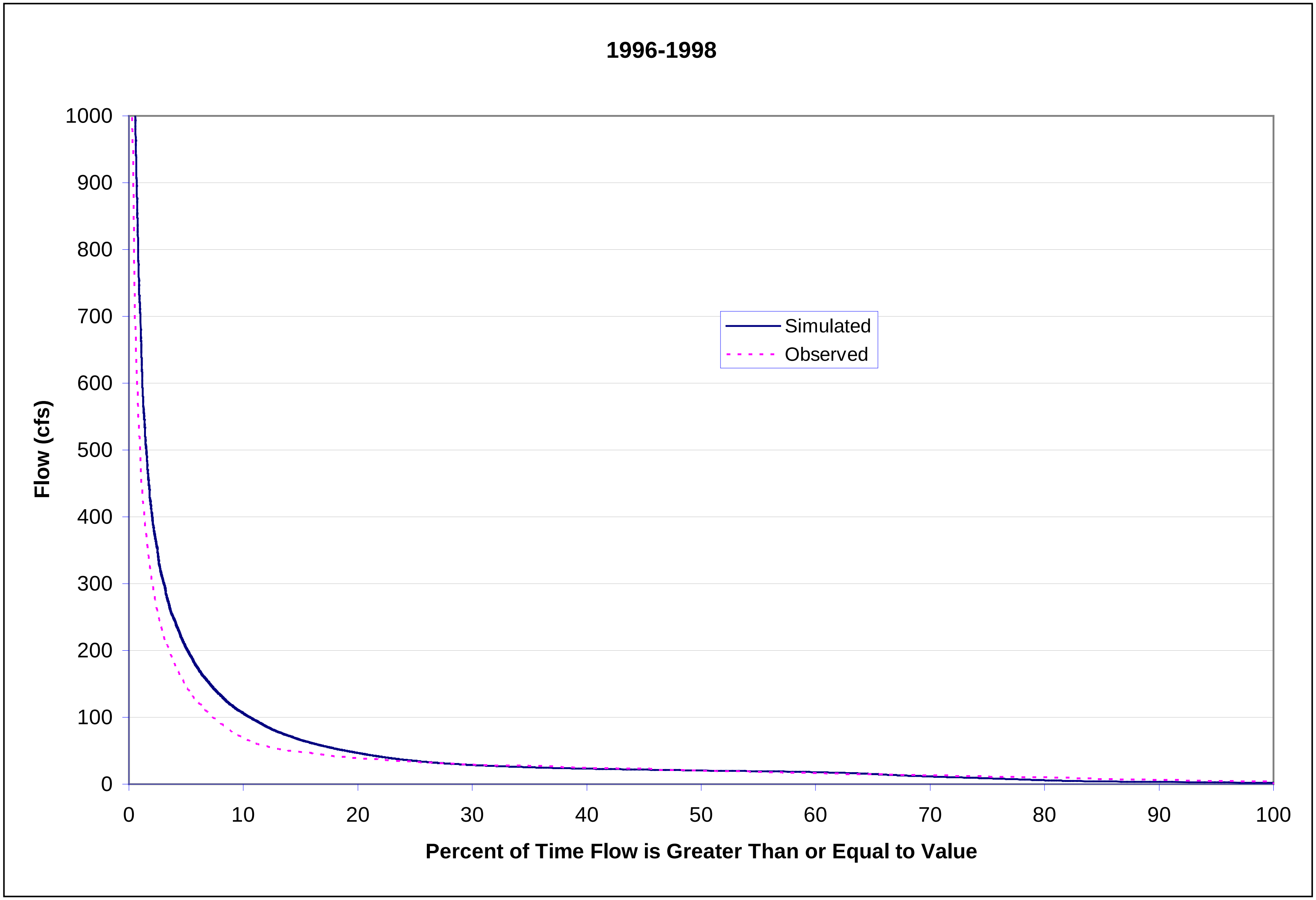

Figure 2-7. Comparison of simulated and observed flows, frequency (1996-1998)

Table 2-5. Cameron Run SWMM model calibration: statistical comparison of simulation results and observed gage data for 1996-1998

Year	Season	Model						Gage						% error
		n	Volume, cubic feet	Mean Flow, cfs	stddev	min	max	n	Volume, cubic feet	Mean Flow, cfs	stddev	min	max	
1996-1998	All	26305	5.1E+09	54	156	2	5930	26304	4.1E+09	43	118	0	4993	23.8
1996	All	8784	2.0E+09	63	163	5.3	3604	8784	1.8E+09	56	158	0	4993	12.0
1997	All	8760	1.3E+09	42	154	2.1	5930	8760	1.0E+09	32	67	0	1783	31.0
1998	All	8760	1.7E+09	55	152	2	3024	8760	1.3E+09	41	111	0	2548	34.2
1996	Jan-Mar	2184	4.6E+08	58	77	16.9	783	2184	3.6E+08	45	167	10	4993	27.9
1997	Jan-Mar	2160	4.0E+08	52	77	18.1	904	2160	3.5E+08	44	66	17	1075	16.9
1998	Jan-Mar	2160	8.3E+08	107	228	4.5	2384	2160	6.8E+08	88	173	12	2548	21.6
1996	Apr-Jun	2184	3.7E+08	47	63	8.2	731	2184	3.7E+08	48	88	0	1853	-2.4
1997	Apr-Jun	2184	3.7E+08	47	221	3.8	5930	2184	2.5E+08	32	78	0	1783	46.2
1998	Apr-Jun	2184	6.4E+08	82	172	16.5	3024	2184	4.3E+08	55	119	0	2198	49.8
1996	Jul-Sep	2208	5.9E+08	75	234	5.3	3604	2208	5.0E+08	62	176	11	3343	19.7
1997	Jul-Sep	2208	2.1E+08	26	112	2.1	1803	2208	1.4E+08	17	43	4	772	53.9
1998	Jul-Sep	2208	1.8E+08	22	60	2.7	984	2208	1.0E+08	13	36	3.5	634	70.9
1996	Oct-Dec	2208	5.7E+08	72	201	13.3	2670	2208	5.5E+08	69	179	12	3055	4.6
1997	Oct-Dec	2208	3.6E+08	45	163	2.1	2192	2208	2.9E+08	37	72	3.7	1089	23.8
1998	Oct-Dec	2208	9.5E+07	12	34	2	423	2208	8.5E+07	11	23	3.5	306	11.3

Table 2-6. Cameron Run SWMM model verification: statistical comparison of simulation results and observed gage data for 1999-2001

Year	Season	Model						Gage						% error
		n	Volume, cubic feet	Mean Flow, cfs	stddev	min	max	n	Volume, cubic feet	Mean Flow, cfs	stddev	min	max	
1999-2001	All	24096	4.23E+09	49	181	2.1	12518	24094	3.52E+09	41	148	2.2	6605	20.0
1999	All	8760	1.5E+09	48	164	2.1	4433	8759	1.06E+09	34	106	2.6	2603	42.0
2000	All	8784	1.54E+09	49	124	2.7	1986	8784	1.48E+09	47	189	2.2	6605	4.0
2001	Jan-Sep	6552	1.19E+09	50	254	3	12518	6551	9.85E+08	42	134	4.6	3720	20.5
1999	Jan-Mar	2160	4.09E+08	53	90	3.7	970	2160	3.38E+08	43	93	6.8	1293	20.9
2000	Jan-Mar	2184	3.13E+08	40	89	5	1350	2184	3.63E+08	46	92	8.6	1885	-13.6
2001	Jan-Mar	2160	2.71E+08	35	87	3	1197	2160	3.78E+08	49	146	4.6	2153	-28.3
1999	Apr-Jun	2184	2.2E+08	28	56	2.6	739	2183	1.37E+08	17	36	2.6	667	60.7
2000	Apr-Jun	2184	4.87E+08	62	135	15.6	1986	2184	4.51E+08	57	156	10.3	4455	7.9
2001	Apr-Jun	2184	4.04E+08	51	110	3.6	1908	2183	3.58E+08	46	147	6	3720	12.8
1999	Jul-Sep	2208	6.41E+08	81	300	2.1	4433	2208	3.79E+08	48	172	3.5	2603	69.4
2000	Jul-Sep	2208	6.02E+08	76	171	3.8	1817	2208	4.9E+08	62	295	2.2	6605	22.7
2001	Jul-Sep	2208	5.12E+08	64	414	5.8	12518	2208	2.48E+08	31	105	4.6	1788	106.1
1999	Oct-Dec	2208	2.3E+08	29	57	6	675	2208	2.03E+08	26	69	6.8	783	13.3
2000	Oct-Dec	2208	1.38E+08	17	63	2.7	1222	2208	1.76E+08	22	145	3	4923	-21.8

Table 2-7. Rainfall variability in 1996-1998, as recorded at these rain gages: Sisler's, Skyline, Jones Point, and National Airport

Year	Season	Min Rain	Max Rain	% Variability	Seasonal Average % Variability
All	All	109.0	121.0	10.2	
1996	All	41.4	52.2	22.5	
1997	All	32.0	34.0	5.9	
1998	All	33.8	38.6	13.7	
1996	Jan-Mar	8.8	11.2	23.6	
1997	Jan-Mar	8.6	10.0	14.1	
1998	Jan-Mar	14.3	17.4	20.0	19.2
1996	Apr-Jun	7.7	12.2	42.6	
1997	Apr-Jun	7.1	8.9	22.8	
1998	Apr-Jun	10.8	14.2	26.1	30.5
1996	Jul-Sep	14.1	15.9	12.0	
1997	Jul-Sep	5.7	6.0	5.3	
1998	Jul-Sep	3.0	4.7	42.3	19.9
1996	Oct-Dec	10.7	13.4	21.6	
1997	Oct-Dec	9.3	10.9	15.4	
1998	Oct-Dec	3.2	3.4	4.8	14.0

The model does not simulate snowmelt and therefore cannot simulate snowfall and snowmelt events during the winter months. As an example, this is shown in January 1996 when snow fell in the early part of the month and melted in middle to late January (see Figure 2-3); thus, the gage shows less response to precipitation than the model in early January and a greater response in the middle and later events of the month than does the model.

The model represents the rising limb and recession limb reasonably well for most of the major events. Base flow rates are also reasonably represented by the SWMM-RUNOFF groundwater routines. The flow-frequency distribution shows that the model overestimates the observed flows about 15-20% of the time; total flow was overestimated by about 24% for the calibration period (1996-1998) and by about 20% for the verification period (1999-2001).

2.5 SWMM WATER QUALITY RESULTS

Average annual loadings for each model subbasin for the period 1996-1998 were calculated by summing the loadings from the detention-controlled areas and uncontrolled areas of each subbasin for current and future imperviousness and land use conditions. (Details concerning calculation of current and future imperviousness and land use are described in Section 1.6). These loadings include the influence of the areas assumed to contain detention controls with water quality treatment. Since these are subbasin loadings, they do not include simulation of pollutant removals by Fairview Lake or Lake Barcroft. Figures 2-9 through 2-23 illustrate loadings for Total Suspended Sediment (TSS), Total Nitrogen (TN) and Total

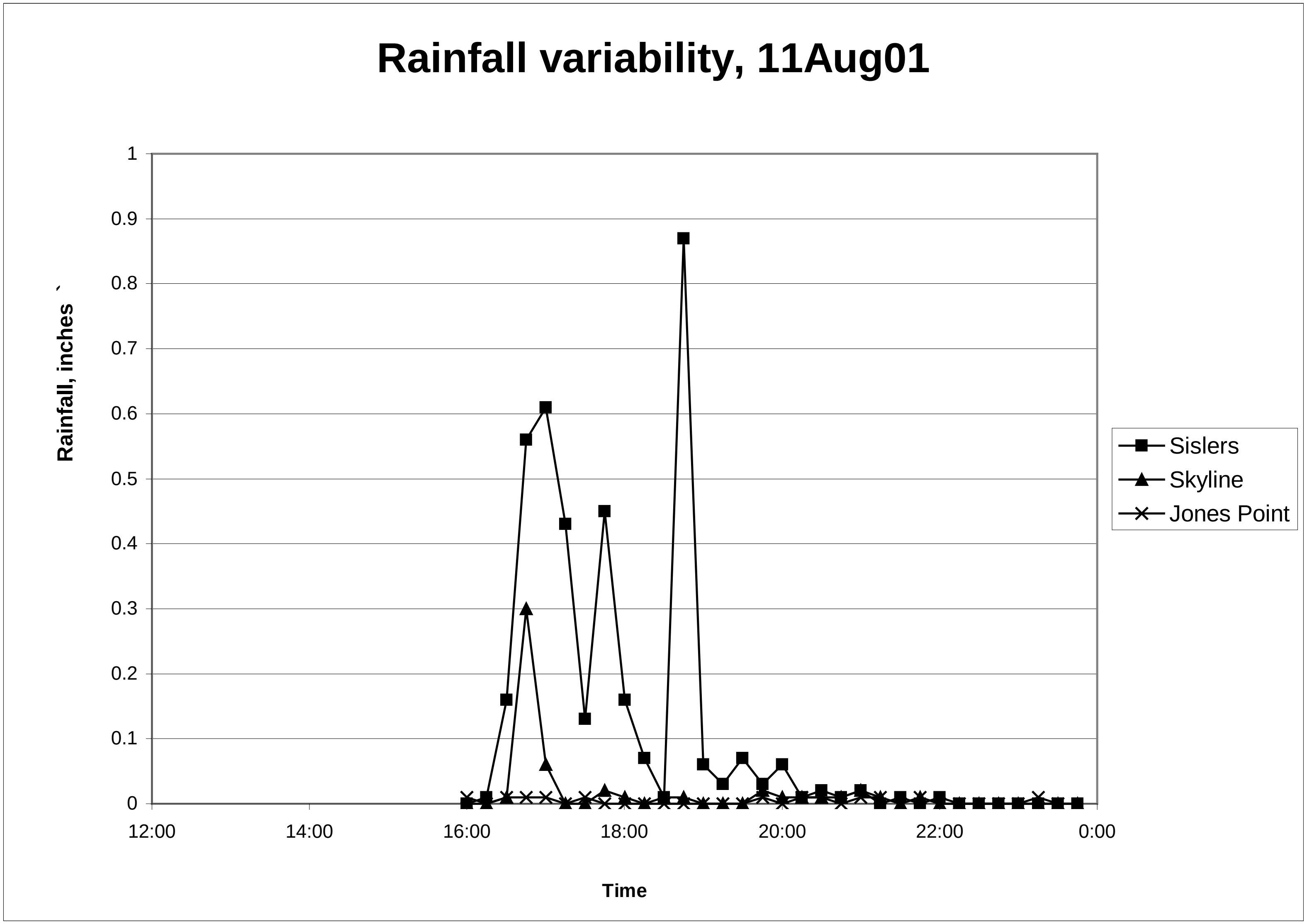

Figure 2-8. Example of rainfall variability at raingages in or near Cameron Run watershed

Phosphorus (TP) in each modeled subbasin throughout the watershed for current and future land use conditions and with the proposed projects, and the changes in loadings between these scenarios.

Average annual loadings for all 11 simulated water quality constituents within each subbasin are shown in Tables 2-8 to 2-10 for current and future land use conditions and for the proposed projects. Table 2-11 summarizes these results by subwatershed.

Results show moderate to high pollutant loadings, as expected from a highly developed watershed such as Cameron Run, which has only a modest amount of stormwater management due to its development prior to implementation of these types of controls. Results also show a relatively small increase in loadings from current to future conditions since most of the watershed has already been developed. The proposed projects show a small decrease in loadings from future conditions.

The model calculates a concentration value for each parameter and instream velocities at each hour. These results were used to develop water quality concentration and velocity distribution curves from the SWMM model outputs at the downstream end of each subwatershed. To focus these results on stormwater effects and its management, the water quality values for the upper 50^{th} percentile of flows were used for this assessment. This results in excluding values during low baseflow conditions, when the model cannot accurately calculate concentration values, since its focus is on stormwater runoff. Figures 2-24 through 2-26 illustrate these results.

2.6 DESIGN STORM SWMM RESULTS

The calibrated SWMM hydrology model was used to generate design storm hydrographs for each subbasin within each subwatershed of the model. Twenty-four-hour design storm (Type-II, NRCS 2002) rainfall for the 1-, 2-, 10-, 25-, and 100-year recurrence intervals were used as input to the model in place of the continuous rainfall data. All calibration parameters remained the same for these simulations. Simulations were made for imperviousness in the current, future, and future with projects scenarios for each subbasin, as previously described for the continuous model. These results can be used to evaluate the change in peak storm flows as a result of changes in land use and potential management measures designed for peak flow reduction. These results are also used as input to the HEC-RAS model (Section 3.0). Tables 2-12 and 2-13 summarize the results by subwatershed for Fairfax County areas; Table 2-14 lists results for each subbasin within each subwatershed. For example, two-year design storm peak flows for each subwatershed ranged from 244 to 349 cfs, with an area-weighted average for the whole watershed of 287 cfs, for current conditions. These peak flows increased an average of 3.8% for the projected future for the whole watershed, with the increase ranging from 0 to 6.3% for the various subwatersheds. This relatively modest increase in peak flow for future conditions is a result of this watershed already being mostly developed. Ten-year peak flows increased from 669 to 676 cfs from present to future over the entire watershed, a 1.0% increase; 100-year peak flows increased from 1054 to 1059 cfs, a 3.0% increase.

Simulation results for the proposed projects are listed in these tables by subwatershed. Results show a modest decrease in peak flows with the proposed projects, ranging from a 5.0% decrease for the 1-year storm over the entire watershed to 2.6% decrease for the 100-year storm for the future watershed.

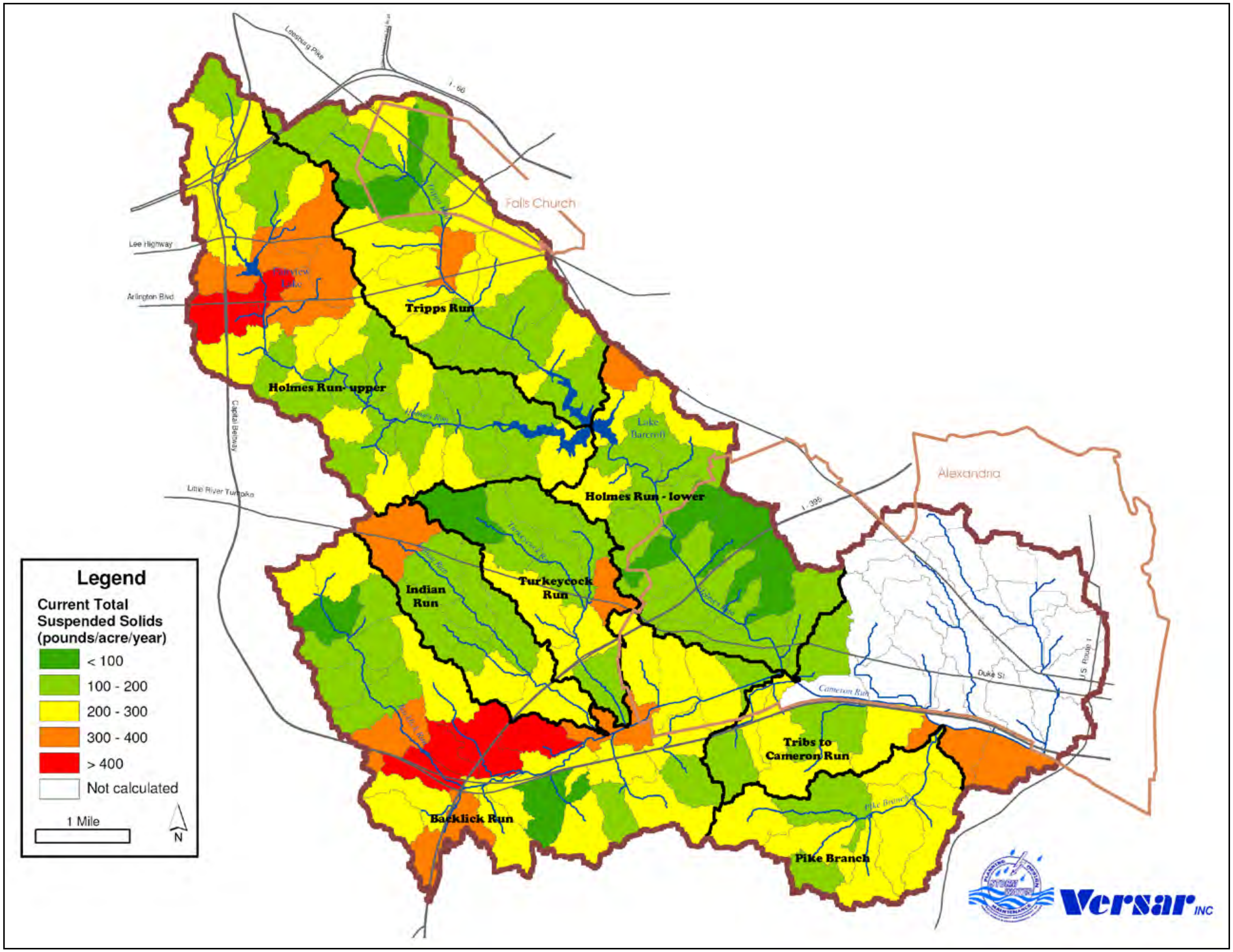

Figure 2-9. Average annual current Total Suspended Solids loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

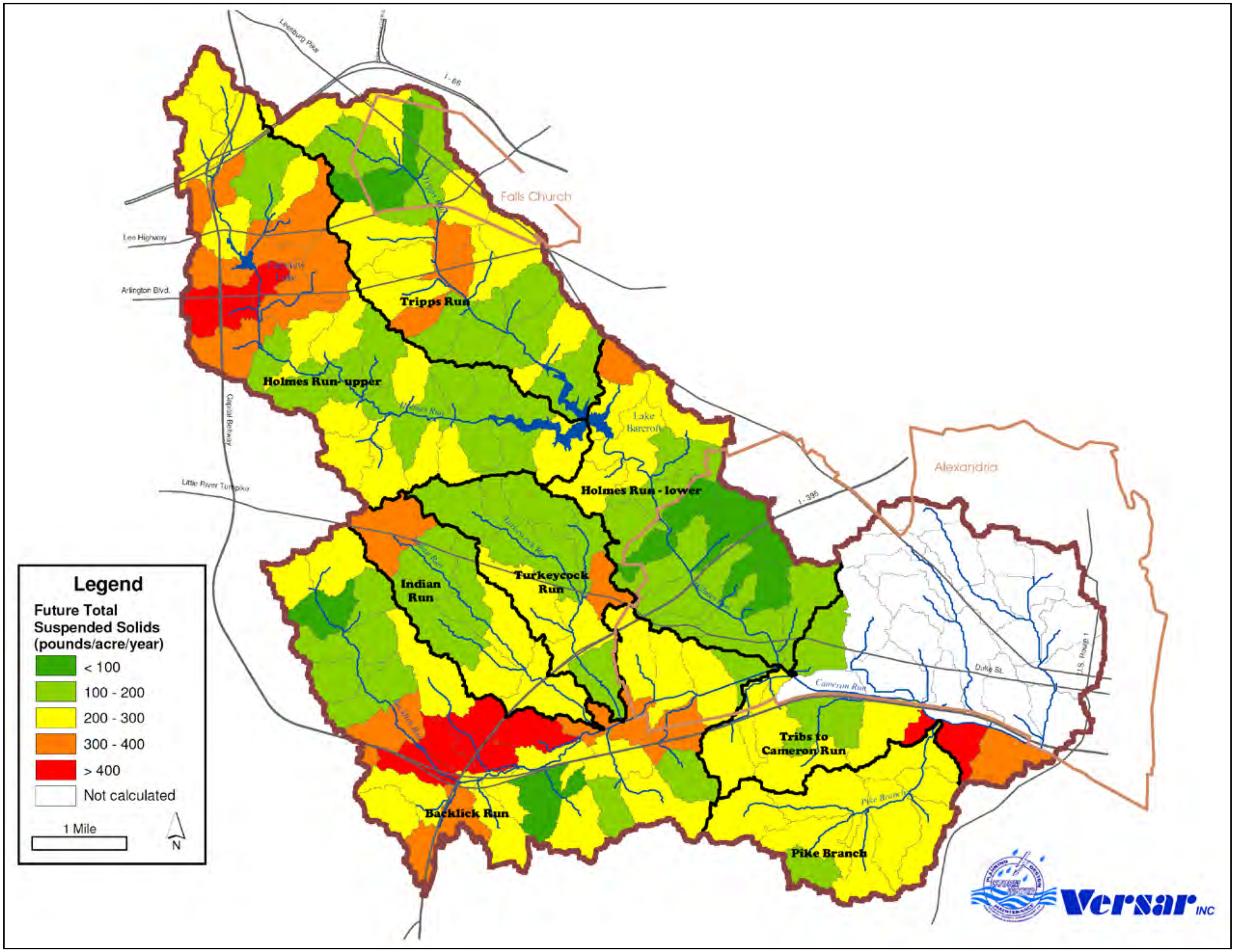

Figure 2-10. Average annual future Total Suspended Solids loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

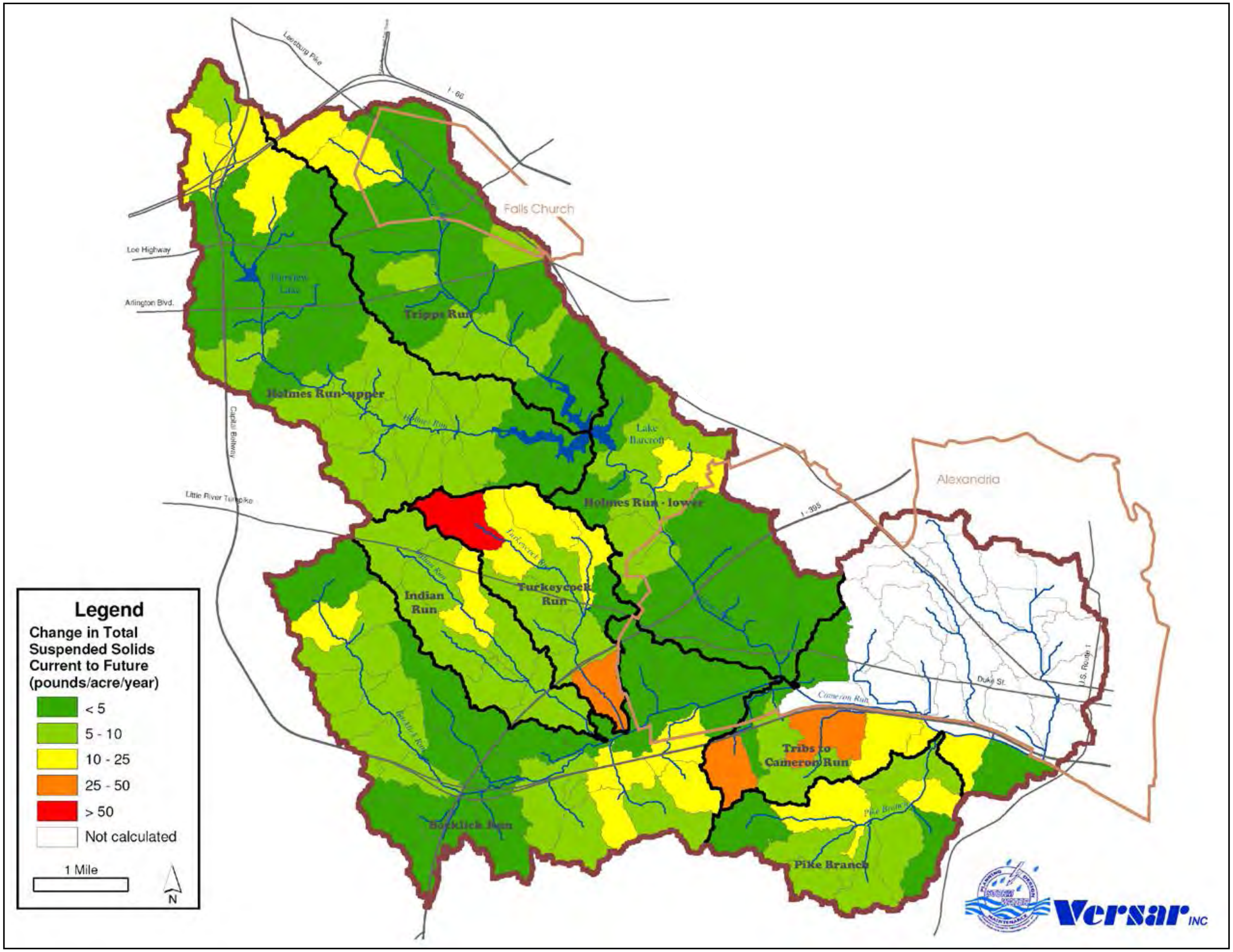

Figure 2-11. Average annual change in Total Suspended Solids loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

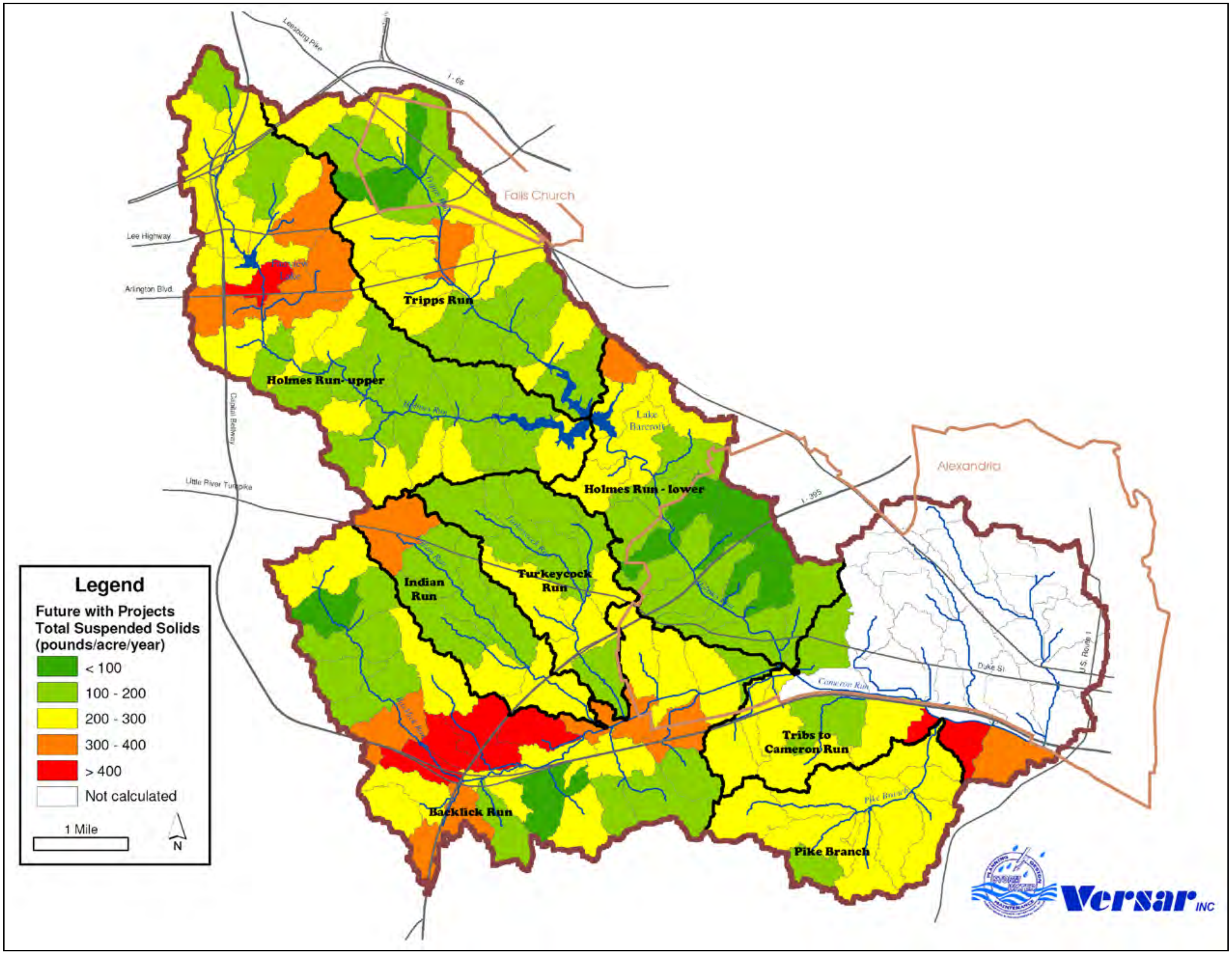

Figure 2-12. Average annual Total Suspended Solids loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM simulating future land use conditions with proposed projects

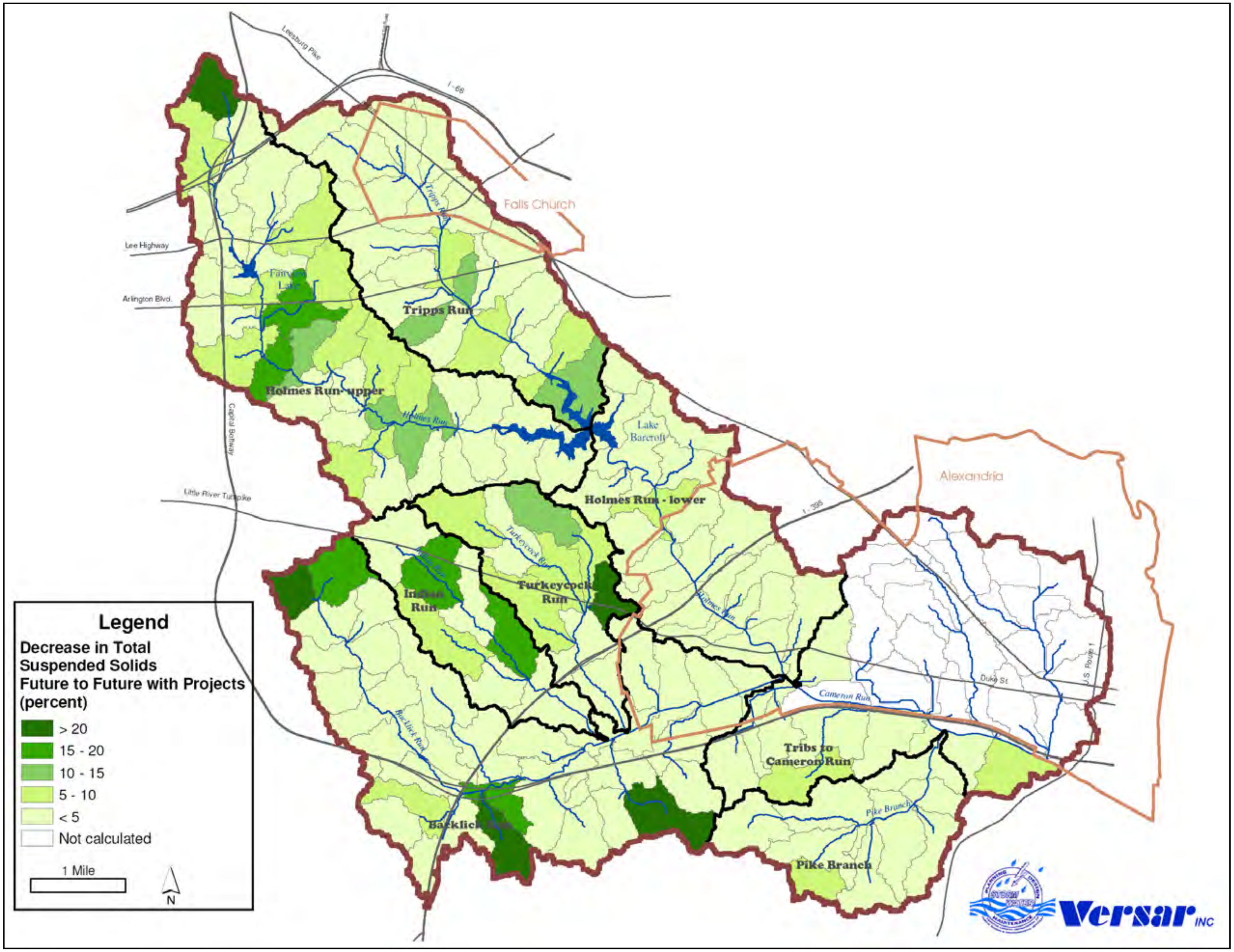

Figure 2-13. Average annual percent decrease in Total Suspended Solids loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM simulating future land use conditions with proposed projects

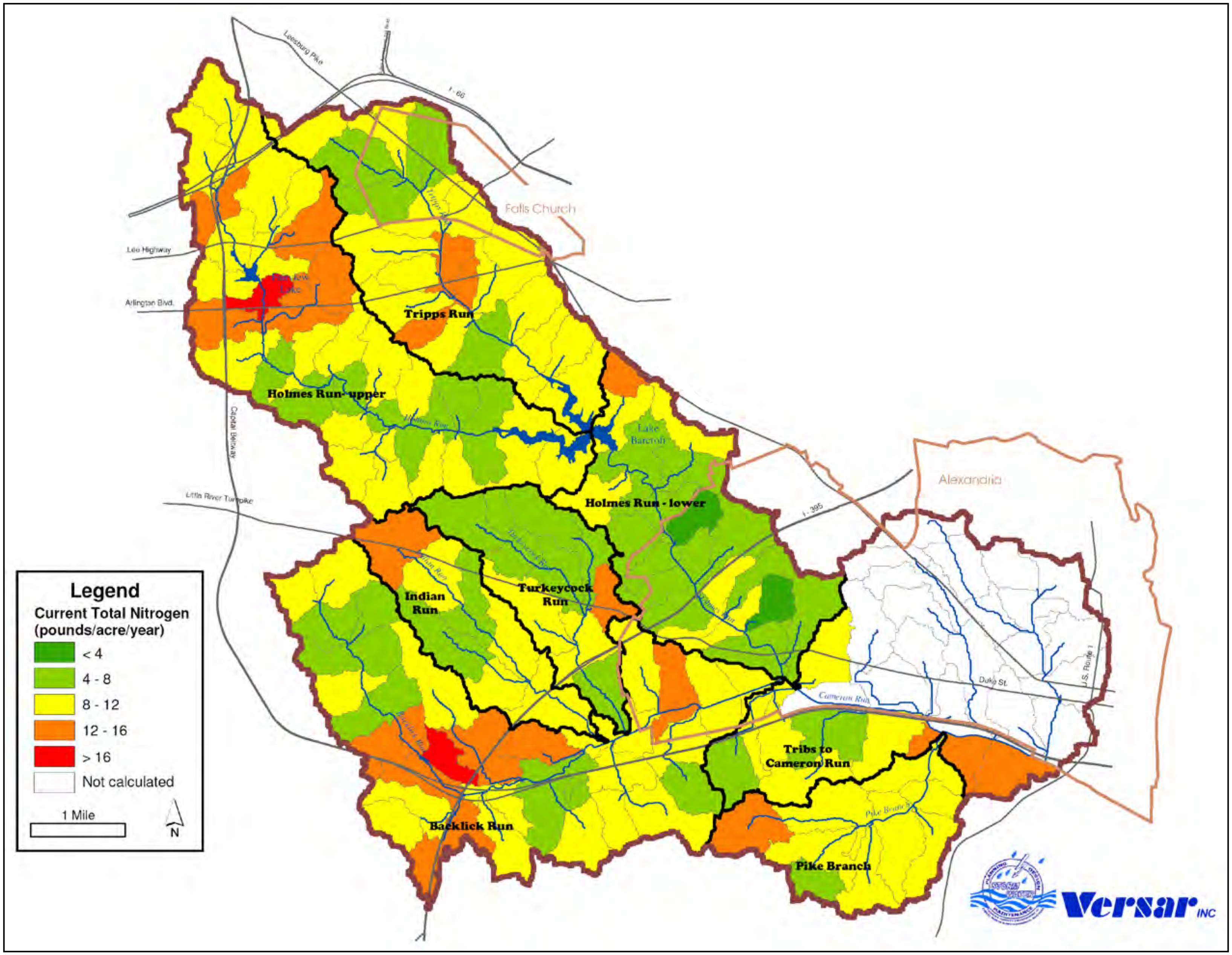

Figure 2-14. Average annual current Total Nitrogen loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

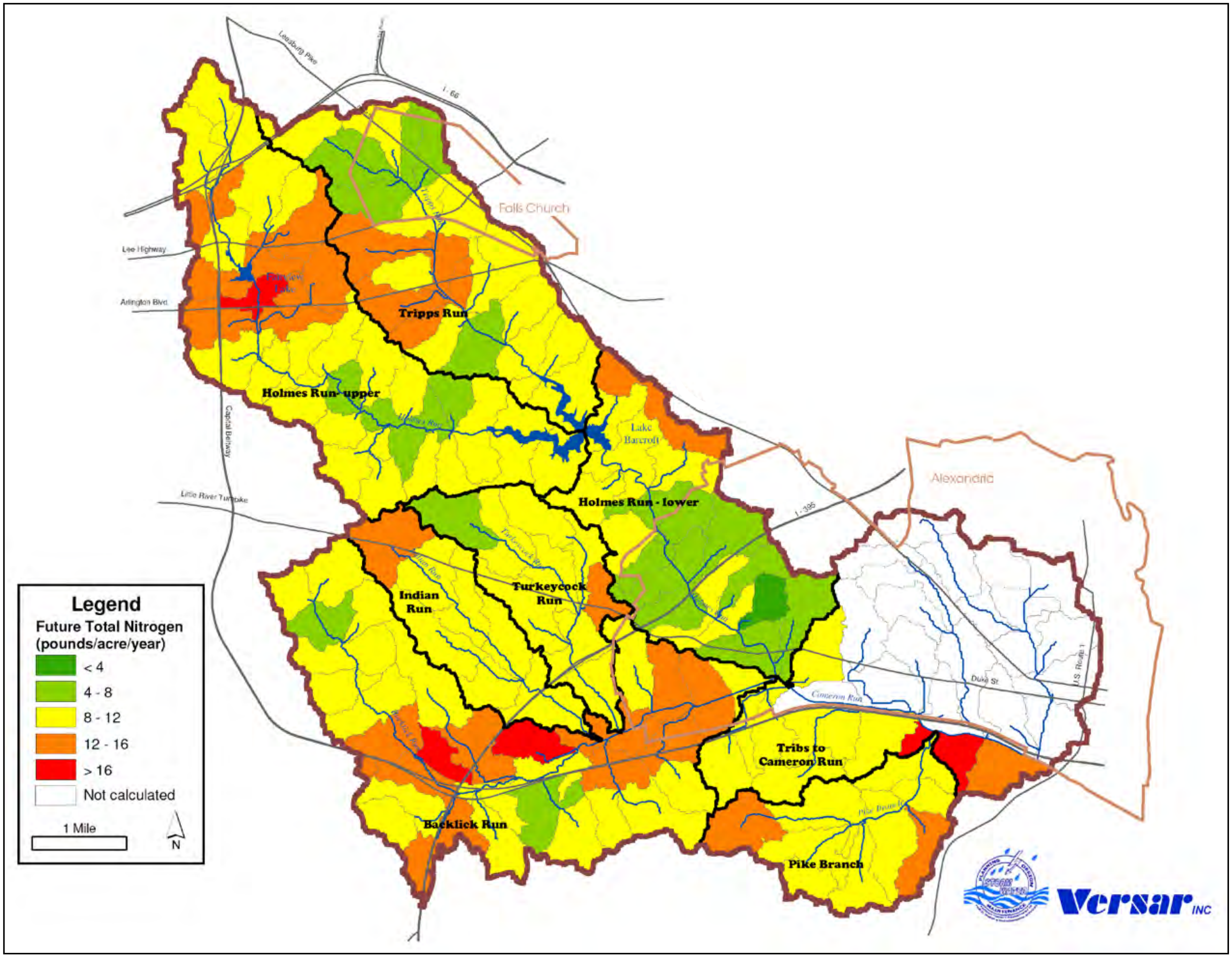

Figure 2-15. Average annual future Total Nitrogen loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

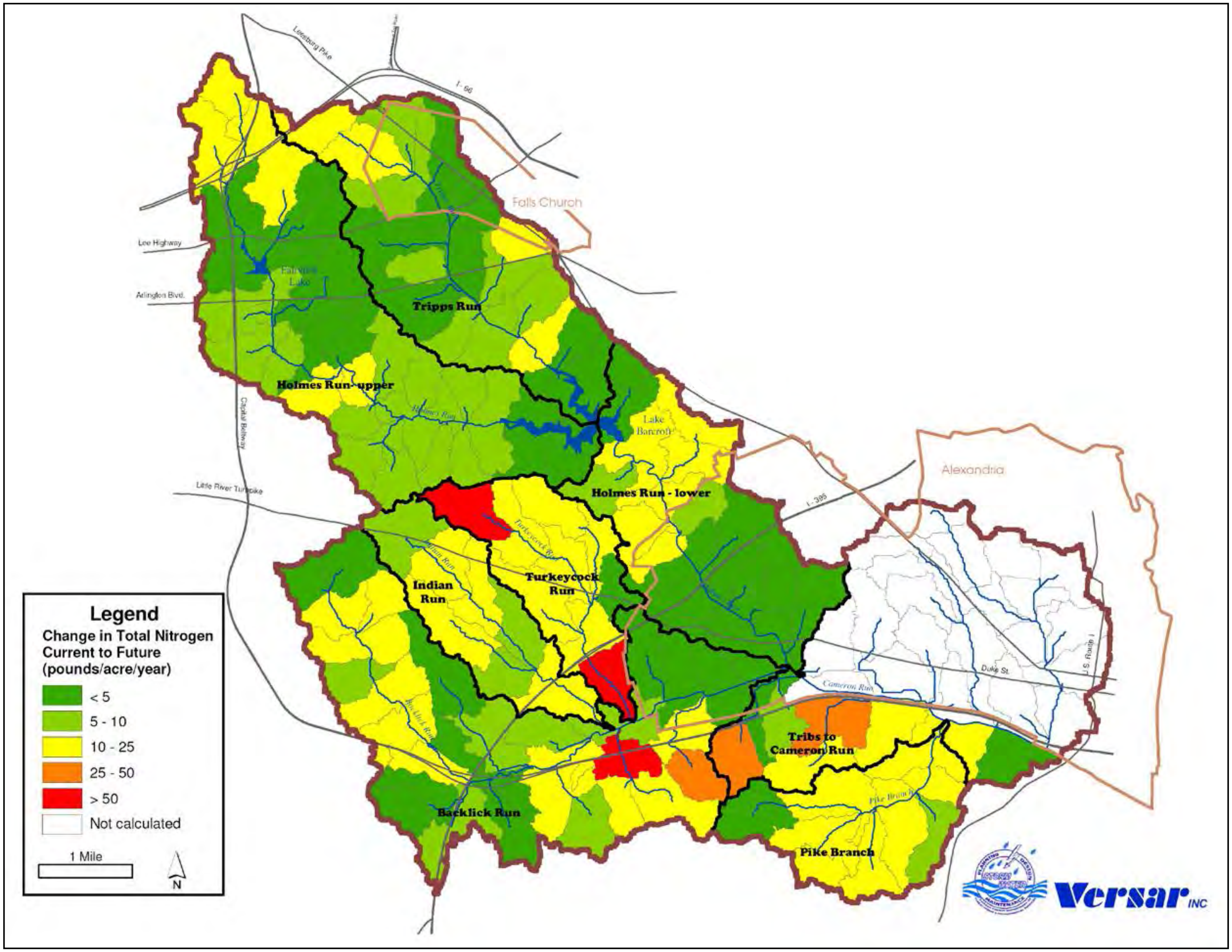

Figure 2-16. Average annual change in Total Nitrogen loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

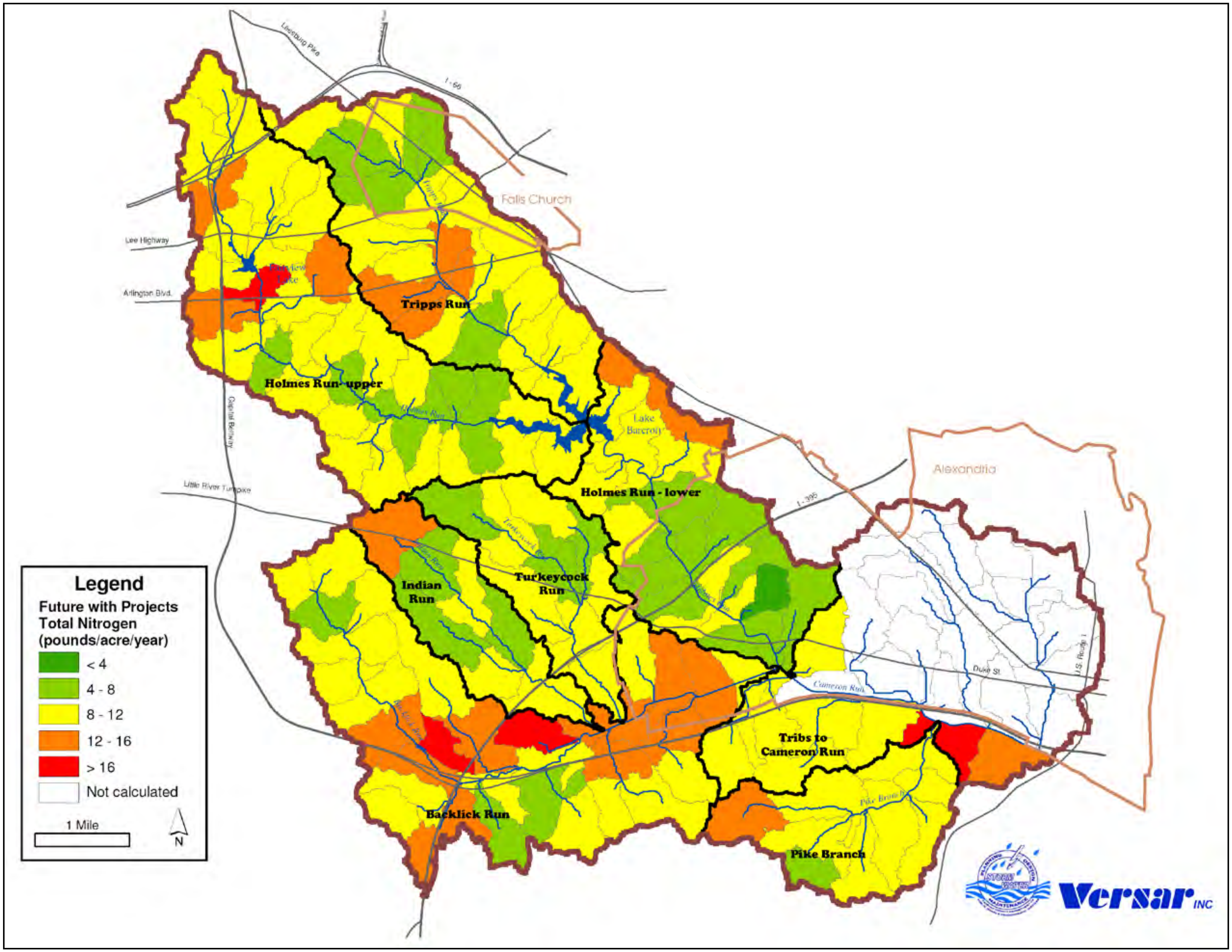

Figure 2-17. Average annual Total Nitrogen loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM simulating future landuse conditions with proposed projects

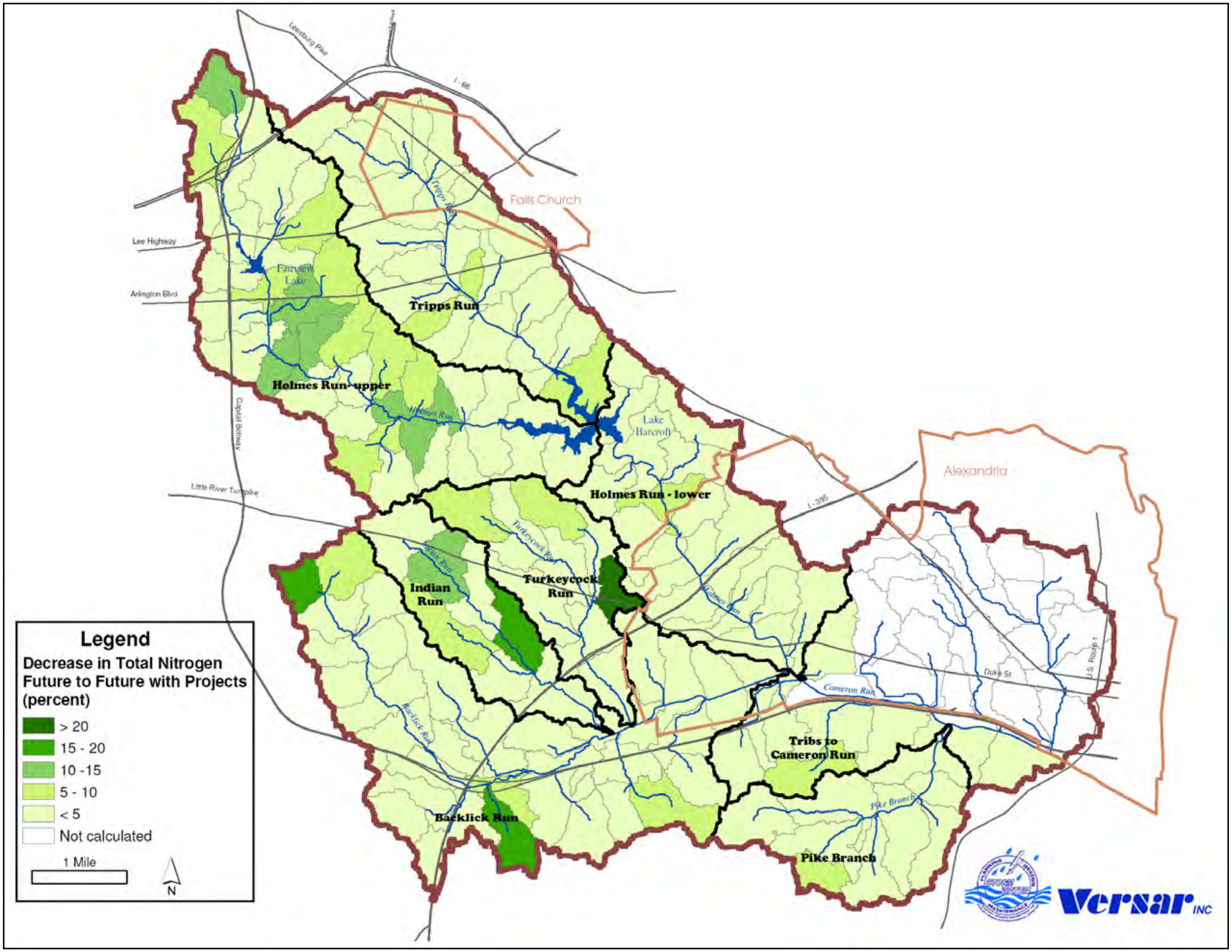

Figure 2-18. Average annual percent decrease in Total Nitrogen loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM simulating future landuse conditions with proposed projects

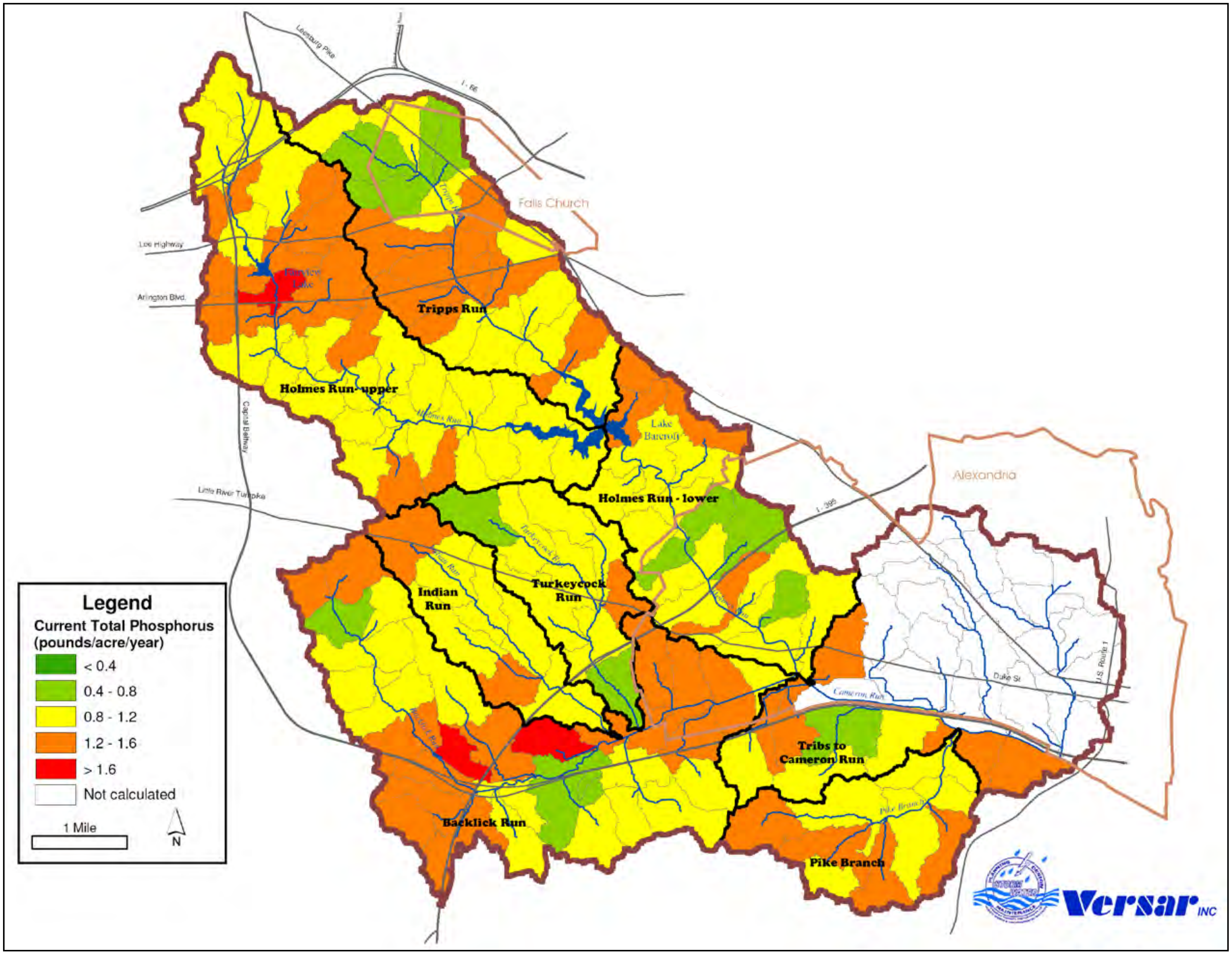

Figure 2-19. Average annual current Total Phosphorus loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

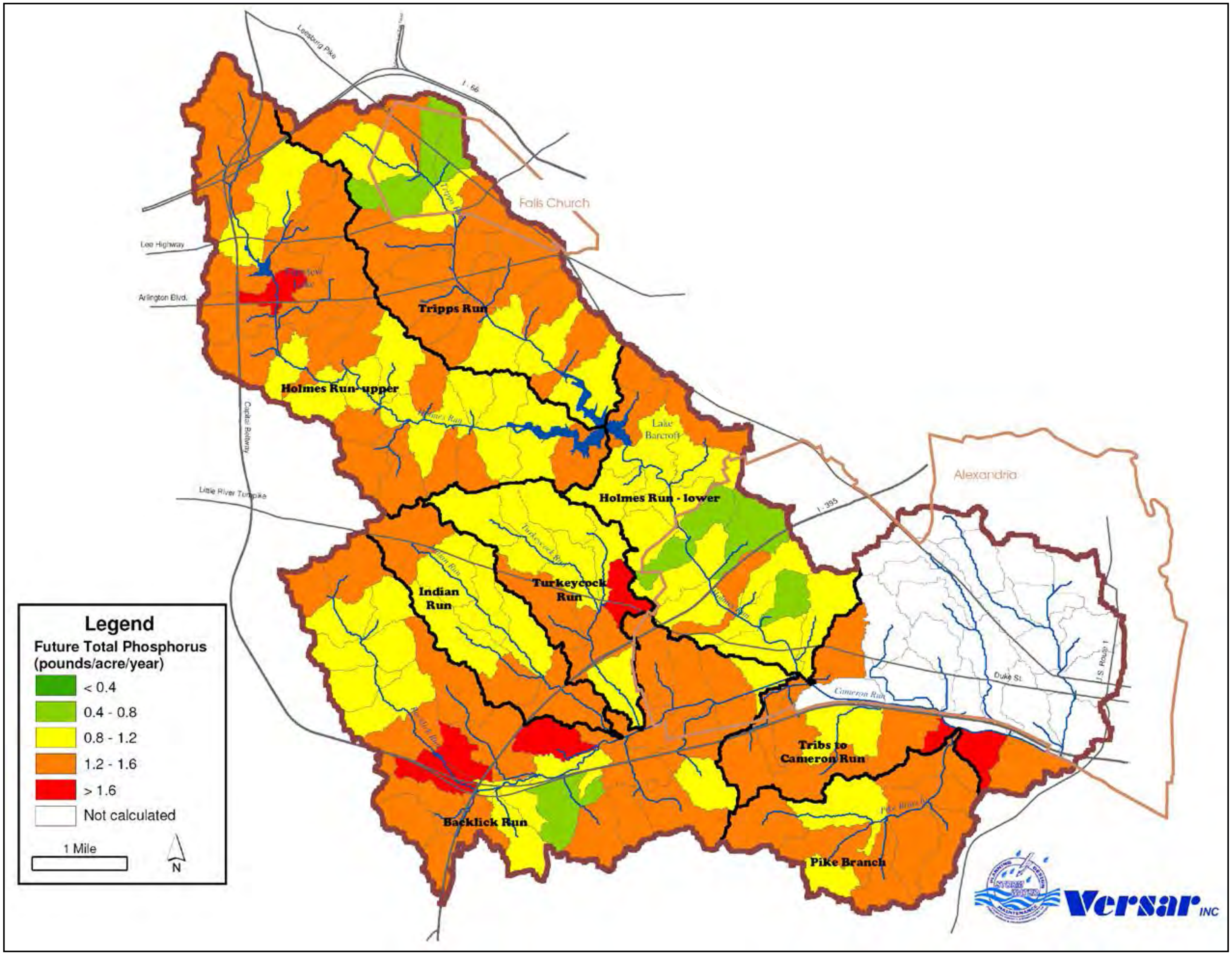

Figure 2-20. Average annual future Total Phosphorus loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

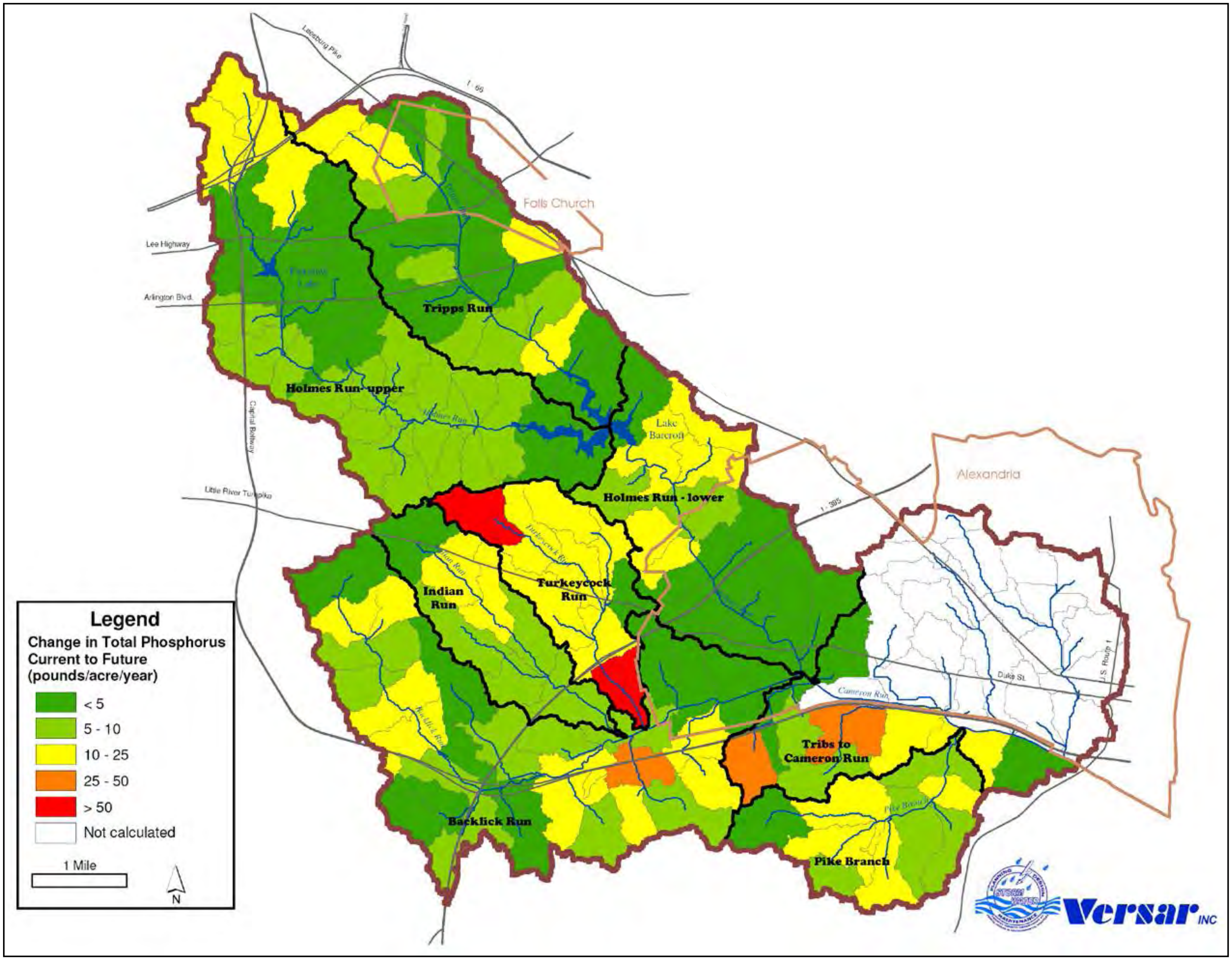

Figure 2-21. Average annual change in Total Phosphorus loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM

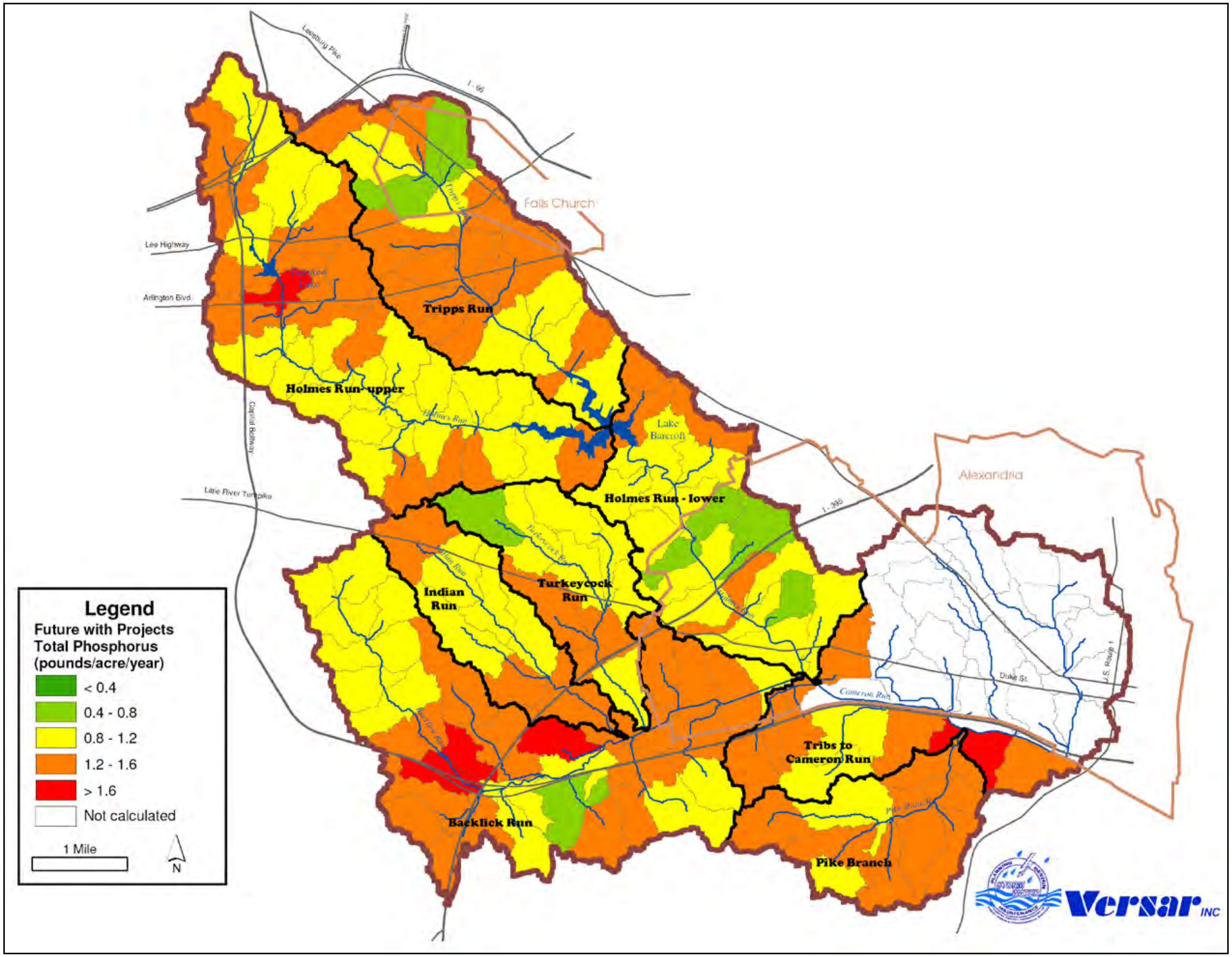

Figure 2-22. Average annual Total Phosphorus loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM simulating future landuse conditions with proposed projects

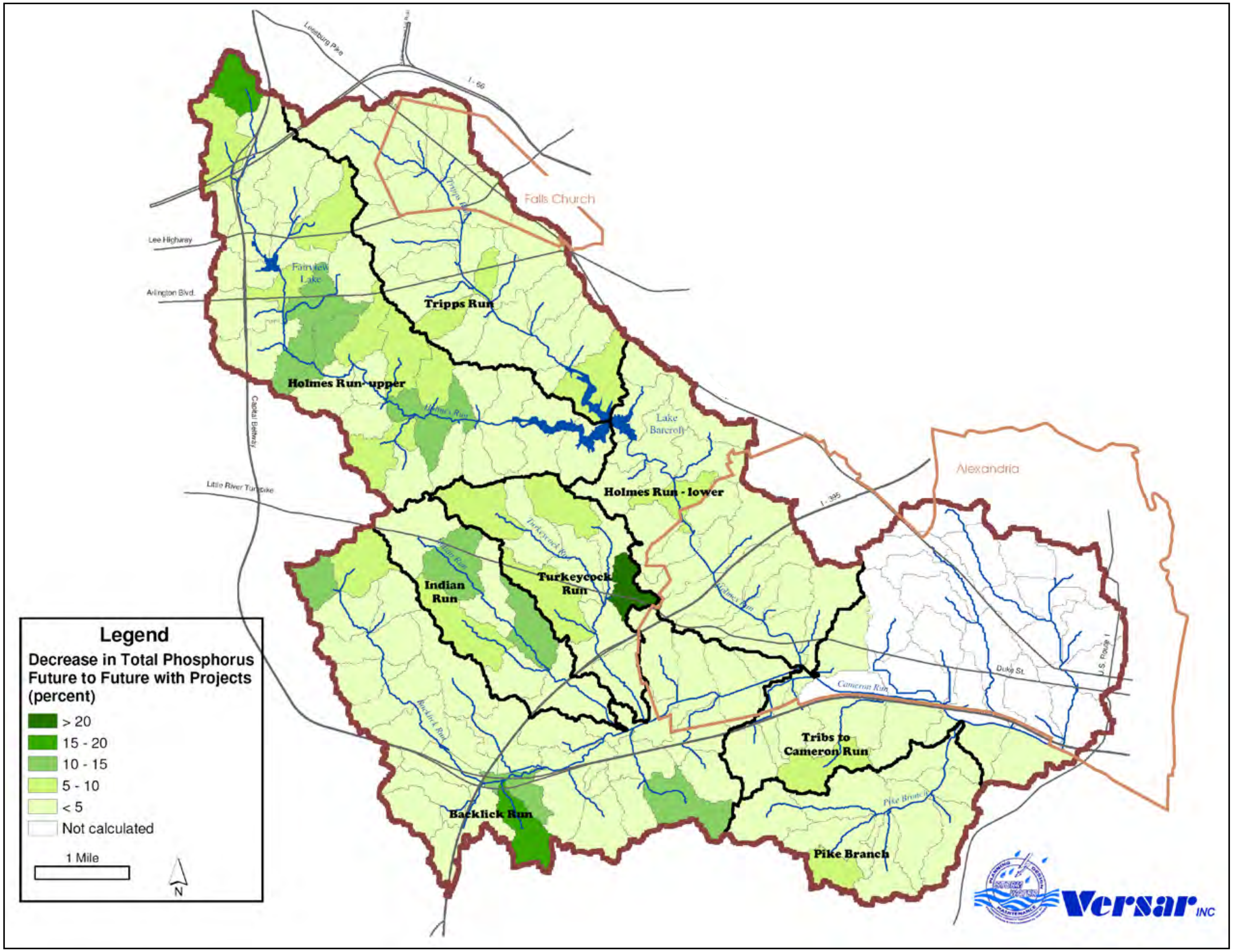

Figure 2-23. Average annual percent decrease in Total Phosphorus loadings in Cameron Run watershed based on simulation of rainfall-runoff events in 1996-1998 using SWMM simulating future landuse conditions with proposed projects

Table 2-8. Pollutant loadings (pounds/acre/year) for subbasins in Cameron Run watershed based SWMM modeling for 1996-1998 hydrologic conditions, for current land use conditions

Subwatershed	Subbasin	Area, Acres	Pollutant										
			TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
Backlick Run	BA1	100	8.31	1.08	0.76	46	263	146	0.008	0.037	0.181	0.0006	200
	BA2	218	11.92	1.43	1.01	78	442	259	0.016	0.095	0.420	0.0007	349
	BA3	170	11.01	1.22	0.85	82	378	294	0.019	0.087	0.472	0.0005	349
	BA4	165	7.78	0.94	0.67	48	244	166	0.010	0.035	0.206	0.0005	203
	BA5	198	13.08	1.57	1.11	85	496	283	0.017	0.107	0.455	0.0008	377
	BA6	229	10.51	1.33	0.93	62	376	202	0.012	0.066	0.264	0.0007	277
	BA7	194	11.76	1.27	0.88	89	395	305	0.023	0.110	0.649	0.0004	392
	BA8	160	8.36	0.89	0.65	66	294	225	0.016	0.068	0.374	0.0004	286
	BA9	129	8.56	1.05	0.74	50	269	173	0.010	0.047	0.228	0.0005	215
	BA10	248	9.57	1.13	0.81	61	342	204	0.012	0.072	0.292	0.0006	265
	BA11	163	15.26	1.62	1.13	117	519	433	0.028	0.138	0.779	0.0006	493
	BA12	134	7.28	0.76	0.53	57	244	209	0.015	0.072	0.439	0.0003	266
	BA13	219	4.38	0.50	0.40	30	146	92	0.006	0.024	0.145	0.0003	150
	BA14	200	10.23	1.16	0.84	67	317	243	0.014	0.069	0.394	0.0005	293
	BA15	244	14.26	1.43	0.99	121	471	407	0.033	0.150	0.941	0.0003	505
	BA16	290	10.44	1.20	0.84	69	326	252	0.015	0.070	0.412	0.0005	296
	BA17	116	9.71	1.05	0.73	76	322	273	0.018	0.060	0.370	0.0005	304
	BA18	184	9.15	1.08	0.76	55	291	216	0.011	0.066	0.336	0.0005	251
	BA19	242	12.86	1.38	0.97	100	434	366	0.024	0.090	0.520	0.0006	403
	BA20	163	10.82	1.27	0.89	72	346	250	0.015	0.052	0.315	0.0006	288
	BA21	146	11.42	1.34	0.94	79	383	265	0.017	0.059	0.331	0.0006	312
	BA22	143	14.08	1.50	1.05	106	483	408	0.025	0.119	0.637	0.0006	443
	BA23	112	18.57	1.86	1.29	158	615	518	0.044	0.203	1.289	0.0004	668
	BA24	219	12.15	1.33	0.92	92	441	322	0.022	0.116	0.604	0.0005	401
	BA25	227	7.71	0.94	0.68	44	232	153	0.009	0.039	0.205	0.0005	194
	BA26	161	8.97	1.10	0.77	56	277	182	0.011	0.034	0.207	0.0006	221
	BA27	245	7.89	0.98	0.68	45	226	158	0.009	0.040	0.209	0.0005	188
	BA28	132	7.44	0.94	0.66	39	206	135	0.008	0.040	0.196	0.0005	168
	BA29	168	5.54	0.72	0.51	26	131	89	0.005	0.019	0.112	0.0004	109
	BA30	125	10.21	1.20	0.85	59	313	247	0.011	0.074	0.400	0.0006	275
	BA31	215	10.77	1.24	0.87	67	387	261	0.014	0.103	0.443	0.0006	315

Table 2-8. (Continued)

Subwatershed	Subbasin	Area, Acres	Pollutant										
			TN	**TP**	**DP**	**BOD**	**COD**	**TSS**	**PB**	**CU**	**ZN**	**CD**	**TDS**
Holmes Run Lower	HR1	210	7.70	0.98	0.69	41	243	150	0.008	0.042	0.204	0.0006	206
	HR2	243	6.92	0.94	0.66	32	188	107	0.006	0.021	0.113	0.0005	154
	HR3	119	3.71	0.52	0.37	15	93	53	0.003	0.008	0.047	0.0003	93
	HR4	119	8.21	1.09	0.77	40	229	134	0.007	0.031	0.158	0.0006	184
	HR5	135	5.95	0.81	0.56	28	164	95	0.005	0.018	0.098	0.0005	145
	HR6	147	10.55	1.35	0.95	57	328	196	0.010	0.050	0.252	0.0007	254
	HR7	166	7.49	0.95	0.67	43	248	141	0.008	0.038	0.184	0.0005	192
	HR8	243	5.00	0.66	0.46	26	154	86	0.005	0.018	0.094	0.0004	130
	HR9	210	6.73	0.87	0.61	37	205	121	0.007	0.028	0.139	0.0005	166
	HR10	101	4.33	0.59	0.41	20	121	71	0.004	0.012	0.068	0.0004	119
	HR11	126	3.97	0.54	0.38	20	118	66	0.004	0.011	0.064	0.0003	110
	HR12	147	7.18	0.90	0.64	41	209	133	0.008	0.024	0.146	0.0005	171
	HR13	160	7.54	0.93	0.66	44	237	154	0.008	0.038	0.201	0.0005	195
	HR14	185	7.12	0.88	0.62	42	220	144	0.008	0.032	0.175	0.0005	186
	HR15	180	11.09	1.28	0.91	76	410	267	0.016	0.088	0.398	0.0006	335
	HR16	265	7.73	0.89	0.64	53	291	191	0.011	0.062	0.278	0.0005	250
	HR17	176	9.34	1.11	0.79	60	298	212	0.012	0.048	0.279	0.0006	255
	HR18	168	10.12	1.22	0.86	67	406	226	0.014	0.084	0.309	0.0008	307
	HR19	104	13.17	1.52	1.07	98	586	323	0.020	0.131	0.457	0.0008	420
Holmes Run Upper	HR21	211	9.53	1.17	0.82	60	301	202	0.013	0.041	0.237	0.0008	254
	HR22	261	8.59	1.07	0.75	51	259	172	0.011	0.034	0.202	0.0007	216
	HR23	265	7.66	0.98	0.69	39	193	134	0.008	0.029	0.169	0.0005	160
	HR24	117	6.98	0.91	0.63	33	162	112	0.007	0.024	0.141	0.0005	132
	HR25	110	9.79	1.19	0.84	58	306	212	0.012	0.062	0.306	0.0006	248
	HR26	246	7.09	0.87	0.61	43	219	147	0.009	0.030	0.179	0.0005	185
	HR27	105	9.79	1.20	0.85	61	309	203	0.012	0.039	0.235	0.0006	246
	HR28	129	9.72	1.18	0.83	57	287	205	0.011	0.048	0.277	0.0006	237
	HR29	196	9.18	1.11	0.79	55	279	196	0.011	0.045	0.259	0.0006	234
	HR30	156	10.71	1.29	0.91	68	335	236	0.014	0.053	0.307	0.0006	280
	HR31	109	9.63	1.16	0.82	62	309	209	0.012	0.041	0.249	0.0006	252
	HR32	114	7.24	0.89	0.65	44	224	142	0.009	0.028	0.167	0.0005	192

Table 2-8. (Continued)														
		Area,	**Pollutant**											
Subwatershed	**Subbasin**	**Acres**	**TN**	**TP**	**DP**	**BOD**	**COD**	**TSS**	**PB**	**CU**	**ZN**	**CD**	**TDS**
Holmes Run Upper (continued)	HR33	161	11.51	1.36	0.96	76	387	262	0.016	0.064	0.339	0.0007	312
	HR34	165	7.89	0.99	0.70	44	230	146	0.009	0.034	0.178	0.0005	186
	HR35	132	10.03	1.19	0.83	62	326	240	0.012	0.067	0.359	0.0006	279
	HR36	122	7.85	0.94	0.66	48	253	186	0.009	0.048	0.266	0.0005	225
	HR37	227	10.45	1.15	0.82	65	333	288	0.014	0.100	0.522	0.0005	325
	HR38	179	13.29	1.50	1.05	93	519	349	0.019	0.131	0.551	0.0007	417
	HR39	183	13.00	1.51	1.06	93	514	313	0.019	0.102	0.426	0.0008	387
	HR40	189	13.05	1.37	0.96	90	424	401	0.020	0.134	0.718	0.0006	423
	HR41	106	16.33	1.71	1.22	111	521	489	0.025	0.167	0.890	0.0007	517
	HR42	253	11.95	1.31	0.96	86	469	301	0.018	0.118	0.516	0.0007	409
	HR43	221	12.48	1.39	0.98	77	421	343	0.016	0.134	0.645	0.0006	378
	HR44	109	10.76	1.22	0.85	62	356	293	0.012	0.116	0.551	0.0006	317
	HR45	244	8.36	0.99	0.73	50	262	173	0.010	0.054	0.268	0.0005	225
	HR46	163	8.02	0.87	0.61	62	284	230	0.015	0.059	0.323	0.0005	282
	HR47	155	12.33	1.40	1.01	89	489	293	0.018	0.105	0.426	0.0007	383
	HR48	242	10.09	1.14	0.82	68	315	248	0.015	0.066	0.363	0.0005	288
	HR49	173	9.76	1.07	0.77	73	312	260	0.017	0.057	0.352	0.0005	298
	HR50	154	9.65	1.13	0.84	59	300	198	0.012	0.056	0.291	0.0006	265
	CW1	204	8.42	1.02	0.72	53	269	182	0.011	0.038	0.223	0.0005	227
Indian Run	262	10.36	1.17	0.83	72	354	260	0.016	0.076	0.384	0.0006	314	262
	192	8.52	1.02	0.73	44	240	191	0.008	0.062	0.331	0.0005	220	192
	199	7.50	0.94	0.66	42	213	147	0.009	0.037	0.193	0.0005	180	199
	230	8.13	1.00	0.70	46	241	170	0.010	0.050	0.247	0.0005	204	230
	282	13.52	1.52	1.07	92	434	348	0.020	0.100	0.529	0.0007	386	282
	157	11.14	1.28	0.93	66	327	249	0.014	0.085	0.459	0.0006	311	157
	264	7.50	0.96	0.68	38	194	134	0.007	0.031	0.176	0.0005	160	264
Pike Branch	190	10.38	1.19	0.85	67	376	235	0.014	0.088	0.373	0.0006	309	190
	114	10.16	1.20	0.84	67	406	230	0.013	0.093	0.340	0.0006	304	114
	181	11.43	1.35	0.98	74	448	244	0.014	0.102	0.372	0.0007	331	181
	270	9.92	1.18	0.85	59	308	218	0.011	0.062	0.323	0.0006	258	270
	198	10.21	1.24	0.88	64	319	215	0.013	0.043	0.260	0.0006	258	198
	274	8.68	1.05	0.74	53	268	185	0.011	0.042	0.250	0.0005	229	274
	248	12.10	1.42	1.00	81	421	279	0.017	0.083	0.408	0.0007	340	248

Table 2-8. (Continued)

Subwatershed	Subbasin	Area, Acres	Pollutant										
			TN	**TP**	**DP**	**BOD**	**COD**	**TSS**	**PB**	**CU**	**ZN**	**CD**	**TDS**
Pike Branch (cont'd)	PK8	218	10.22	1.25	0.88	63	316	211	0.012	0.042	0.254	0.0006	254
	PK9	123	7.48	0.89	0.65	45	232	165	0.009	0.041	0.232	0.0005	213
Tribs	CA1	202	13.60	1.50	1.05	109	625	361	0.024	0.154	0.563	0.0007	475
	CA2	169	14.28	1.53	1.06	110	481	392	0.027	0.118	0.691	0.0006	464
	CA5	215	9.45	1.12	0.78	59	287	215	0.012	0.050	0.291	0.0006	250
	CA8	249	6.29	0.76	0.54	35	187	128	0.007	0.036	0.176	0.0004	166
	CA9	207	9.41	1.10	0.77	53	286	231	0.010	0.076	0.394	0.0005	259
	CA11	125	10.70	1.30	0.91	68	340	231	0.015	0.056	0.319	0.0007	295
	CA12	192	7.55	0.89	0.65	50	245	170	0.010	0.037	0.219	0.0005	224
	CA13	138	10.45	1.24	0.88	67	311	229	0.015	0.054	0.325	0.0006	275
	CA14	211	9.41	1.25	0.88	45	260	154	0.008	0.037	0.188	0.0007	208
Tripps Run	TR0	271	8.87	1.08	0.76	54	280	190	0.012	0.049	0.252	0.0007	238
	TR1	185	10.50	1.27	0.89	65	326	229	0.013	0.053	0.300	0.0006	267
	TR2	174	8.07	1.00	0.71	43	221	162	0.008	0.043	0.237	0.0005	188
	TR3	173	9.19	1.14	0.80	54	272	182	0.011	0.039	0.224	0.0006	219
	TR4	216	7.11	0.90	0.63	37	188	135	0.007	0.033	0.185	0.0005	160
	TR5	137	9.19	1.14	0.80	55	272	183	0.011	0.035	0.213	0.0006	219
	TR6	177	11.18	1.35	0.94	70	378	244	0.015	0.080	0.346	0.0007	297
	TR7	148	9.32	1.12	0.79	60	318	213	0.012	0.058	0.282	0.0006	275
	TR8	157	12.81	1.51	1.06	85	444	296	0.017	0.084	0.406	0.0007	356
	TR9	199	11.93	1.43	1.00	79	383	266	0.016	0.052	0.318	0.0007	313
	TR10	125	13.23	1.48	1.04	92	427	341	0.021	0.090	0.508	0.0007	383
	TR11	119	11.17	1.33	0.94	74	355	247	0.015	0.048	0.295	0.0007	290
	TR12	267	11.77	1.37	0.97	80	395	278	0.017	0.068	0.366	0.0007	325
	TR13	164	10.21	1.28	0.90	55	329	205	0.010	0.066	0.302	0.0007	266
	TR14	161	9.17	1.15	0.81	54	294	183	0.011	0.049	0.241	0.0006	246
	TR15	162	5.11	0.67	0.46	28	159	100	0.005	0.020	0.112	0.0004	152
	TR16	271	4.37	0.57	0.39	25	142	90	0.005	0.016	0.094	0.0004	144
	TR17	167	9.79	1.17	0.83	58	321	225	0.012	0.071	0.353	0.0006	288
	TR18	254	6.06	0.76	0.53	36	189	123	0.007	0.023	0.137	0.0004	172
	TR19	179	9.01	1.09	0.78	56	276	189	0.011	0.038	0.229	0.0005	231

Table 2-8. (Continued)														
		Area,	**Pollutant**											
Subwatershed	**Subbasin**	**Acres**	**TN**	**TP**	**DP**	**BOD**	**COD**	**TSS**	**PB**	**CU**	**ZN**	**CD**	**TDS**
Turkeycock Run	TK1	183	5.94	0.67	0.50	44	269	131	0.009	0.064	0.243	0.0004	227
	TK2	198	10.02	1.17	0.82	70	372	236	0.015	0.078	0.323	0.0006	296
	TK3	268	10.1	1.20	0.84	64	316	228	0.014	0.066	0.337	0.00057	270
	TK3	268	10.09	1.20	0.84	64	316	228	0.014	0.066	0.337	0.0006	270
	TK4	183	7.21	0.87	0.61	42	203	156	0.009	0.037	0.212	0.0004	188
	TK5	209	7.52	0.94	0.66	45	251	148	0.009	0.042	0.183	0.0005	197
	TK6	234	4.15	0.50	0.35	25	135	93	0.005	0.020	0.113	0.0003	135
	TK7	119	13.80	1.56	1.11	105	661	345	0.022	0.168	0.526	0.0008	464
	TK8	135	7.19	0.87	0.64	37	193	136	0.007	0.038	0.198	0.0004	166

Table 2-9. Pollutant loadings (pounds/acre/year) for subbasins in Cameron Run watershed based SWMM modeling for 1996-1998 hydrologic conditions, for projected future land use conditions

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
Backlick Run	BA1	100	8.3	1.08	0.76	46	263	146	0.008	0.037	0.181	0.0006	200
	BA2	218	12.4	1.47	1.05	81	458	264	0.016	0.099	0.442	0.0007	366
	BA3	170	13.6	1.45	1.08	100	459	325	0.022	0.109	0.600	0.0006	447
	BA4	165	9.8	1.17	0.86	60	304	198	0.011	0.046	0.270	0.0006	259
	BA5	198	13.1	1.57	1.11	85	497	283	0.017	0.107	0.456	0.0008	377
	BA6	229	10.5	1.33	0.93	62	376	202	0.012	0.066	0.264	0.0007	277
	BA7	194	12.7	1.36	0.98	96	426	318	0.023	0.117	0.695	0.0005	428
	BA8	160	12.7	1.30	1.09	92	435	280	0.019	0.106	0.570	0.0005	444
	BA9	129	10.2	1.22	0.92	61	330	196	0.011	0.056	0.270	0.0006	265
	BA10	248	10.7	1.24	0.92	68	385	219	0.013	0.081	0.326	0.0006	301
	BA11	163	16.4	1.70	1.20	134	564	447	0.033	0.144	0.855	0.0006	549
	BA12	134	8.4	0.86	0.62	67	281	229	0.017	0.080	0.498	0.0003	309
	BA13	219	4.8	0.55	0.44	33	161	100	0.006	0.026	0.158	0.0003	164
	BA14	200	11.2	1.26	0.94	76	357	261	0.016	0.073	0.419	0.0006	329
	BA15	244	15.4	1.54	1.09	131	513	426	0.035	0.160	1.012	0.0003	558
	BA16	290	10.9	1.24	0.89	73	341	261	0.016	0.073	0.429	0.0006	312
	BA17	116	9.9	1.07	0.74	77	329	279	0.019	0.061	0.377	0.0005	310
	BA18	184	9.5	1.12	0.79	57	309	224	0.011	0.070	0.351	0.0006	267
	BA19	242	13.7	1.47	1.05	107	468	379	0.025	0.096	0.540	0.0006	427
	BA20	163	11.3	1.33	0.93	76	362	261	0.016	0.054	0.329	0.0006	301
	BA21	146	11.9	1.39	0.98	82	398	275	0.017	0.060	0.341	0.0007	324
	BA22	143	15.8	1.65	1.19	126	550	434	0.029	0.131	0.736	0.0006	521
	BA23	112	18.9	1.88	1.31	161	626	522	0.044	0.206	1.308	0.0004	681
	BA24	219	14.2	1.50	1.10	111	499	353	0.026	0.128	0.719	0.0005	486
	BA25	227	8.6	1.04	0.78	49	261	166	0.009	0.044	0.231	0.0005	219
	BA26	161	9.7	1.19	0.85	61	307	197	0.012	0.037	0.226	0.0006	246
	BA27	245	8.7	1.07	0.77	50	250	169	0.010	0.043	0.227	0.0005	207
	BA28	132	8.3	1.04	0.76	44	232	147	0.008	0.044	0.216	0.0005	189
	BA29	168	6.2	0.81	0.58	29	148	99	0.006	0.022	0.125	0.0004	122
	BA30	125	10.6	1.25	0.88	61	326	256	0.012	0.077	0.415	0.0006	285
	BA31	215	11.1	1.28	0.91	70	399	272	0.014	0.104	0.446	0.0006	324

Table 2-9. (Continued)

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	**TP**	**DP**	**BOD**	**COD**	**TSS**	**PB**	**CU**	**ZN**	**CD**	**TDS**
Holmes Run Lower	HR1	210	7.7	0.98	0.69	41	243	150	0.008	0.042	0.204	0.0006	206
	HR2	243	6.9	0.94	0.66	32	188	107	0.006	0.021	0.113	0.0005	154
	HR3	119	3.7	0.52	0.37	15	93	53	0.003	0.008	0.047	0.0003	93
	HR4	119	8.2	1.09	0.77	40	229	134	0.007	0.031	0.158	0.0006	184
	HR5	135	5.9	0.81	0.56	28	164	95	0.005	0.018	0.098	0.0005	145
	HR6	147	10.6	1.35	0.95	57	328	196	0.010	0.050	0.252	0.0007	254
	HR7	166	7.5	0.95	0.67	43	248	141	0.008	0.038	0.184	0.0005	192
	HR8	243	5.0	0.66	0.46	26	155	87	0.005	0.018	0.094	0.0004	131
	HR9	210	7.0	0.90	0.64	38	215	123	0.007	0.029	0.143	0.0005	173
	HR10	101	4.9	0.66	0.48	23	137	76	0.004	0.013	0.075	0.0004	132
	HR11	126	4.2	0.57	0.40	21	125	69	0.004	0.012	0.067	0.0004	116
	HR12	147	7.9	0.99	0.72	46	235	145	0.009	0.026	0.161	0.0005	193
	HR13	160	8.6	1.05	0.77	50	273	169	0.009	0.043	0.224	0.0005	226
	HR14	185	8.3	1.01	0.74	50	257	159	0.009	0.036	0.198	0.0005	216
	HR15	180	12.5	1.42	1.05	87	467	288	0.017	0.096	0.434	0.0007	379
	HR16	265	8.9	1.03	0.76	61	335	208	0.012	0.069	0.305	0.0005	281
	HR17	176	9.8	1.17	0.83	63	314	222	0.013	0.051	0.293	0.0006	268
	HR18	168	10.4	1.26	0.89	69	418	230	0.014	0.085	0.315	0.0009	315
	HR19	104	13.6	1.57	1.11	101	604	331	0.020	0.135	0.476	0.0008	437
Holmes Run Upper	HR21	211	9.9	1.20	0.85	62	312	207	0.014	0.042	0.244	0.0008	263
	HR22	261	8.9	1.11	0.78	53	267	177	0.011	0.035	0.208	0.0007	223
	HR23	265	8.1	1.03	0.74	42	207	142	0.008	0.031	0.180	0.0005	172
	HR24	117	7.5	0.98	0.70	37	179	122	0.007	0.026	0.155	0.0005	147
	HR25	110	10.4	1.26	0.90	62	329	224	0.012	0.066	0.325	0.0006	268
	HR26	246	7.5	0.93	0.65	46	234	157	0.009	0.032	0.190	0.0005	198
	HR27	105	10.5	1.28	0.91	65	331	215	0.013	0.041	0.250	0.0007	264
	HR28	129	10.2	1.25	0.88	60	303	215	0.012	0.051	0.291	0.0006	250
	HR29	196	10.0	1.21	0.88	61	308	210	0.012	0.049	0.283	0.0006	260
	HR30	156	11.4	1.36	0.98	73	362	249	0.014	0.055	0.326	0.0007	303
	HR31	109	10.2	1.23	0.88	66	327	221	0.013	0.044	0.264	0.0006	268

Table 2-9. (Continued)

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	**TP**	**DP**	**BOD**	**COD**	**TSS**	**PB**	**CU**	**ZN**	**CD**	**TDS**
Holmes Run Upper (continued)	HR32	114	8.0	0.97	0.73	49	253	154	0.009	0.030	0.184	0.0005	218
	HR33	161	11.9	1.40	0.99	79	400	272	0.016	0.066	0.349	0.0007	323
	HR34	165	8.7	1.08	0.79	50	262	159	0.009	0.037	0.197	0.0006	213
	HR35	132	10.5	1.24	0.87	64	341	250	0.013	0.071	0.376	0.0006	293
	HR36	122	8.3	0.99	0.70	51	268	195	0.010	0.051	0.280	0.0005	237
	HR37	227	11.4	1.26	0.92	71	364	303	0.014	0.105	0.550	0.0006	349
	HR38	179	13.8	1.55	1.10	98	543	354	0.021	0.135	0.574	0.0007	436
	HR39	183	13.4	1.56	1.10	96	532	323	0.020	0.107	0.441	0.0008	399
	HR40	189	13.9	1.45	1.06	95	448	407	0.021	0.136	0.731	0.0006	440
	HR41	106	17.4	1.77	1.26	139	576	499	0.035	0.168	0.995	0.0005	589
	HR42	253	12.0	1.32	0.97	87	476	302	0.018	0.119	0.517	0.0007	415
	HR43	221	12.6	1.40	0.99	79	430	348	0.016	0.135	0.650	0.0006	389
	HR44	109	10.8	1.22	0.86	63	359	293	0.012	0.116	0.551	0.0006	318
	HR45	244	9.3	1.09	0.82	56	298	192	0.011	0.061	0.305	0.0005	256
	HR46	163	8.0	0.87	0.61	62	289	227	0.015	0.061	0.323	0.0005	282
	HR47	155	12.9	1.46	1.08	94	518	303	0.019	0.110	0.447	0.0007	408
	HR48	242	11.6	1.30	0.98	80	376	280	0.017	0.077	0.428	0.0006	344
	HR49	173	11.2	1.23	0.90	83	357	288	0.019	0.067	0.404	0.0005	333
	HR50	154	11.0	1.26	0.99	71	349	216	0.014	0.057	0.307	0.0006	304
	CW1	204	9.1	1.10	0.79	58	292	196	0.011	0.040	0.240	0.0006	247
Indian Run	IR1	262	11.4	1.28	0.93	80	390	281	0.017	0.082	0.417	0.0006	343
	IR2	192	9.1	1.09	0.78	47	256	202	0.009	0.066	0.352	0.0005	234
	IR3	199	9.0	1.11	0.81	50	254	169	0.010	0.045	0.232	0.0006	210
	IR4	230	9.1	1.11	0.79	51	271	186	0.010	0.056	0.274	0.0005	227
	IR5	282	14.2	1.58	1.13	101	464	366	0.022	0.100	0.541	0.0007	413
	PR1	157	12.0	1.35	1.01	78	359	263	0.017	0.090	0.514	0.0005	349
	PR2	264	8.3	1.05	0.75	42	213	146	0.008	0.034	0.192	0.0005	175
Pike Branch	PK1	190	11.4	1.31	0.96	74	416	251	0.015	0.095	0.403	0.0007	340
	PK2	114	11.8	1.36	1.03	80	487	258	0.015	0.105	0.391	0.0007	370
	PK3	181	12.2	1.42	1.06	79	483	256	0.015	0.109	0.397	0.0007	360
	PK4	270	10.9	1.29	0.95	66	348	237	0.012	0.068	0.358	0.0006	293
	PK5	198	11.4	1.38	1.00	72	361	236	0.014	0.048	0.289	0.0007	293

Table 2-9. (Continued)

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
Pike Branch (continued)	PK6	274	9.9	1.18	0.86	61	309	209	0.012	0.050	0.293	0.0006	263
	PK7	248	12.7	1.48	1.06	85	443	290	0.018	0.086	0.425	0.0007	358
	PK8	218	11.4	1.37	1.00	71	358	231	0.014	0.047	0.283	0.0007	290
	PK9	123	8.4	0.98	0.74	51	262	177	0.010	0.045	0.256	0.0005	240
Tribs	CA1	202	14.2	1.56	1.12	114	660	368	0.025	0.161	0.584	0.0008	499
	CA2	169	16.9	1.82	1.27	126	562	464	0.030	0.145	0.825	0.0007	529
	CA5	215	11.2	1.31	0.97	72	357	248	0.014	0.059	0.342	0.0006	310
	CA8	249	8.6	1.03	0.77	50	265	161	0.009	0.044	0.222	0.0005	221
	CA9	207	10.4	1.21	0.87	59	317	247	0.011	0.081	0.423	0.0006	284
	CA11	125	10.7	1.30	0.91	68	341	231	0.015	0.056	0.320	0.0007	297
	CA12	192	11.1	1.29	1.03	71	355	215	0.013	0.052	0.305	0.0006	312
	CA13	138	11.3	1.33	0.98	74	348	242	0.016	0.058	0.351	0.0006	309
	CA14	211	9.4	1.24	0.87	45	260	153	0.008	0.037	0.187	0.0007	207
Tripps Run	TR0	271	9.1	1.10	0.78	55	286	194	0.012	0.050	0.259	0.0007	245
	TR1	185	10.7	1.29	0.91	67	336	233	0.014	0.055	0.306	0.0006	275
	TR2	174	9.0	1.10	0.81	49	256	177	0.009	0.048	0.263	0.0005	219
	TR3	173	9.8	1.21	0.87	57	291	190	0.011	0.041	0.236	0.0006	234
	TR4	216	7.7	0.98	0.70	40	205	145	0.008	0.036	0.200	0.0005	174
	TR5	137	10.1	1.25	0.89	60	298	197	0.012	0.038	0.232	0.0006	239
	TR6	177	11.8	1.40	1.01	76	403	252	0.016	0.082	0.354	0.0007	317
	TR7	148	10.5	1.24	0.90	70	359	230	0.014	0.061	0.303	0.0006	312
	TR8	157	13.4	1.58	1.13	89	464	305	0.018	0.087	0.423	0.0008	373
	TR9	199	12.4	1.48	1.05	82	401	276	0.017	0.055	0.335	0.0007	327
	TR10	125	13.8	1.55	1.10	96	446	349	0.021	0.091	0.514	0.0007	395
	TR11	119	11.9	1.43	1.01	80	384	262	0.016	0.051	0.315	0.0007	314
	TR12	267	12.2	1.41	1.01	84	410	286	0.018	0.070	0.376	0.0007	341
	TR13	164	10.7	1.33	0.96	59	347	207	0.010	0.069	0.315	0.0007	284
	TR14	161	9.4	1.16	0.83	55	303	185	0.011	0.050	0.246	0.0006	253
	TR15	162	5.3	0.68	0.48	29	165	102	0.005	0.021	0.114	0.0004	156
	TR16	271	4.6	0.60	0.43	27	151	94	0.005	0.017	0.099	0.0004	152
	TR17	167	10.3	1.22	0.89	63	347	230	0.012	0.074	0.363	0.0006	309
	TR18	254	6.8	0.84	0.60	41	215	138	0.008	0.028	0.165	0.0005	195

Table 2-9. (Continued)

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	**TP**	**DP**	**BOD**	**COD**	**TSS**	**PB**	**CU**	**ZN**	**CD**	**TDS**
Tripps Run	TR19	179	10.4	1.24	0.92	65	321	214	0.013	0.046	0.275	0.0006	269
Turkeycock Run	TK1	183	10.0	1.12	0.96	67	395	171	0.012	0.078	0.317	0.0005	327
	TK2	198	11.1	1.30	0.93	77	410	254	0.016	0.085	0.350	0.0006	320
	TK3	268	11.1	1.32	0.94	70	345	244	0.015	0.071	0.360	0.0006	290
	TK4	183	8.2	0.99	0.72	48	231	170	0.010	0.041	0.234	0.0005	211
	TK5	209	8.5	1.06	0.76	51	294	164	0.010	0.050	0.205	0.0006	222
	TK6	234	7.0	0.81	0.59	40	220	170	0.008	0.054	0.286	0.0004	210
	TK7	119	14.2	1.60	1.15	108	684	353	0.022	0.173	0.539	0.0008	480
	TK8	135	8.2	0.99	0.76	44	229	155	0.008	0.044	0.230	0.0005	196
	TK9	197	9.2	1.12	0.82	51	261	181	0.010	0.048	0.260	0.0005	220

Table 2-10. Pollutant loadings (pounds/acre/year) for subbasins in Cameron Run watershed based SWMM modeling for 1996-1998 hydrologic conditions, for projected future with projects land use conditions

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
Backlick Run	BA1	100	8.3	1.08	0.76	46	263	146	0.008	0.037	0.181	0.0006	200
	BA2	218	12.4	1.47	1.05	81	458	264	0.016	0.099	0.442	0.0007	366
	BA3	170	13.6	1.45	1.09	100	460	326	0.022	0.109	0.600	0.0006	447
	BA4	165	9.6	1.14	0.85	59	299	189	0.011	0.044	0.256	0.0006	256
	BA5	198	13.1	1.58	1.11	85	497	283	0.017	0.108	0.456	0.0008	377
	BA6	229	10.5	1.33	0.93	63	376	202	0.012	0.066	0.264	0.0007	277
	BA7	194	12.8	1.37	0.98	97	430	321	0.024	0.118	0.702	0.0005	432
	BA8	160	12.7	1.31	1.09	92	436	280	0.019	0.106	0.570	0.0005	445
	BA9	129	10.2	1.23	0.92	61	330	196	0.011	0.056	0.270	0.0006	266
	BA10	248	9.6	1.08	0.93	61	353	156	0.009	0.068	0.272	0.0005	301
	BA11	163	16.4	1.71	1.20	134	564	448	0.034	0.145	0.856	0.0006	550
	BA12	134	8.4	0.86	0.62	68	282	229	0.017	0.080	0.498	0.0003	310
	BA13	219	4.8	0.54	0.45	32	160	97	0.006	0.026	0.156	0.0003	163
	BA14	200	11.0	1.23	0.92	75	349	256	0.016	0.071	0.408	0.0005	321
	BA15	244	15.4	1.54	1.09	131	513	426	0.035	0.161	1.015	0.0003	558
	BA16	290	10.8	1.23	0.88	72	339	257	0.016	0.072	0.424	0.0005	310
	BA17	116	9.0	0.93	0.76	72	306	224	0.015	0.055	0.337	0.0004	311
	BA18	184	7.7	0.92	0.66	49	256	169	0.010	0.047	0.233	0.0005	211
	BA19	242	13.9	1.49	1.06	108	475	386	0.025	0.097	0.547	0.0006	431
	BA20	163	10.9	1.27	0.93	73	350	242	0.015	0.051	0.309	0.0006	297
	BA21	146	11.9	1.39	0.98	82	398	276	0.017	0.060	0.341	0.0007	325
	BA22	143	15.5	1.62	1.16	125	542	424	0.029	0.126	0.713	0.0006	512
	BA23	112	18.9	1.89	1.32	161	626	523	0.044	0.207	1.308	0.0004	681
	BA24	219	13.8	1.46	1.07	108	498	339	0.025	0.129	0.701	0.0005	477
	BA25	227	8.4	1.02	0.76	48	254	162	0.009	0.043	0.226	0.0005	214
	BA26	161	9.7	1.19	0.86	61	308	197	0.012	0.037	0.226	0.0006	247
	BA27	245	8.3	1.02	0.74	48	239	164	0.010	0.041	0.221	0.0005	200
	BA28	132	8.2	1.03	0.75	43	228	144	0.008	0.043	0.210	0.0005	186
	BA29	168	6.1	0.80	0.57	29	147	98	0.006	0.022	0.124	0.0004	121
	BA30	125	8.9	1.06	0.75	53	274	204	0.010	0.055	0.305	0.0005	231
	BA31	215	10.4	1.17	0.91	66	371	229	0.012	0.089	0.401	0.0006	325

Table 2-10. Pollutant loadings (pounds/acre/year) for subbasins in Cameron Run watershed based SWMM modeling for 1996-1998 hydrologic conditions, for projected future with projects land use conditions

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
Holmes Run Lower	HR1	210	7.7	0.98	0.69	41	243	150	0.008	0.042	0.204	0.0006	206
	HR2	243	6.9	0.94	0.66	32	188	107	0.006	0.021	0.113	0.0005	154
	HR3	119	3.7	0.52	0.37	15	93	53	0.003	0.008	0.047	0.0003	93
	HR4	119	8.2	1.09	0.77	40	229	134	0.007	0.031	0.158	0.0006	184
	HR5	135	5.9	0.81	0.56	28	164	95	0.005	0.018	0.098	0.0005	145
	HR6	147	10.6	1.35	0.95	57	328	196	0.010	0.050	0.252	0.0007	254
	HR7	166	7.5	0.95	0.67	43	248	141	0.008	0.038	0.184	0.0005	192
	HR8	243	5.0	0.66	0.46	26	155	87	0.005	0.018	0.094	0.0004	131
	HR9	210	7.0	0.90	0.64	38	215	123	0.007	0.029	0.143	0.0005	173
	HR10	101	4.9	0.66	0.48	23	137	76	0.004	0.013	0.075	0.0004	132
	HR11	126	4.2	0.57	0.40	21	125	69	0.004	0.012	0.067	0.0004	116
	HR12	147	7.4	0.92	0.66	42	217	133	0.008	0.024	0.148	0.0005	179
	HR13	160	8.6	1.05	0.77	50	274	169	0.009	0.043	0.224	0.0005	226
	HR14	185	8.1	1.00	0.73	49	254	156	0.009	0.034	0.192	0.0005	213
	HR15	180	12.5	1.42	1.05	87	467	288	0.017	0.096	0.434	0.0007	379
	HR16	265	8.6	0.99	0.73	59	321	200	0.012	0.065	0.292	0.0005	271
	HR17	176	9.4	1.12	0.80	60	301	212	0.012	0.048	0.278	0.0006	256
	HR18	168	10.3	1.24	0.88	69	413	224	0.014	0.083	0.302	0.0009	309
	HR19	104	13.4	1.54	1.10	101	598	325	0.020	0.133	0.464	0.0008	431
Holmes Run Upper	HR21	211	9.9	1.21	0.85	62	312	207	0.014	0.042	0.244	0.0008	263
	HR22	261	8.7	1.09	0.77	52	263	173	0.011	0.033	0.200	0.0007	219
	HR23	265	7.8	1.00	0.71	40	199	135	0.008	0.029	0.169	0.0005	165
	HR24	117	7.3	0.96	0.68	36	174	119	0.007	0.026	0.151	0.0005	143
	HR25	110	10.0	1.21	0.86	60	318	216	0.012	0.063	0.314	0.0006	260
	HR26	246	6.7	0.82	0.58	40	207	137	0.008	0.028	0.167	0.0004	176
	HR27	105	10.1	1.22	0.88	63	319	205	0.012	0.040	0.240	0.0006	256
	HR28	129	9.6	1.18	0.83	57	284	200	0.011	0.045	0.263	0.0006	234
	HR29	196	9.5	1.14	0.83	57	291	197	0.011	0.045	0.260	0.0006	244
	HR30	156	11.1	1.32	0.96	71	352	242	0.014	0.054	0.316	0.0006	294
	HR31	109	9.9	1.19	0.85	63	318	214	0.013	0.042	0.255	0.0006	260

Table 2-10. (Continued)

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	**TP**	**DP**	**BOD**	**COD**	**TSS**	**PB**	**CU**	**ZN**	**CD**	**TDS**
Holmes Run Upper (continued)	HR32	114	7.8	0.94	0.71	48	245	150	0.009	0.029	0.179	0.0005	212
	HR33	161	11.3	1.33	0.93	75	380	255	0.016	0.060	0.321	0.0007	304
	HR34	165	8.4	1.05	0.77	48	255	155	0.009	0.036	0.191	0.0006	207
	HR35	132	9.3	1.10	0.78	58	305	217	0.011	0.058	0.309	0.0006	258
	HR36	122	7.1	0.85	0.60	44	229	162	0.009	0.040	0.221	0.0005	202
	HR37	227	10.9	1.20	0.88	68	345	287	0.014	0.098	0.520	0.0005	333
	HR38	179	12.0	1.35	0.96	88	484	301	0.019	0.113	0.465	0.0007	378
	HR39	183	12.7	1.48	1.04	92	507	306	0.019	0.100	0.410	0.0007	380
	HR40	189	13.5	1.41	1.03	92	435	395	0.020	0.133	0.711	0.0006	427
	HR41	106	16.4	1.66	1.18	133	545	468	0.034	0.155	0.929	0.0005	557
	HR42	253	11.5	1.26	0.93	84	461	288	0.018	0.114	0.490	0.0007	398
	HR43	221	11.8	1.31	0.93	74	404	323	0.015	0.126	0.601	0.0006	360
	HR44	109	10.5	1.18	0.83	61	350	285	0.012	0.113	0.536	0.0005	310
	HR45	244	9.0	1.06	0.80	54	288	183	0.010	0.058	0.288	0.0005	244
	HR46	163	8.2	0.88	0.62	63	287	229	0.015	0.062	0.330	0.0005	274
	HR47	155	12.5	1.41	1.04	91	502	294	0.019	0.106	0.434	0.0007	396
	HR48	242	11.0	1.23	0.93	77	358	263	0.016	0.072	0.396	0.0005	326
	HR49	173	10.9	1.19	0.88	80	346	280	0.018	0.065	0.392	0.0005	323
	HR50	154	9.4	1.02	0.95	61	310	141	0.009	0.046	0.244	0.0005	294
	CW1	204	8.3	1.00	0.72	52	266	178	0.010	0.037	0.221	0.0005	226
Indian Run	IR1	262	11.3	1.26	0.91	79	383	277	0.017	0.079	0.407	0.0006	338
	IR2	192	7.7	0.93	0.67	40	214	162	0.008	0.050	0.268	0.0005	193
	IR3	199	8.9	1.11	0.80	49	252	168	0.010	0.044	0.230	0.0005	208
	IR4	230	7.8	0.97	0.70	43	226	153	0.008	0.045	0.222	0.0005	189
	IR5	282	13.9	1.54	1.11	99	456	356	0.022	0.097	0.524	0.0007	405
	PR1	157	11.8	1.33	0.99	76	352	259	0.017	0.088	0.504	0.0005	342
	PR2	264	7.8	0.99	0.71	39	200	135	0.008	0.030	0.172	0.0005	163
Pike Branch	PK1	190	11.2	1.28	0.95	73	408	244	0.014	0.093	0.391	0.0006	332
	PK2	114	11.7	1.35	1.02	80	483	256	0.015	0.105	0.389	0.0007	367
	PK3	181	11.9	1.39	1.04	78	474	249	0.015	0.106	0.381	0.0007	352

Table 2-10. (Continued)

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
	PK4	270	10.9	1.28	0.94	65	346	236	0.012	0.068	0.354	0.0006	291
	PK5	198	11.3	1.37	0.99	71	358	233	0.014	0.047	0.285	0.0007	290
Pike Branch (continued)	PK6	274	9.5	1.13	0.82	59	297	201	0.012	0.048	0.283	0.0006	252
	PK7	248	12.6	1.47	1.05	84	439	286	0.017	0.085	0.420	0.0007	354
	PK8	218	11.3	1.36	0.99	70	355	229	0.013	0.047	0.280	0.0007	287
	PK9	123	7.9	0.92	0.70	48	244	164	0.009	0.041	0.233	0.0005	220
Tribs	CA1	202	13.7	1.49	1.11	111	641	337	0.023	0.152	0.556	0.0007	501
	CA2	169	17.0	1.82	1.27	127	565	467	0.031	0.146	0.832	0.0007	532
	CA5	215	11.2	1.31	0.97	72	354	248	0.014	0.059	0.342	0.0006	310
	CA8	249	8.6	1.03	0.77	49	264	160	0.009	0.043	0.220	0.0005	221
	CA9	207	9.6	1.12	0.81	54	294	224	0.010	0.072	0.376	0.0005	261
	CA11	125	10.8	1.30	0.91	68	342	232	0.015	0.056	0.321	0.0007	298
	CA12	192	11.0	1.28	1.02	70	352	211	0.013	0.050	0.295	0.0006	309
	CA13	138	11.3	1.33	0.98	74	348	243	0.016	0.058	0.352	0.0006	309
	CA14	211	9.4	1.25	0.88	45	260	154	0.008	0.037	0.188	0.0007	208
Tripps Run	TR0	271	8.3	1.02	0.72	51	264	172	0.011	0.041	0.215	0.0007	223
	TR1	185	10.2	1.23	0.87	64	320	220	0.013	0.051	0.283	0.0006	260
	TR2	174	9.0	1.10	0.80	49	253	176	0.009	0.047	0.261	0.0005	217
	TR3	173	9.6	1.19	0.86	56	285	183	0.011	0.039	0.227	0.0006	231
	TR4	216	7.5	0.95	0.68	38	197	137	0.008	0.033	0.185	0.0005	167
	TR5	137	10.0	1.24	0.89	60	296	195	0.012	0.038	0.231	0.0006	238
	TR6	177	11.6	1.38	1.00	75	397	246	0.015	0.079	0.346	0.0007	315
	TR7	148	10.5	1.24	0.90	70	358	229	0.014	0.060	0.302	0.0006	311
	TR8	157	12.6	1.47	1.09	85	441	274	0.016	0.079	0.380	0.0007	358
	TR9	199	12.4	1.47	1.04	82	397	275	0.017	0.055	0.334	0.0007	326
	TR10	125	13.3	1.47	1.10	92	430	321	0.019	0.085	0.488	0.0007	392
	TR11	119	11.9	1.42	1.01	79	383	261	0.016	0.051	0.314	0.0007	313
	TR12	267	11.9	1.38	0.99	81	393	277	0.017	0.064	0.360	0.0007	329
	TR13	164	10.6	1.30	0.96	58	343	203	0.010	0.068	0.311	0.0007	283
	TR14	161	9.3	1.16	0.82	55	301	184	0.011	0.049	0.245	0.0006	252
	TR15	162	5.2	0.68	0.48	29	164	101	0.005	0.020	0.114	0.0004	156
	TR16	271	4.6	0.60	0.42	27	150	93	0.005	0.017	0.098	0.0004	151

Table 2-10. (Continued)

Subwatershed	Subbasin	Area, acres	Pollutant										
			TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
	TR17	167	10.3	1.22	0.89	63	346	229	0.012	0.074	0.362	0.0006	308
	TR18	254	6.7	0.83	0.60	40	214	138	0.008	0.028	0.164	0.0005	194
Tripps Run	TR19	179	10.2	1.22	0.90	64	316	209	0.013	0.045	0.268	0.0006	264
Turkeycock Run	TK1	183	9.8	1.10	0.94	66	386	167	0.011	0.077	0.310	0.0005	320
	TK2	198	10.8	1.26	0.92	75	394	243	0.016	0.079	0.337	0.0006	314
	TK3	268	10.7	1.25	0.92	67	323	225	0.014	0.063	0.339	0.0006	281
	TK4	183	7.9	0.96	0.71	47	225	161	0.010	0.039	0.222	0.0005	207
	TK5	209	8.4	1.05	0.75	50	289	161	0.010	0.049	0.202	0.0006	218
	TK6	234	6.5	0.75	0.55	37	204	158	0.007	0.051	0.269	0.0004	195
	TK7	119	10.6	1.17	0.84	78	454	264	0.017	0.112	0.405	0.0006	341
	TK8	135	7.9	0.95	0.73	42	214	146	0.008	0.039	0.214	0.0005	184
	TK9	197	8.4	1.03	0.76	47	238	159	0.009	0.038	0.213	0.0005	197

Table 2-11. Pollutant loadings (pounds/acre/year) in Cameron Run watershed based on SWMM modeling for 1996-1998 hydrologic conditions, for current, projected future, and projected future with projects land use conditions

Subwatershed	TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
	Current land use										
Backlick Run	10.1	1.14	0.81	70	332	250	0.016	0.075	0.419	0.00050	302
Holmes Run Lower	8.9	1.06	0.75	58	319	201	0.012	0.061	0.274	0.00058	258
Holmes Run Upper	10.0	1.16	0.83	64	327	236	0.013	0.068	0.350	0.00059	282
Indian Run	9.6	1.14	0.81	58	291	218	0.012	0.063	0.332	0.00054	257
Pike Branch	10.1	1.21	0.86	64	342	222	0.013	0.065	0.314	0.00061	277
Tribs	9.9	1.16	0.82	64	329	229	0.014	0.068	0.343	0.00058	284
Tripps Run	10.1	1.22	0.86	64	320	222	0.013	0.054	0.293	0.00062	265
Turkeycock Run	8.0	0.95	0.68	51	277	176	0.011	0.057	0.253	0.00049	229
Weighted Average	9.8	1.14	0.81	64	321	227	0.014	0.066	0.341	0.00056	276
	Projected future land use										
Backlick Run	11.1	1.25	0.90	78	366	265	0.017	0.082	0.459	0.00053	337
Holmes Run Lower	9.8	1.16	0.84	64	352	215	0.013	0.065	0.295	0.00062	283
Holmes Run Upper	10.6	1.23	0.89	69	350	247	0.014	0.072	0.370	0.00061	302
Indian Run	10.5	1.23	0.89	65	320	234	0.014	0.068	0.359	0.00057	281
Pike Branch	11.2	1.32	0.97	71	381	240	0.014	0.071	0.345	0.00066	310
Tribs	11.4	1.33	0.97	74	381	254	0.015	0.076	0.387	0.00064	325
Tripps Run	10.8	1.29	0.92	68	342	233	0.014	0.057	0.309	0.00065	284
Turkeycock Run	9.6	1.13	0.84	60	327	203	0.012	0.067	0.303	0.00056	268
Weighted Average	10.7	1.24	0.90	70	354	243	0.015	0.071	0.371	0.00060	305
	Percentage change, current to future land use										
Backlick Run	10.0	8.9	11.9	11.1	10.4	6.3	8.8	8.6	9.5	5.2	11.7
Holmes Run Lower	10.0	9.6	12.4	10.1	10.2	6.7	6.9	7.3	7.7	7.2	9.9
Holmes Run Upper	6.3	5.7	7.5	7.6	7.1	4.7	6.7	4.9	5.7	3.8	7.1
Indian Run	9.3	8.6	10.5	11.6	9.9	7.6	11.4	6.6	8.2	5.7	9.5
Pike Branch	10.1	9.2	12.3	11.2	11.6	8.1	8.0	9.5	9.9	7.5	11.9
Tribs	14.9	14.0	18.1	14.8	15.6	11.0	9.9	12.4	12.9	10.6	14.4
Tripps Run	6.4	5.8	7.6	7.1	6.8	4.7	5.2	5.2	5.5	4.4	7.0
Turkeycock Run	19.7	19.0	23.9	18.0	18.3	15.1	12.7	18.2	19.6	13.6	17.0
Weighted Average	9.6	8.8	11.5	10.5	10.2	6.9	8.2	8.1	8.8	6.2	10.3
	Projected future with projects land use										
Backlick Run	10.8	1.21	0.89	77	357	253	0.017	0.078	0.442	0.00050	332
Holmes Run Lower	9.6	1.13	0.82	63	344	209	0.012	0.063	0.286	0.00061	277
Holmes Run Upper	10.0	1.16	0.85	65	332	231	0.013	0.067	0.345	0.00058	287
Indian Run	10.0	1.17	0.85	62	303	220	0.013	0.062	0.332	0.00055	266
Pike Branch	11.0	1.29	0.95	70	375	235	0.014	0.069	0.336	0.00064	304
Tribs	11.2	1.31	0.96	73	375	247	0.015	0.074	0.377	0.00063	322
Tripps Run	10.5	1.25	0.91	66	332	223	0.013	0.054	0.293	0.00063	277
Turkeycock Run	9.0	1.06	0.79	56	298	186	0.011	0.059	0.278	0.00052	249
Weighted Average	10.3	1.20	0.88	68	341	231	0.014	0.067	0.352	0.00057	295

Table 2-11. (Continued)

	TN	TP	DP	BOD	COD	TSS	PB	CU	ZN	CD	TDS
Subwatershed	**Percentage change, future to future with projects land use**										
Backlick Run	-2.7	-3.2	-1.5	-2.2	-2.4	-4.7	-3.5	-4.3	-3.7	-4.2	-1.6
Holmes Run Lower	-2.3	-2.3	-2.2	-2.1	-2.1	-2.6	-2.2	-2.7	-3.1	-1.9	-2.2
Holmes Run Upper	-5.3	-5.3	-4.8	-4.9	-5.0	-6.3	-5.3	-6.7	-6.8	-5.3	-5.1
Indian Run	-5.2	-5.1	-4.9	-4.9	-5.4	-6.2	-4.7	-8.0	-7.5	-5.1	-5.5
Pike Branch	-1.8	-1.8	-1.8	-1.6	-1.7	-2.0	-1.6	-2.2	-2.4	-1.9	-2.0
Tribs	-1.3	-1.4	-0.7	-1.3	-1.4	-2.6	-2.1	-3.0	-2.5	-1.5	-0.8
Tripps Run	-2.7	-2.8	-2.0	-2.8	-2.9	-4.3	-3.4	-6.0	-5.0	-2.8	-2.6
Turkeycock Run	-6.3	-6.5	-5.5	-7.1	-9.0	-8.3	-7.8	-12.2	-8.3	-7.4	-7.1
Weighted Average	-3.6	-3.8	-3.0	-3.3	-3.7	-4.9	-4.0	-5.6	-5.0	-4.0	-3.3

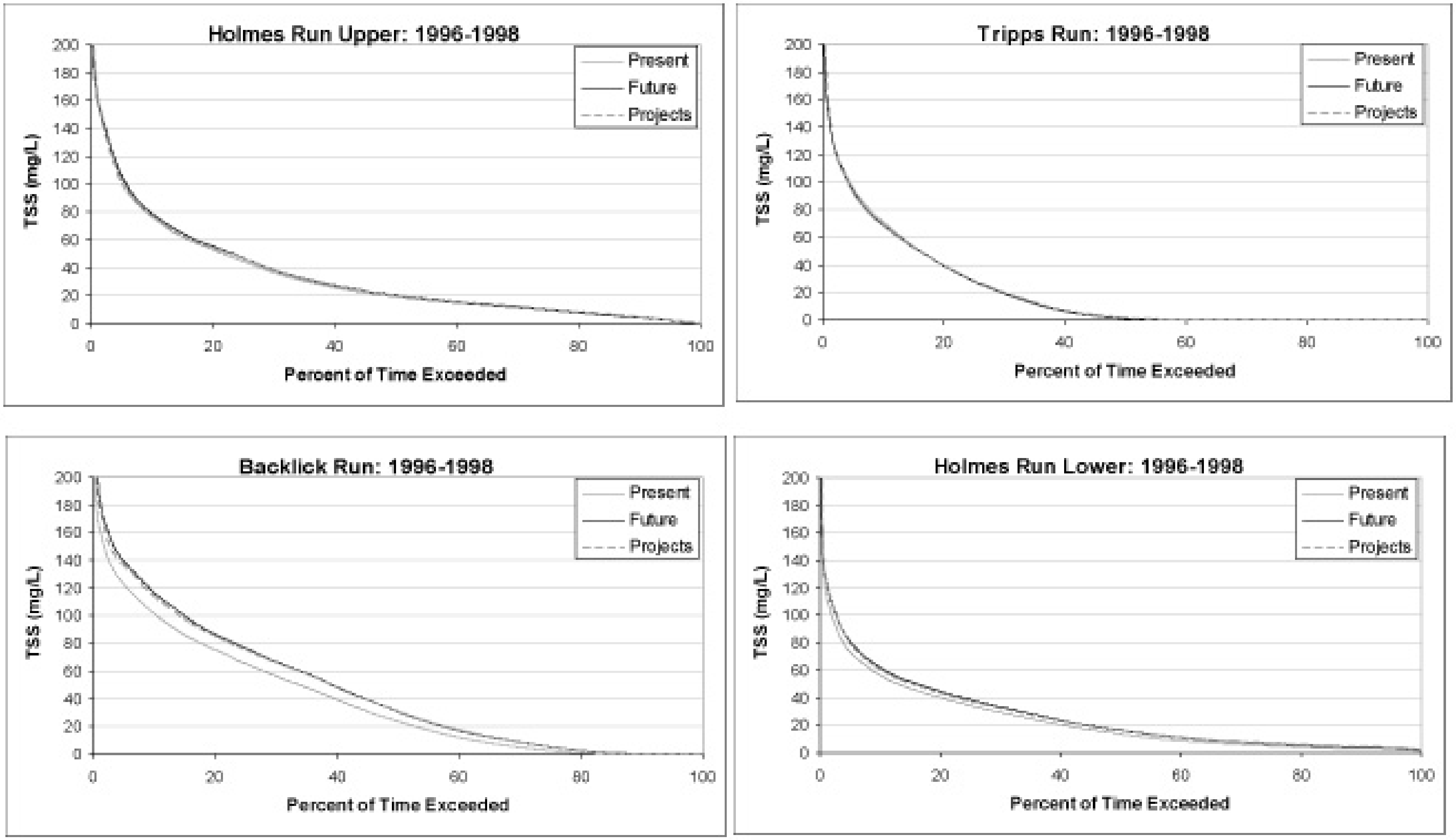

Figure 2-24. Total Suspended Solids exceedance curves for subwatersheds in Cameron Run

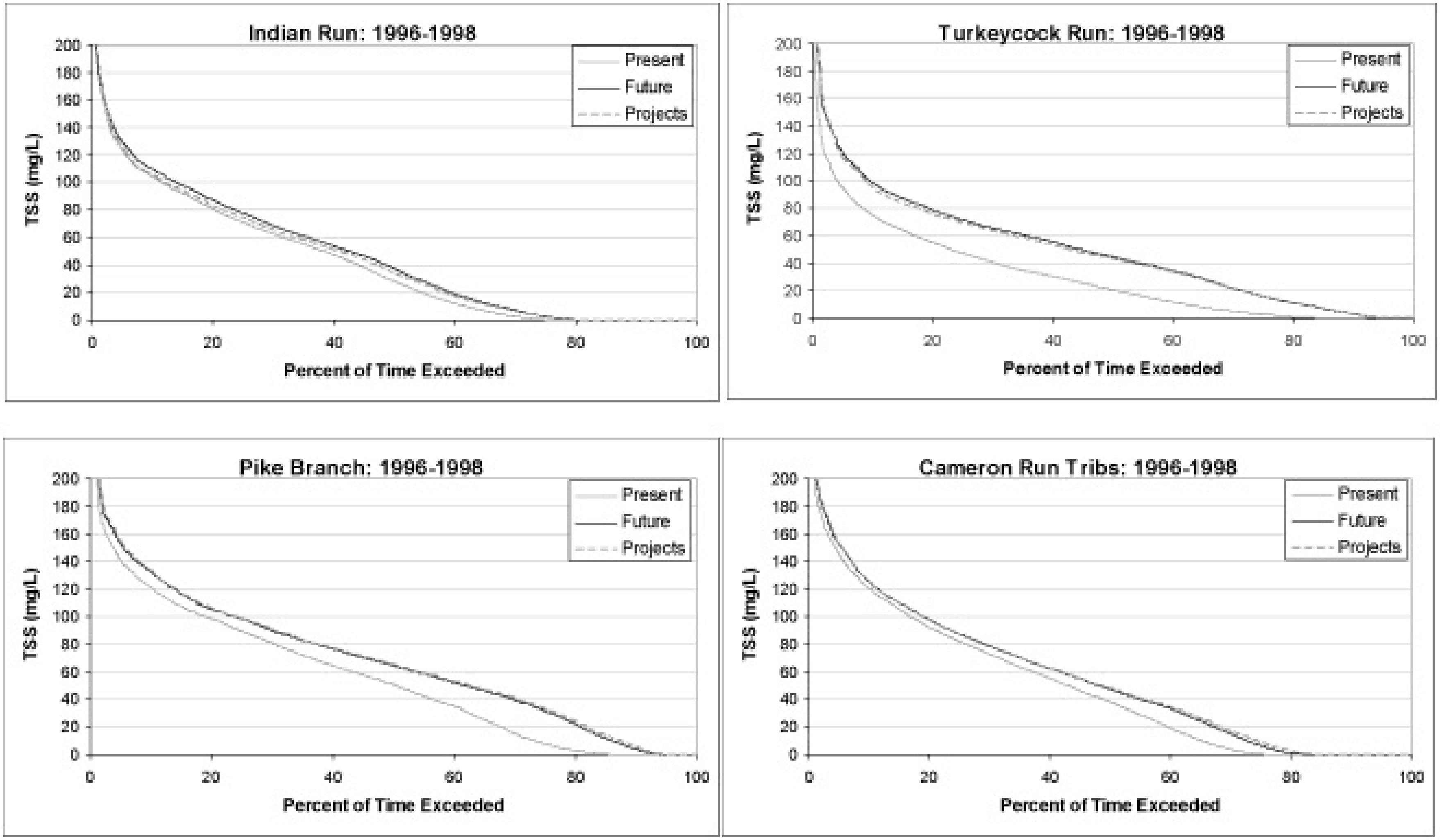

Figure 2-24. (Continued)

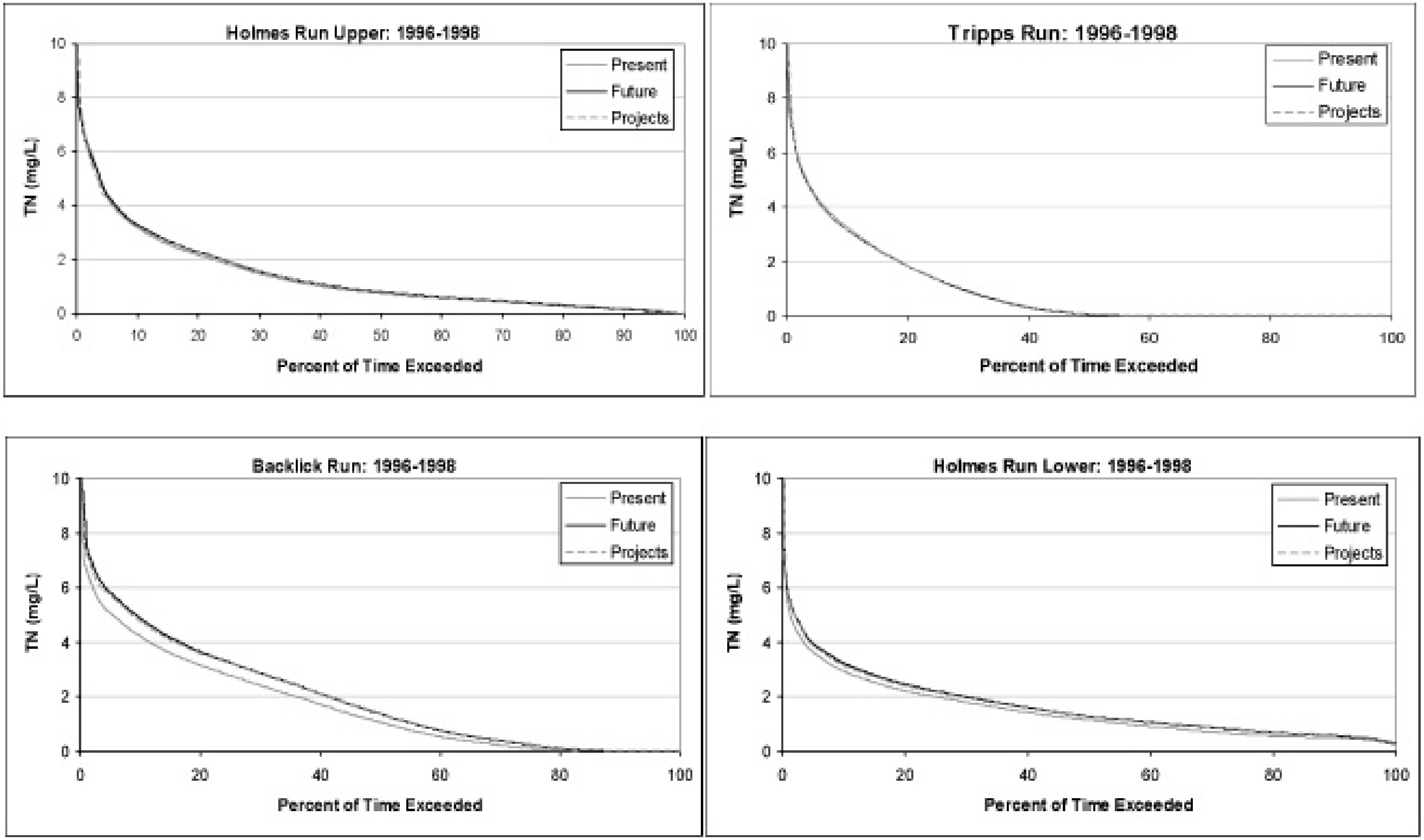

Figure 2-25. Total Nitrogen exceedance curves for subwatersheds in Cameron Run

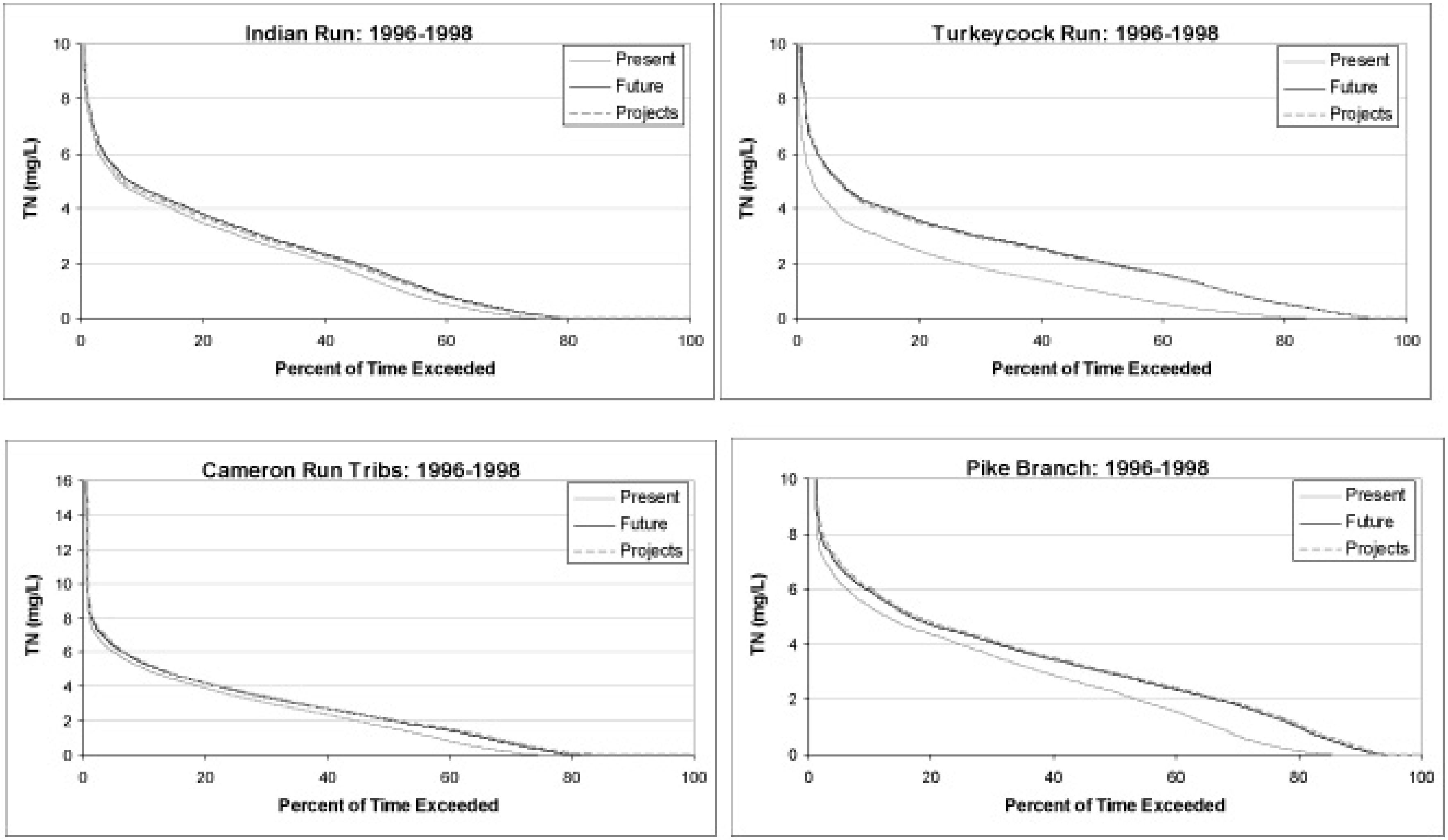

Figure 2-25. (Continued)

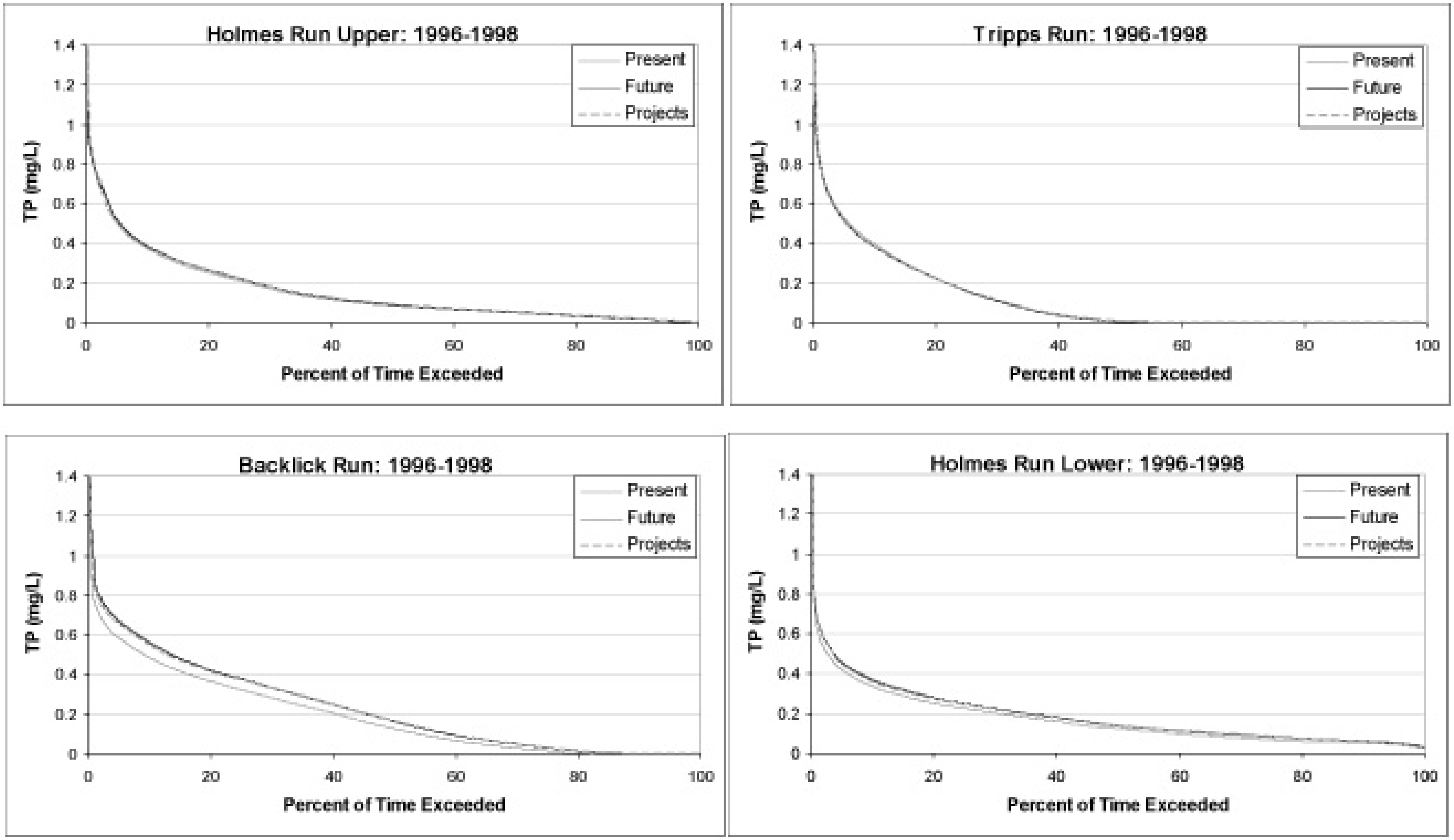

Figure 2-26. Total Phosphors exceedance curves for subwatersheds in Cameron Run

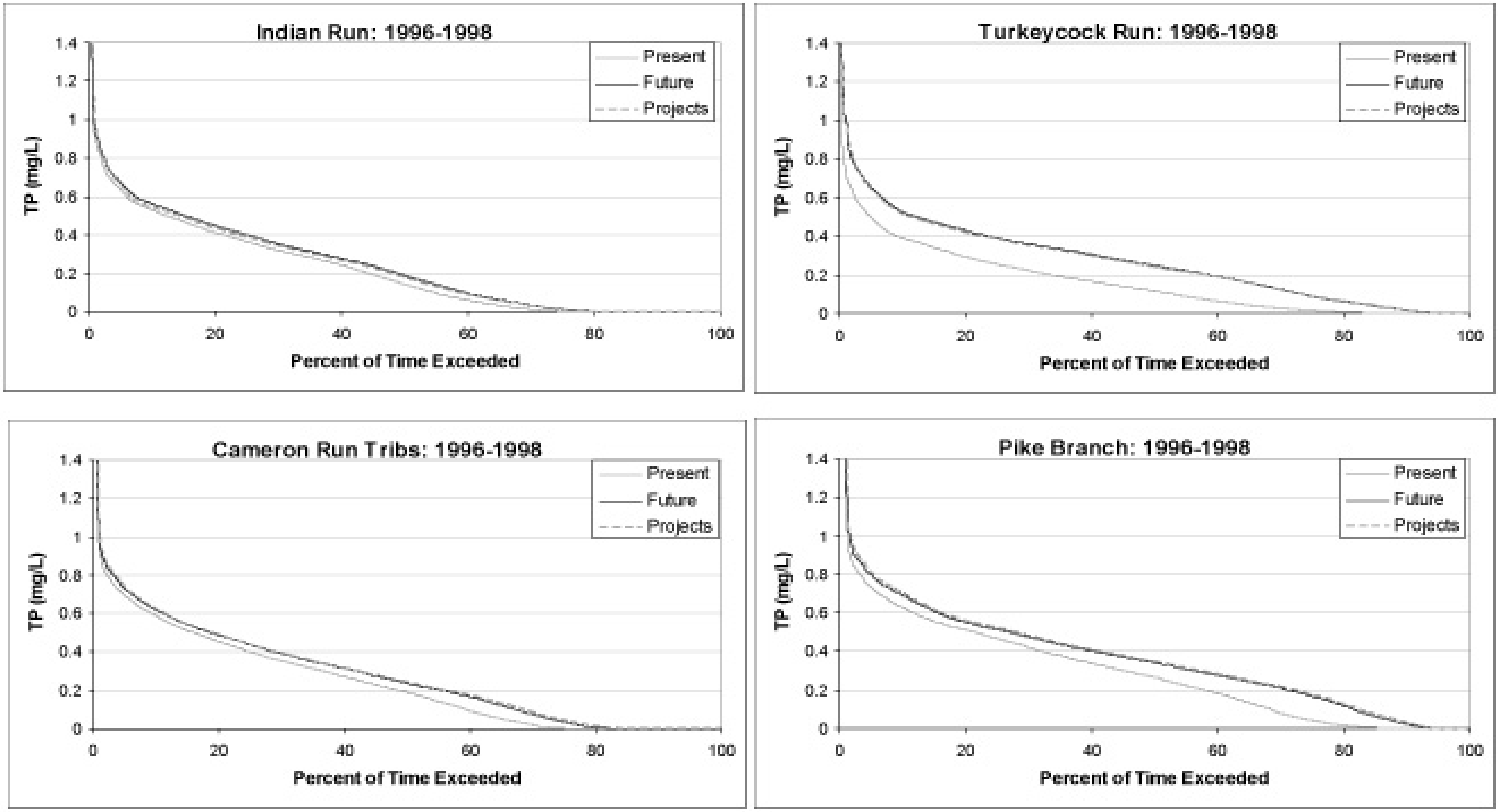

Figure2-26. (Continued)

Table 2-12. Weighted average of design storm peak flows (cfs) in Cameron Run summarized by subwatershed, for current, projected future, and projected future with projects land use (Fairfax County only)

Subwatershed	1 year			2 year`			10 year			25 year			100 year		
	Cur-rent	Future	Future Projects	Cur-rent	Future	Future Projects	Cur-rent	Future	Future Projects	Cur-rent	Future	Future Projects	Cur-rent	Future	Future Projects
Backlick Run	212	224	209	277	289	270	622	626	592	708	711	683	993	1018	991
Cameron Rub Tribs	231	249	241	306	322	311	711	731	715	811	864	846	1105	1193	1168
Holmes Run Lower	219	232	224	292	303	293	674	675	662	773	782	769	1046	1077	1056
Holmes Run Upper	209	217	206	276	285	270	647	649	630	739	751	732	1015	1038	1004
Indian Run	263	277	260	349	361	343	809	818	795	913	923	900	1291	1331	1303
Pike Branch	221	235	229	297	308	301	742	742	730	851	870	856	1153	1190	1175
Tripps Run	225	243	233	298	317	304	673	697	677	755	786	765	1038	1078	1045
Turkeycock Run	182	185	174	244	242	229	611	614	591	710	723	703	1006	1032	1007
Cameron Run Average	217	229	217	287	298	284	669	676	654	763	779	758	1054	1089	1061

Table 2-13. Percent change of design storm peak flows (cfs) in Cameron Run summarized by subwatershed, for current, projected future, and projected future with projects land use (Fairfax County subbasins only)

Subwatershed	1 year		2 year		10 year		25 year		100 year	
	Current vs Future	Future vs Projects	Current vs Future	Future vs Projects	Current vs Future	Future vs Projects	Current vs Future	Future vs Projects	Current vs Future	Future vs Projects
Backlick Run	5.4	-6.5	4.2	-6.6	0.6	-5.5	0.4	-3.9	2.6	-2.7
Cameron Rub Tribs	8.1	-3.3	5.3	-3.3	2.8	-2.1	6.6	-2.1	7.9	-2.1
Holmes Run Lower	5.9	-3.6	3.9	-3.2	0.1	-1.9	1.2	-1.7	3.0	-2.0
Holmes Run Upper	4.2	-5.2	3.1	-5.0	0.3	-3.0	1.7	-2.5	2.2	-3.3
Indian Run	5.0	-5.9	3.3	-5.0	1.2	-2.9	1.1	-2.5	3.1	-2.1
Pike Branch	6.4	-2.6	3.6	-2.1	0.0	-1.6	2.2	-1.6	3.2	-1.3
Tripps Run	8.0	-4.2	6.3	-3.8	3.6	-2.9	4.1	-2.7	3.9	-3.0
Turkeycock Run	1.9	-5.8	-0.7	-5.5	0.5	-3.8	1.9	-2.8	2.5	-2.4
Cameron Run Average	5.5	-5.0	3.8	-4.7	1.0	-3.3	2.1	-2.7	3.2	-2.6

Table 2-14. Subbasin design storm peak flows (cfs) in Cameron Run grouped by subwatershed, for current and projected future land use

			1 year					2 year					10 year					25 year					100 year				
Sub-watershed	Sub-basin	Area, Acres	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects
Backlick Run	BA1	100	143	0.0	143	0.0	143	195	0.0	195	0.0	195	429	0.0	429	0.0	429	478	0.0	478	0.0	478	649	0.0	649	0.0	649
	BA2	218	467	0.7	471	0.0	471	591	0.5	593	0.0	593	1173	-0.3	1170	0.0	1170	1297	-0.3	1292	0.0	1292	1724	-0.5	1716	0.0	1716
	BA3	170	232	4.2	241	0.0	241	295	3.2	304	0.0	304	618	-0.1	618	0.0	618	690	-0.5	686	0.0	686	939	-1.7	923	0.0	923
	BA4	165	131	30.1	170	-4.0	163	172	26.8	218	-4.0	210	434	8.2	469	-3.8	451	500	8.3	541	-3.2	524	691	11.3	769	-2.0	753
	BA5	198	447	0.0	447	0.0	447	566	0.0	566	0.0	566	1115	0.0	1114	0.0	1114	1231	0.0	1230	0.0	1230	1631	0.0	1631	0.0	1631
	BA6	229	428	0.0	428	0.0	428	542	0.0	542	0.0	542	1099	0.0	1099	0.0	1099	1219	0.0	1219	0.0	1219	1631	0.0	1631	0.0	1631
	BA7	194	265	2.8	273	2.5	279	347	1.8	354	2.3	362	746	-0.6	742	1.7	754	831	-0.9	824	1.6	837	1182	1.8	1203	0.7	1211
	BA8	160	147	12.2	165	0.0	165	193	8.6	210	0.0	210	586	-26.6	430	0.0	430	687	-26.6	504	0.1	505	871	5.0	915	0.1	916
	BA9	129	130	11.8	145	0.0	145	172	8.4	186	0.0	186	431	-3.8	414	0.1	414	517	-5.1	491	0.1	491	690	5.1	726	0.1	726
	BA10	248	234	-2.2	229	-31.2	157	300	-2.9	291	-32.3	197	646	-4.7	616	-32.8	414	735	-6.4	688	-17.5	567	1100	-0.2	1097	-10.8	979
	BA11	163	231	3.7	239	0.0	239	293	3.1	302	0.0	302	589	1.4	597	0.0	597	652	1.2	660	0.0	660	917	1.1	927	0.4	930
	BA12	134	150	2.7	154	0.0	154	211	1.0	213	0.0	213	487	-0.8	483	0.0	483	558	-0.5	555	0.0	555	833	2.5	853	0.1	854
	BA13	219	132	4.9	139	-7.7	128	189	3.7	196	-7.1	182	549	1.8	559	-3.9	537	702	0.0	702	-2.6	684	956	1.8	973	-2.5	948
	BA14	200	175	1.1	177	-3.5	171	221	0.4	222	-3.1	215	493	-7.5	456	-0.6	453	605	-9.1	550	2.6	564	901	1.2	912	-1.5	898
	BA15	244	237	6.7	253	0.0	253	303	5.9	321	0.0	321	649	3.5	672	0.0	672	726	3.2	750	0.0	750	1097	2.3	1122	0.1	1123
	BA16	290	293	5.6	309	-2.3	302	377	5.0	395	-2.2	387	813	3.4	840	-1.9	824	915	2.6	938	-1.9	921	1358	2.5	1392	-1.2	1376
	BA17	116	150	2.3	153	-27.2	111	206	1.8	210	-28.4	150	461	1.1	466	-12.4	408	514	1.2	520	1.9	531	698	1.7	710	-0.3	708
	BA18	184	199	4.1	207	-23.8	158	260	3.4	269	-23.8	205	583	1.9	594	-17.3	491	654	1.7	665	-16.0	558	908	1.8	924	-12.9	805
	BA19	242	363	2.5	372	1.8	379	461	2.1	470	1.6	478	948	0.8	956	1.2	967	1055	0.6	1061	1.2	1074	1429	1.2	1446	1.1	1462
	BA20	163	217	8.8	236	-9.3	214	285	7.9	308	-9.4	279	627	5.7	662	-9.9	596	700	5.4	738	-5.7	696	954	5.1	1003	-3.8	964
	BA21	146	186	9.0	203	-0.1	203	239	8.5	259	-0.1	259	512	6.8	547	-0.1	547	573	6.6	610	-0.1	610	780	6.1	828	-0.1	827
	BA22	143	252	4.7	264	-3.1	256	327	3.1	337	-3.1	326	664	-0.3	662	-3.0	642	735	-0.7	730	-3.0	708	1005	0.1	1005	-1.3	992
	BA23	112	279	0.3	280	0.0	280	350	0.0	350	0.0	350	661	-0.5	657	0.0	657	726	-0.5	722	0.0	722	953	-0.7	947	0.0	947
	BA24	219	276	4.5	288	-5.5	272	352	3.4	364	-5.5	344	740	0.4	743	-4.7	709	826	0.0	826	-4.6	788	1120	1.6	1138	-3.1	1103
	BA25	227	200	8.6	218	-4.7	207	265	6.7	282	-4.6	269	637	1.6	647	-2.8	629	740	3.4	765	-2.3	747	1048	3.6	1085	-2.3	1060
	BA26	161	172	11.2	192	0.0	192	229	9.4	250	0.0	250	533	3.3	550	0.0	550	600	5.6	633	0.0	634	822	7.0	879	0.0	879
	BA27	245	223	7.0	239	-8.6	218	298	4.8	313	-8.9	285	729	3.2	752	-5.3	712	844	3.4	873	-5.0	829	1173	2.9	1207	-4.5	1152
	BA28	132	129	6.2	137	-3.2	133	180	2.3	184	-2.1	180	444	4.6	464	-1.3	458	498	7.8	537	-1.2	530	689	3.7	715	-1.1	707
	BA29	168	133	4.2	139	-2.6	135	193	1.1	195	-2.2	191	512	4.4	534	-1.5	526	583	4.8	611	-1.5	602	804	1.8	818	-1.2	808
	BA30	125	153	7.6	165	-23.2	127	202	6.8	216	-22.4	167	449	4.9	471	-14.9	401	503	4.8	527	-14.3	452	690	4.9	723	-13.9	623
	BA31	215	242	3.6	251	-21.7	197	312	3.3	322	-22.0	252	673	2.5	690	-22.3	536	753	2.4	771	-21.2	607	1044	2.0	1066	-8.3	977
Cameron Run Tribs	CA1	202	292	5.7	309	-6.2	289	379	4.4	396	-8.0	364	804	1.5	816	1.4	828	913	4.0	950	6.0	1007	1244	3.0	1281	3.7	1328
	CA2	169	303	4.7	318	0.0	318	386	1.2	391	0.0	391	773	-1.4	763	0.2	764	932	-0.6	926	0.2	928	1312	8.4	1422	0.1	1422
	CA5	215	210	30.7	275	-5.0	261	281	23.8	348	-3.9	335	665	24.0	824	-9.7	744	749	36.3	1021	-13.7	881	1040	29.1	1343	-12.4	1177
	CA8	249	185	8.8	201	-1.1	199	258	3.8	267	-1.0	265	692	3.1	713	-0.6	709	807	11.0	896	-0.6	890	1122	8.4	1216	-0.6	1209
	CA9	207	210	4.2	218	-12.8	190	286	2.2	293	-11.2	260	757	2.9	779	-5.6	735	841	6.9	899	-5.1	853	1122	8.2	1215	-4.6	1159
	CA11	125	241	2.2	247	0.0	247	321	1.8	326	0.0	326	663	1.2	671	0.0	671	734	1.2	743	0.0	743	982	1.1	992	0.0	992
	CA12	192	151	15.0	174	-3.0	168	207	8.2	224	-3.0	217	587	-10.2	527	-1.7	518	681	-10.0	613	-1.7	603	899	5.6	949	-1.3	937
	CA13	138	165	6.2	175	0.1	175	220	4.1	229	0.0	229	526	-0.7	522	0.1	523	591	4.7	619	0.1	619	799	4.6	835	0.1	836
	CA14	211	318	0.0	318	0.0	318	408	0.0	408	0.0	408	861	0.0	861	0.0	861	960	0.0	960	0.0	960	1298	0.0	1298	0.0	1298

Table 2-14. Subbasin design storm peak flows (cfs) in Cameron Run grouped by subwatershed, for current and projected future land use

			1 year					2 year					10 year					25 year					100 year				
Sub-water-shed	**Sub-basin**	**Area, Acres**	**Cur-rent**	**% Change Current vs Future**	**Future**	**% Change Future vs Projects**	**Projects**	**Cur-rent**	**% Change Current vs Future**	**Future**	**% Change Future vs Projects**	**Projects**	**Cur-rent**	**% Change Current vs Future**	**Future**	**% Change Future vs Projects**	**Projects**	**Cur-rent**	**% Change Current vs Future**	**Future**	**% Change Future vs Projects**	**Projects**	**Cur-rent**	**% Change Current vs Future**	**Future**	**% Change Future vs Projects**	**Projects**
Holmes Run Lower	HR1	210	318	0.0	318	0.0	318	410	0.0	410	0.0	410	868	0.0	868	0.0	868	967	0.0	967	0.0	967	1307	0.0	1307	0.0	1307
	HR2	243	322	0.0	322	0.0	322	416	0.0	416	0.0	416	896	0.0	896	0.0	896	1001	0.0	1001	0.0	1001	1362	0.0	1362	0.0	1362
	HR3	119	121	0.0	121	0.0	121	169	0.0	169	0.0	169	406	0.0	406	0.0	406	456	0.0	456	0.0	456	631	0.0	631	0.0	631
	HR4	119	211	0.0	211	0.0	211	276	0.0	276	0.0	276	580	0.0	580	0.0	580	643	0.0	643	0.0	643	863	0.0	863	0.0	863
	HR5	135	190	0.0	190	0.0	190	250	0.0	250	0.0	250	545	0.0	545	0.0	545	607	0.0	607	0.0	607	824	0.0	824	0.0	824
	HR6	147	302	0.0	302	0.0	302	387	0.0	387	0.0	387	779	0.0	779	0.0	779	862	0.0	862	0.0	862	1147	0.0	1147	0.0	1147
	HR7	166	170	0.1	171	0.0	171	234	0.1	234	0.0	234	551	0.0	551	0.0	551	619	0.0	619	0.0	619	855	0.0	856	0.0	856
	HR8	243	197	0.7	198	0.0	198	269	0.5	271	0.0	271	659	0.3	661	0.0	661	746	0.3	748	0.0	748	1050	0.2	1052	0.0	1052
	HR9	210	228	0.4	229	0.0	229	314	-0.5	313	0.0	313	730	-0.7	725	0.0	725	822	0.2	824	0.0	824	1145	0.7	1153	0.0	1153
	HR10	101	120	6.1	127	0.0	127	165	3.0	170	0.0	170	395	1.6	401	0.0	401	442	3.6	458	0.0	459	596	3.1	615	0.0	615
	HR11	126	120	2.5	123	0.0	123	169	1.7	171	0.0	171	412	0.9	415	0.0	415	463	1.7	471	0.0	471	643	1.3	651	0.0	651
	HR12	147	188	3.4	195	-8.7	178	260	1.5	264	-6.3	247	623	2.1	636	-3.4	614	695	3.7	721	-3.2	697	926	3.4	957	-2.8	930
	HR13	160	166	10.9	184	0.1	184	227	6.2	241	0.1	242	550	1.5	559	0.1	559	623	5.4	657	0.1	657	849	4.2	884	0.1	885
	HR14	185	163	10.7	180	-2.1	177	215	8.5	234	-2.0	229	579	-6.0	544	-1.1	538	675	0.3	677	-0.9	671	891	3.9	926	-0.9	918
	HR15	180	236	8.2	255	0.0	255	303	6.9	324	0.0	324	642	3.2	663	0.0	663	716	2.8	736	0.0	736	980	3.9	1018	0.0	1018
	HR16	265	284	3.8	295	-5.3	279	388	0.5	390	-5.0	370	929	-1.1	919	-2.4	896	1111	-1.9	1089	-2.1	1066	1503	2.3	1537	-1.9	1508
	HR17	176	216	7.3	231	-6.7	216	284	6.5	302	-6.5	282	642	1.5	652	-4.7	622	729	2.4	747	-3.5	721	1000	3.9	1039	-4.9	988
	HR18	168	279	2.7	286	-2.7	279	360	2.2	368	-2.5	359	755	0.7	761	-1.4	750	841	0.8	847	-1.6	834	1143	1.7	1163	-3.1	1127
	HR19	104	164	3.1	169	-2.0	165	210	2.7	216	-0.6	215	440	1.6	447	-1.1	442	490	1.3	497	-1.2	491	668	0.9	674	-2.2	659
Holmes Run Upper	HR21	211	332	4.6	347	0.3	348	426	4.1	444	0.2	445	894	2.8	920	0.1	921	995	2.7	1022	0.1	1023	1346	3.1	1387	-0.4	1381
	HR22	261	325	5.6	343	-1.4	338	424	5.1	446	-1.4	440	954	2.4	977	-3.2	946	1072	2.8	1103	-4.3	1055	1488	3.2	1536	-6.9	1431
	HR23	265	239	2.3	245	-1.9	240	334	0.7	336	-1.7	331	886	4.2	923	-0.8	916	1007	5.5	1062	-0.7	1055	1354	3.1	1396	-1.8	1370
	HR24	117	106	3.4	109	0.0	109	151	1.3	153	0.0	153	375	4.7	392	0.0	393	423	5.3	445	-0.2	444	589	2.2	602	-0.5	599
	HR25	110	167	0.7	168	-0.3	168	231	-0.9	229	-0.2	228	497	2.8	511	-0.1	511	552	2.5	565	-0.1	565	749	3.3	774	-0.2	773
	HR26	246	223	6.2	236	-13.6	204	314	5.0	329	-12.1	289	791	1.5	803	-6.8	748	895	2.4	916	-6.3	859	1235	2.1	1261	-5.5	1191
	HR27	105	140	4.9	146	-2.9	142	193	3.4	199	-3.3	193	433	2.4	443	1.7	451	483	2.8	497	1.1	502	652	3.7	677	0.6	681
	HR28	129	142	6.8	152	-6.3	142	196	4.4	204	-4.3	196	465	3.4	481	-2.8	467	520	3.9	540	-2.9	525	713	2.6	731	-2.7	712
	HR29	196	194	9.6	212	-5.2	201	257	8.1	278	-5.0	264	621	0.7	626	-3.0	607	703	0.8	709	-2.9	688	962	3.6	996	-2.8	969
	HR30	156	202	8.3	218	-0.1	218	268	6.6	286	-0.1	286	616	1.6	626	-0.1	625	699	3.5	723	0.1	724	946	4.5	989	0.3	992
	HR31	109	122	11.2	136	-0.6	135	167	8.0	181	-0.6	180	396	3.8	411	-0.3	410	445	3.6	461	-0.3	460	605	4.6	633	-0.4	630
	HR32	114	90	11.7	100	-0.1	100	122	7.2	131	-0.1	131	318	0.4	319	-0.2	318	377	2.0	385	0.4	387	515	3.8	535	-0.5	532
	HR33	161	220	6.9	235	-4.5	225	290	6.2	308	-4.1	295	634	4.6	663	-3.4	641	708	4.5	739	-3.4	715	963	4.1	1002	-3.2	970
	HR34	165	159	4.0	165	-0.2	165	220	1.4	223	-0.1	223	586	-4.0	563	0.1	563	675	3.1	696	0.2	697	904	3.1	932	-0.6	927
	HR35	132	162	6.4	172	-13.5	149	220	4.2	229	-9.9	206	529	2.0	539	-5.1	512	599	1.1	606	-4.8	577	792	3.6	820	-5.8	773
	HR36	122	118	1.7	120	-15.3	102	162	1.2	164	-11.1	146	471	-4.8	448	-8.6	409	533	0.8	537	-8.1	493	701	1.8	713	-7.1	663
	HR37	227	151	7.0	162	-1.4	160	191	5.6	202	-1.4	199	600	-6.0	564	3.7	585	736	-1.6	724	2.0	739	963	2.4	986	-1.9	968
	HR38	179	274	1.4	278	-14.4	237	354	1.0	357	-14.3	306	745	-0.1	745	-11.3	661	828	-0.2	827	-11.1	735	1129	0.2	1131	-9.8	1021
	HR39	183	258	8.8	280	-3.1	272	331	8.2	358	-2.9	348	703	6.5	749	-2.5	730	784	6.3	833	-2.5	813	1063	5.9	1126	-2.4	1099
	HR40	189	167	-6.0	157	-0.4	156	210	-7.1	195	-0.3	194	489	-5.8	460	-0.6	458	649	-4.6	620	1.2	627	904	-0.7	898	-1.5	884
	HR41	106	166	0.5	166	-5.8	157	212	0.3	213	-5.6	201	429	-0.2	428	-5.1	406	474	-0.2	474	-5.0	450	671	0.9	677	-1.9	665

Table 2-14. Subbasin design storm peak flows (cfs) in Cameron Run grouped by subwatershed, for current and projected future land use

			1 year					2 year					10 year					25 year					100 year				
Sub-watershed	Sub-basin	Area, Acres	Cur-rent	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Cur-rent	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Cur-rent	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Cur-rent	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Cur-rent	% Change Current vs Future	Future	% Change Future vs Projects	Projects
Holmes Run Upper (Continued)	HR42	253	352	-0.2	351	-1.7	345	449	-0.3	448	-1.6	441	923	-0.5	919	-1.3	907	1025	-0.5	1020	-1.3	1006	1464	0.0	1464	-1.3	1446
	HR43	221	264	0.9	266	-6.5	249	344	0.8	347	-6.2	325	758	0.3	761	-4.9	724	848	0.3	851	-4.8	810	1169	-0.4	1164	-3.1	1128
	HR44	109	124	-0.3	123	0.0	123	173	-0.3	172	0.0	172	405	-1.0	400	0.0	400	456	-1.8	448	0.0	448	626	-1.7	615	0.0	615
	HR45	244	197	6.3	209	-6.2	196	261	4.1	272	-6.5	254	683	-3.2	662	-4.5	632	806	1.8	821	-3.1	796	1104	2.6	1133	-4.0	1088
	HR46	163	186	-6.2	174	-15.9	146	245	-5.8	230	-16.1	193	544	-4.6	519	-10.3	466	609	-4.1	584	-9.9	527	869	-5.5	821	-8.9	748
	HR47	155	200	3.2	207	0.0	207	263	1.9	268	0.0	268	569	-0.9	563	0.0	563	633	-0.7	629	-0.1	628	925	2.2	945	-0.5	940
	HR48	242	243	7.1	261	-5.0	248	318	4.8	333	-5.0	316	754	-2.2	737	-3.4	712	902	0.4	906	-2.8	881	1218	3.0	1254	-3.0	1216
	HR49	173	183	3.6	189	-0.1	189	243	2.3	248	-0.1	248	585	-0.8	580	-0.2	579	678	2.1	692	0.2	694	916	1.9	933	0.0	933
	HR50	154	126	-0.8	125	-44.6	69	162	-2.1	158	-46.6	85	388	-8.0	357	-11.9	314	468	-2.2	458	8.4	496	737	0.8	743	-11.4	658
	CW1	204	201	11.7	224	-10.9	200	267	10.0	294	-11.0	262	645	2.7	662	-6.7	618	733	4.9	769	-6.2	721	1006	5.1	1057	-6.7	986
Indian Run	IR1	262	333	5.8	352	-2.3	344	442	4.5	462	-2.1	452	977	1.7	994	-1.8	976	1097	1.0	1108	-1.0	1097	1554	2.9	1599	-0.9	1585
	IR2	192	188	4.8	197	-17.0	164	261	3.1	269	-15.5	227	623	1.4	632	-8.3	579	705	1.6	716	-7.9	660	989	2.1	1010	-6.9	941
	IR3	199	146	11.6	163	0.0	163	196	8.4	213	0.0	213	584	-0.8	579	-0.1	579	692	-1.4	682	0.0	682	1053	4.3	1098	0.1	1100
	IR4	230	310	0.8	313	-12.8	272	425	-0.7	422	-9.0	384	1018	-1.6	1002	-3.8	964	1132	-1.6	1115	-3.6	1074	1515	3.3	1565	-3.4	1512
	IR5	282	389	3.3	402	-2.5	392	489	2.6	502	-2.4	490	992	0.7	999	-2.1	977	1102	0.4	1106	-2.1	1083	1532	2.7	1573	-1.3	1552
	PR1	157	185	1.6	188	-1.7	185	240	-0.1	239	-1.6	236	507	-0.2	506	-0.8	502	584	3.6	605	0.2	607	952	3.1	981	-0.6	976
	PR2	264	209	11.2	233	-8.1	214	287	6.9	306	-6.6	286	748	6.2	794	-3.2	768	853	5.4	899	-3.1	871	1177	3.6	1220	-2.8	1186
Pike Branch	PK1	190	233	1.8	238	-6.6	222	317	-0.1	317	-4.7	302	756	-4.6	721	-2.7	702	870	-6.8	810	-2.6	789	1186	1.6	1205	-2.1	1180
	PK2	114	146	3.5	151	-0.3	151	200	-0.2	200	-0.3	199	479	-2.0	469	-0.4	467	533	6.2	566	-0.4	563	711	6.5	758	-0.4	754
	PK3	181	197	3.8	205	-3.7	197	258	2.5	264	-3.5	255	595	-1.1	589	-1.9	577	702	1.6	713	-1.7	701	998	2.0	1019	-1.5	1004
	PK4	270	240	3.8	249	-0.3	248	326	0.1	327	-0.3	326	962	-1.6	946	0.0	946	1126	2.4	1152	0.0	1152	1467	2.3	1501	0.0	1500
	PK5	198	205	12.2	230	-0.7	228	276	9.0	301	-0.7	298	685	1.2	694	-0.3	691	779	4.7	816	-0.3	813	1045	5.6	1104	-0.5	1099
	PK6	274	226	10.7	250	-6.4	234	311	6.1	330	-6.3	309	811	1.0	819	-3.5	790	931	3.3	962	-4.3	921	1271	3.6	1317	-3.3	1273
	PK7	248	276	5.8	292	-0.1	292	355	5.2	374	0.0	373	768	3.5	795	0.0	796	861	3.2	889	0.1	889	1201	3.6	1244	-0.1	1243
	PK8	218	257	8.5	279	-0.4	277	354	4.7	371	-0.4	369	837	1.6	851	-0.3	848	949	4.6	992	-0.2	990	1280	4.1	1332	-0.2	1330
	PK9	123	102	2.5	105	-10.3	94	132	0.9	134	-3.9	129	419	-2.2	410	-14.5	351	476	0.5	479	-12.4	420	631	-0.2	630	-8.2	578
Tripps Run	TR0	271	363	3.3	376	-7.8	346	472	2.9	486	-7.7	448	1028	1.5	1043	-5.4	987	1154	1.1	1167	-5.8	1100	1586	2.1	1620	-8.1	1488
	TR1	185	238	2.0	243	-7.3	225	317	1.6	322	-4.2	308	712	-0.4	709	-1.3	700	798	-0.8	792	-1.3	782	1098	-0.4	1094	-3.5	1055
	TR2	174	146	6.9	156	-1.0	154	204	2.9	210	-0.7	208	525	1.1	530	-0.5	528	593	6.0	629	-0.4	626	819	4.5	856	-0.4	852
	TR3	173	162	8.7	176	-4.1	169	218	6.2	232	-3.9	223	539	0.0	539	-2.7	524	613	2.1	625	-4.4	598	838	3.0	863	-1.3	852
	TR4	216	187	4.8	196	-4.7	187	265	2.6	272	-4.0	261	676	5.0	709	-2.4	692	758	6.7	808	-2.3	790	1056	2.0	1077	-2.1	1054
	TR5	137	143	12.7	161	-0.6	160	197	7.8	213	-0.6	212	476	6.9	509	0.0	509	530	9.3	580	-0.3	578	729	7.1	781	-0.5	777
	TR6	177	225	3.9	233	-2.2	228	294	2.7	302	-2.2	295	644	0.0	644	-2.2	629	720	-0.3	717	-2.2	701	990	1.1	1001	-0.9	992
	TR7	148	210	15.4	243	0.0	243	270	13.9	307	0.0	307	568	9.6	622	0.0	622	633	9.1	690	0.0	690	863	8.4	935	0.0	936
	TR8	157	278	8.0	300	-10.3	269	366	6.3	389	-10.4	349	763	2.9	784	-10.9	699	849	2.2	867	-5.9	816	1157	2.3	1183	-7.0	1100
	TR9	199	267	12.2	299	0.0	299	346	11.1	385	0.0	385	751	8.2	813	0.0	813	840	7.9	905	0.0	905	1143	7.2	1225	0.0	1225
	TR10	125	204	5.3	215	-8.4	197	265	4.3	276	-8.7	252	556	1.8	566	-9.2	514	618	1.7	629	-9.4	569	836	3.7	867	-8.7	792
	TR11	119	149	15.0	171	0.0	171	197	12.9	223	0.0	223	441	8.1	477	0.0	477	494	7.7	531	0.0	531	675	8.3	731	0.0	731
	TR12	267	299	10.1	329	-2.6	321	388	9.0	423	-2.5	412	847	6.2	899	-2.1	880	948	5.8	1004	-2.1	983	1324	5.1	1392	-1.9	1365
	TR13	164	270	4.1	282	-2.2	275	345	3.4	357	-2.3	348	713	1.4	723	-2.5	705	793	1.2	802	-2.6	782	1071	1.3	1085	-1.9	1065

Table 2-14. Subbasin design storm peak flows (cfs) in Cameron Run grouped by subwatershed, for current and projected future land use

			1 year					2 year					10 year					25 year					100 year				
Sub-watershed	Sub-basin	Area, Acres	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects	Current	% Change Current vs Future	Future	% Change Future vs Projects	Projects
Tripps Run	TR14	161	242	7.2	260	0.0	260	314	6.3	334	0.0	334	671	3.9	697	0.0	697	748	3.7	776	0.0	776	1015	4.5	1061	0.0	1061
	TR15	162	166	4.8	174	0.0	174	229	2.8	235	0.0	235	544	1.1	550	0.0	550	613	2.0	626	0.0	626	844	1.7	859	0.0	859
	TR16	271	257	10.7	284	0.0	284	353	6.9	377	0.0	377	843	3.7	874	0.0	874	950	3.9	987	0.0	987	1321	3.4	1365	0.0	1365
	TR17	167	269	6.8	288	0.0	288	344	6.0	365	0.0	365	715	3.5	740	0.0	740	794	3.3	820	0.0	821	1073	3.5	1110	0.0	1110
	TR18	254	237	13.0	268	0.0	268	321	9.5	352	0.0	352	795	3.8	824	0.0	825	901	4.7	943	0.0	944	1234	4.3	1287	0.0	1287
	TR19	179	160	12.8	181	-2.5	176	216	8.9	236	-2.3	230	551	0.7	555	-1.2	548	639	3.9	664	-1.1	657	865	4.6	905	-1.0	896
Turkey-cock	TK1	183	138	-2.1	135	0.0	135	196	-13.4	170	0.0	170	504	7.9	544	0.4	546	605	18.8	719	0.3	722	1006	10.9	1116	0.1	1117
	TK2	198	241	4.3	252	0.0	252	317	3.1	327	0.0	327	734	1.4	744	-2.2	727	855	0.3	857	2.3	878	1158	0.3	1162	2.3	1189
	TK3	268	258	2.1	264	-8.0	243	334	1.4	339	-7.9	312	732	-0.4	729	-7.6	674	821	0.1	822	-7.4	761	1214	1.3	1229	-3.2	1190
	TK4	183	156	-0.2	155	-2.8	151	217	-3.2	210	-2.6	205	526	6.6	561	0.1	561	618	7.1	661	0.2	663	964	3.4	997	-0.6	991
	TK5	209	185	-5.1	176	-0.1	176	253	-4.7	242	-0.1	241	681	-13.6	589	0.0	589	818	-14.5	700	-0.1	699	1087	-1.3	1073	0.0	1073
	TK6	234	145	4.9	152	-7.9	140	199	2.5	204	-6.3	191	663	-0.6	659	-4.2	631	774	0.7	779	-5.0	740	999	2.1	1020	-3.5	984
	TK7	119	210	0.2	210	-29.9	147	266	0.1	266	-30.0	186	532	-0.3	530	-23.9	404	596	-0.9	590	-20.0	472	831	0.0	831	-22.2	647
	TK8	135	122	1.3	124	-6.3	116	168	-3.8	162	-4.8	154	489	6.8	522	-2.2	511	563	9.6	617	-2.1	604	724	4.8	759	-3.1	735
	TK9	197	147	10.2	162	-2.7	158	199	5.7	210	-2.8	204	496	6.5	528	0.8	532	572	9.7	628	1.4	636	833	4.0	867	-2.3	846

3.0 HEC-RAS MODEL DEVELOPMENT

3.1 INTRODUCTION

This section documents procedures used to develop the HEC-RAS model of the Cameron Run watershed. HEC-RAS is the U.S. Army Corps of Engineers River Analysis System developed by the Hydrologic Engineering Center. The HEC-RAS hydraulic model is used for 1-, 2-, 10-, 25-, and 100-year single event flow simulations. HEC-RAS is used to evaluate road crossing overtopping, structure flooding, detailed analysis of bankfull capacity, and erosion velocities for selected design storms. The model can be used to evaluate the benefits of low-impact development (LID), and regional and onsite detention on hydraulic conditions in streams. The model can also be used to optimize the location of peak shaving detention storage facilities and other stormwater facilities to provide the greatest reduction in peak flows in the stream mainstem.

Procedures used to develop data on the stream network for input to the model are described in the following sections. These procedures are based partly on guidelines and recommendations contained in CDM's Technical Memorandum No.3 – Stormwater Model and GIS Interface Guidelines (TM3; CDM 2003).

3.1.1 Background

WEST Consultants, Inc. was tasked to complete the comprehensive steady flow HEC-RAS (Hydrologic Engineering Center, River Analysis System) hydraulic model of the major streams within the Cameron Run watershed. This section of the model report discusses development of the model, its execution, and results to be used for the overall watershed study.

Two major reservoirs exist within the watershed. Lake Barcroft is the biggest reservoir with a storage volume of about 2270 acre-ft, and it is fed by Holmes Run from the west and Tripps Run from the northwest. Fairview Lake is located in Holmes Run about 4 miles upstream of Lake Barcroft and has a storage volume of about 130 acre-ft.

WEST Consultants, Inc., constructed a steady-state HEC-RAS hydraulic model of Cameron Run and its major tributary streams. In addition, a number of unnamed third-order streams are included. A SWMM model of the watershed was used to supply boundary condition flows for the HEC-RAS model. Both current and future conditions were modeled for 1-, 2-, 10-, 25-, and 100-year recurrence interval storms (since SWMM results did not show a great reduction in peak flows with the proposed projects, these were not simulated in HEC-RAS). The lower end of Holmes Run and portions of Cameron Run flow through the City of Alexandria, which is outside of Fairfax County. These sections were not modeled in HEC-RAS with enough detail to provide flood inundation and stream velocity coverage; however, to maintain continuity of the comprehensive HEC-RAS model, portions of the streams that flow through the City of Alexandria were included at a minimum level of detail required to provide adequate results at the Fairfax County boundaries.

3.2 MODEL DEVELOPMENT

3.2.1 Survey Data

The extent of the stream network included in the model was based on the Fairfax Hydrography Dataset (FHD). The FHD is a GIS data set comprised of nodes, points, lines and polygon themes that were derived from 1997 aerial photography. The FHD contains a polyline stream network layer used to define the stream channel network which was used to develop the geometric data in HEC-RAS. The hydraulic model network starts at the outlets of the headwater subbasins and only includes major stream segments. In HEC-RAS, each river and reach is given a unique identifier. The river and reach labels define in which reach the cross-section is located.

i.e River: Pike Branch
Reach: PK001

A digital terrain model (DTM) was constructed using a compilation of 2-foot contour plots from the cities of Falls Church and Alexandria, and the portion of Fairfax County that falls within the Cameron Run watershed. The DTM was compiled in the form of a Triangular Irregular Network (TIN) for use in HEC-RAS model development. In addition to the DTM, field-surveyed cross-sections were collected near many of the crossings in the watershed. Contour plots were developed from aerial photogrammetry and do not include bathymetry; therefore, the TIN does not provide coverage for “submerged” terrain. Most of the streams in the watershed are very small, and an absence of bathymetric data will make little difference in the results; however, larger streams such as Cameron Run and lower Holmes Run may show results that skew towards higher water surface elevations. When field survey cross-sections were taken, they were merged with DTM-generated cross-sections to capture the bathymetry.

3.2.2 Geometry

The Cameron Run watershed was broken into three HEC-RAS models as (1) Pike Branch, (2) Cameron Run Unnamed Tributary # 2, and (3) the rest of the watershed upstream of the USGS gage on Cameron Run (called Cameron Run). Figure 3-1 illustrates the scope of the three models.

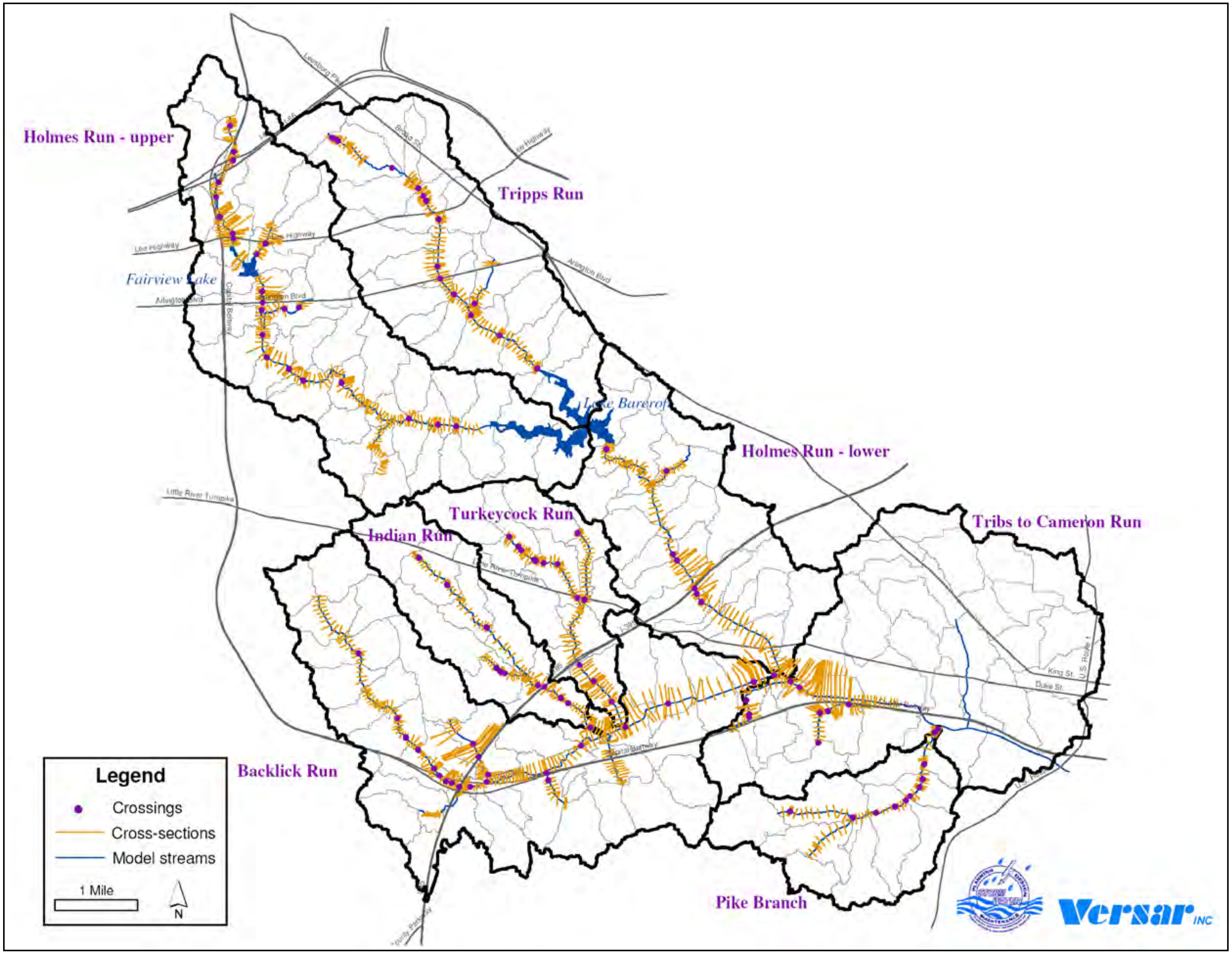

Figure 3-1. Cameron Run watershed model cross-sections and crossings

3.2.3 Cross-sections

Cross-sections are used to define the shape of the stream and its characteristics, such as roughness, expansion and contraction losses, and ineffective flow areas. Over 1000 cross-sections were defined as a GIS layer to characterize the terrain in the Cameron Run watershed. Additionally, fifty cross-sections were surveyed in the field. Field cross-sections were typically taken near crossings and include bathymetric data. Where possible, these cross-sections were merged with DTM cross-sections to produce composite cross-sections that include terrain as well as bathymetric survey points.

Each stream cross-section was assigned a unique identifier Section ID which was based on the stream segment identifier established by the Stream Physical Assessment (SPA) Project. The identifier is tied to the corresponding location in the HEC-RAS models and includes the River-Reach-station. The River Station tag defines where the cross-section is located within the specified reach. Cross-sections are ordered in the reach from the highest river station upstream to lowest river station downstream, with the value of the river station being the distance (in feet) from the downstream end of the stream reach.

i.e. River: Pike Branch
Reach: PK001
River Station: 11979.90

The locations of stream cross-sections were placed according to the guidelines. Stream cross-sections were added as needed; additional stream cross-sections were inserted at the end of stream reaches and near junctions.

3.2.4 Crossings

Field data investigations were conducted at each stream crossing to be modeled within the watershed using traditional surveying techniques. Benchmark elevations of stream crossing locations (point features of crossing locations from the SPA) were calculated using TIN data. A GPS unit was used to navigate to the crossing and recover benchmark locations identified in the office, and capture new field data. Field data were recorded in GIS and included replacement benchmark locations (if needed), actual cross-section endpoints, corrected crossing locations, new crossings encountered in the field that were not in the SPA dataset, and, on occasion, conveyance length.

At each site, field crews recovered the GIS-generated benchmark location and based subsequent rod and level surveys on this benchmark elevation. Field crews measured conveyance slope and length, conveyance dimensions, channel roughness, cross-sectional profiles, and other site details on field data sheets, and documented site conditions with digital photographs. In total, 153 crossings were surveyed. Included in this total were 26 additional sites that were either new crossings or crossings located in the cities of Alexandria or Falls Church that were needed for the model. In the HEC-RAS model, crossings include bridges, culverts, and inline weirs. Each crossing was included as a structural element in the RAS models; the Cameron Run HEC-RAS models included 113 crossings.

In the HEC-RAS model, bridges are defined by station-elevation points of high and low chords, piers, overflow weir coefficient, and modeling approach. High and low chords were determined using a combination of field survey data for the structure and points taken from the TIN for the roadway elevation. Weir coefficients were initially set to the default value of 2.6, which represents a relatively inefficient broad-crested weir. Some of the coefficients were adjusted on a case-by-case basis, using photographs and survey notes.

Culverts are defined by station elevation points of the embankment, size and shape of the culvert, and its energy loss coefficients. Most of the culverts in the Cameron Run watershed were box culverts, frequently consisting of multiple boxes in parallel. The watershed also has some circular pipes, pipe arches, and conspan structures. All culverts are lined with concrete or corrugated metal. Loss coefficients were set for each culvert based on entrance and exit conditions, shape, and degree of blockage. Severely blocked culverts were assigned entrance loss coefficients as high as 1.0. Very efficient, unblocked culverts had entrance coefficients as low as 0.2. Exit loss coefficients were normally left at the default value of 1.0. When a culvert was partially blocked with sediment along its length, an average blockage depth was used and the roughness of the sediment was considered in selecting coefficients to define culvert bottom roughness.

One inline weir was entered into the model. This weir is located at the downstream end of Holmes Run, just upstream of its confluence with Backlick Run. The weir is constructed of sheet piling and has a drop of about 7 feet. A discharge coefficient of 3.0 was used to define the structure's rating curve.

3.2.5 Roughness Values

Manning's *n* values were used in the model to define roughness for each cross-section. The *n* values were assigned in two steps. The first step involved defining land use characteristics for common areas throughout the watershed. Each land use characteristic was given an *n* value based on published values for similar conditions (Chow 1959; Barnes 1967) and on engineering judgment and experience. In-stream *n* values for small streams were not assigned in the first step. Once land use was defined for the entire watershed, representative *n* values were assigned to the portion of each cross-section that intersects the respective land use area. These *n* values were then exported to the HEC-RAS model using HEC-GeoRAS. The following land use and corresponding *n* values were used in the GIS model are given in Table 3-1.

The second step involved entering in-stream *n* values. These *n* values were based on field inspections and ranged from 0.015 for some concrete-lined channels to 0.07 for steep, cobbly streams with a lot of overhanging vegetation and debris.

TABLE 3-1. LAND USE AND CORRESPONDING MANNINGS *N* VALUES USED IN THE HEC-RAS MODEL

LAND USE CHARACTERISTIC	*N* VALUE
BACKLICK RUN	0.045
LOWER BACKLICK RUN	0.045
LOWER CAMERON RUN	0.035
CONCRETE CANAL	0.018
FIELD 1: OPEN AND MAINTAINED FIELDS, PARKS	0.030
FIELD 2: OPEN FIELDS WITH SCATTERED BRUSH, NOT MOWED	0.045
FIELD 3: FIELDS WITH THICK VEGETATION, NOT MAINTAINED	0.065
FOREST 1: LIGHT TREES AND UNDERBRUSH	0.070
FOREST 2: MEDIUM TREES AND DENSE UNDERBRUSH	0.085
FOREST 3: THICK TREES AND VERY DENSE UNDERBRUSH	0.120
INDUSTRIAL	0.100
PAVEMENT	0.015
RAILWAYS	0.020
RESERVOIRS	0.030
RESIDENTIAL, TYPICALLY WITH LANDSCAPED BACKYARDS	0.050
SPARSE RESIDENTIAL AND WITH FORESTED BACKYARDS	0.085

3.2.6 Ineffective Flow Area

Ineffective flow areas define portions of a cross-section in which water does not move effectively in the downstream direction. Examples of ineffective flow areas include flow separation zones at constrictions such as bridges and culverts, backwater eddies, overbank areas shadowed by obstructions, etc. These areas were defined in the GIS model using aerial photos to locate zones of potential ineffective flow. A 1:1 contraction ratio and a 2:1 expansion ratio were typically used to define ineffective flow areas bounding bridges and culverts. Ineffective flow areas were also defined where significant infrastructure existed within a cross-section and appreciable downstream conveyance was not expected. Once these areas were defined in the GIS model, they were intersected with the cross-sections and exported to the HEC-RAS model via HEC-GeoRAS.

3.2.7 Flows

HEC-RAS requires flows to be entered at all upstream boundaries in the model. In addition, flow changes can be specified along any of the streams. Flows were provided to the model for 1-, 2-, 10-, 25-, and 100-year recurrence interval storm events for both present and future (complete build-out of the watershed) conditions.

3.2.8 Hydrologic Model

The SWMM model of the Cameron Run watershed was developed as described in Sections 1 and 2 above. Rainfall hyetographs for each storm event were entered into the SWMM model. After defining hydrologic characteristics of the watershed and routing method for the streams, watershed-wide peak discharges were specified for each cross-section in the HEC-RAS model. These discharges were provided to WEST Consultants by Versar, Inc. for inclusion in the model.

3.2.9 Reservoirs

There are two major reservoirs in the Cameron Run watershed: Lake Barcroft and Fairview Lake, both on Holmes Run. No bathymetric data were available for these reservoirs, so defining them with cross-sections was not possible. It was possible to model the reservoirs as storage areas; however, the storage area element in HEC-RAS was developed for use in unsteady flow applications, and was not originally intended for steady flow modeling. For the Cameron Run watershed, reservoirs were modeled using a single cross-section, with a specified water surface for a given flow. In other words, reservoirs are treated as internal boundary conditions. Water surface elevations were programmed into flow files and were taken from storage elevation curves as described in Tables 2-1 and 2-2.

3.2.10 External Boundary Conditions

For steady flow models, upstream boundary conditions are entered as discharges. Downstream boundary conditions can be set to normal depth, a rating curve, a known water surface elevation, or critical depth. Since no gage data information was available at the down-stream end of the model, normal depth was selected for the Cameron Run watershed model downstream boundary condition. The normal depth option requires an energy slope be entered by the user, and then the program back-calculates a starting water surface elevation using Manning's equation. Error involved in selection of the energy slope is normally minimized by placing the downstream boundary far from the area of interest in the model. In this case, the downstream boundary for the Cameron Run Tributary model was set about 1800 feet downstream of the first tributary and over 1 mile downstream of the calibration gage.

3.2.11 Calibration

Model calibration is a necessary technique used to increase confidence in uncertain parameters used in the model. Uncertain parameters include roughness values, coefficients of contraction and expansion, weir and culvert coefficients, and ineffective flow area definitions. Since these uncertain parameters are used throughout the watershed, the widest application of calibration data is preferable in constructing a hydraulic model. Calibration data typically come in the form of stage gage readings or high water marks. Unfortunately, historical stream gage data and high water marks are not widely available in the Cameron Run watershed. A USGS gage located near crossing CA003.C018 in Cameron Run provided the only calibration data for this model.

A storm event was selected for model calibration from the SWMM model long-term calibration period. An event on September 11, 1996 (Figure 2-5) resulted in a peak flow at the Cameron Run gage of 3,690 cfs, which corresponds to a peak flow recurrence interval of slightly less than the 4,020-cfs 2-year recurrence interval reported by USGS for this gage (USGS, 1994). Rainfall on that date ranged from 1.8 inches at the Sislers rain gage to 2.8 inches at the Skyline rain gage and averaged 2.3 inches which was slightly less than the 2.7 inch NRCS 1-year 24-hour rainfall amount.

Since there was only one calibration mark, calibrating uncertain parameters in the HEC-RAS model was not possible for most of the watershed; however, being located on the downstream portion of the watershed, the calibration mark at crossing CA003.C018 did provide a good measure for timing of peak flood waves through the system. The SWMM model supplied boundary condition flows for the HEC-RAS model. SWMM can simulate lag times in peak flows traveling through the watershed. As a result, the peak at the calibration gage on Cameron Run was not a summation of the peaks of Holmes Run and Backlick Run, but rather some quantity less than that. SWMM was able to capture this reduction in peak due to timing and was calibrated to the gage on Cameron Run. This provided sufficient confidence in the flows used in HEC-RAS model.

Calculated water surface elevations should be accepted with caution. Until further calibration data are retrieved and used to increase confidence of the results, the HEC-RAS model should be used as a comparison tool between different flow conditions and for ranking purposes of different alternatives, not necessarily for design work where quantification of hydraulic parameters is important.

3.3 POST-PROCESSING

Once the HEC-RAS model was complete, output data were exported to GIS. HEC-GeoRAS was used to compile data into useful graphical output such as floodplain polygon shape files and velocity line plots.

To generate floodplain shape files, GeoRAS first creates a water surface TIN for each of the flood events. The water surface TIN is clipped to fall within the bounds of the cross-sections (i.e., it does not extend beyond the end points of any cross-section), and is completely independent of the terrain TIN. After the water surface TIN is created, rasterization of the water surface TIN and the terrain TIN takes place, and the floodplain is delineated where the water surface exceeds the terrain elevations.

Because the resulting floodplain GIS file is only as good as the TINs that are used to create it, some manual adjustment of the floodplain boundary is necessary for the final product. Isolated "ponds" are removed from the floodplain file if it is determined that water cannot enter the ponds as surface water. There were areas where the floodplain extended beyond the extent of some of the cross-sections. Because the water surface TIN is clipped at the end of the cross-sections, manual extension of the floodplain was necessary. This process involved starting at a point within the water surface TIN bounds and tracing the floodplain boundary outside the TIN along a consistent contour elevation. This was continued until the floodplain boundary returned within the bounds of the water surface TIN (Figure 3-2).

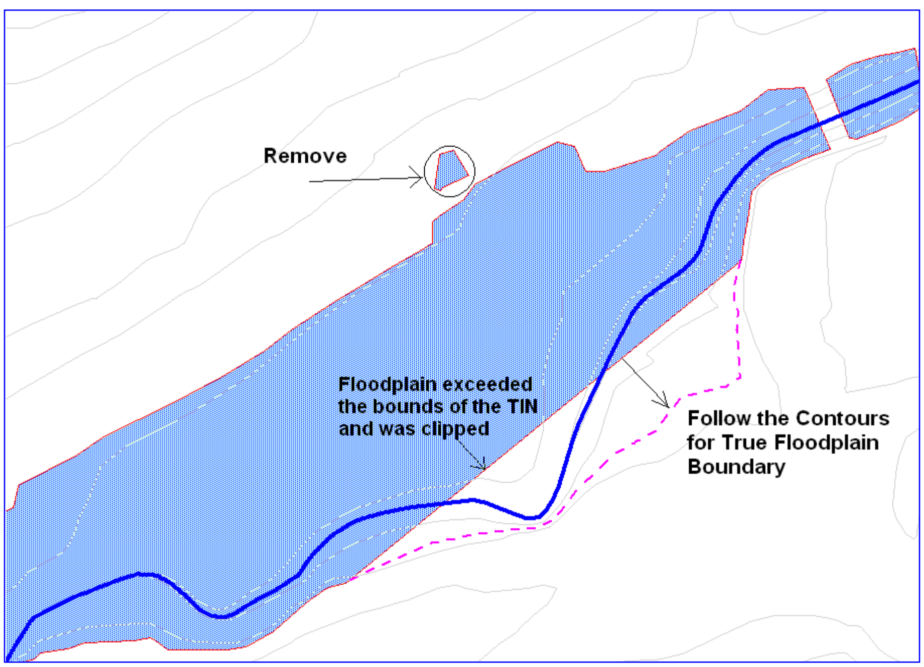

Figure 3-2. Manual adjustment of floodplain delineation

Velocity line plots were also created based on average channel velocities for 1- and 2-year events. After the HEC-RAS model is run, each cross-section has an average channel velocity. Every point that defines the streamline in GIS is then associated with the nearest cross-section and given the velocity of that cross-section. The resulting line plot is actually a series of points, each with its own velocity.

3.4 RESULTS AND CONCLUSIONS

At relatively low recurrence interval floods (1- and 2-year events), Holmes Run just downstream of Arlington Boulevard comes out of bank, creating a large floodplain. The majority of the overbank of this reach is forested and reserved as park land (Figure 3-3). Other areas of significant overbank flooding at low flows are the middle Backlick Run and the unnamed Backlick tributary, BA048, as well as a small unimproved stretch of Turkeycock Run between I-395 and Edsall Road. Most of the flooding at the low recurrence interval floods occurs in undeveloped parks and wetland areas.

Figure 3-3. 1-year flood event on Holmes Run downstream of Arlington Boulevard

Significant flooding occurs for the 100-year event on the lower Backlick Run and its confluence with Holmes Run. As shown in Figure 3-4, this location is mostly industrial and a substantial area is inundated. Interstate 395 initiates a large amount of flooding on Backlick Run, Indian Run, Turkeycock Run, and Holmes Run during the 100-year flood event. These areas are characterized by industrial and residential land uses with some park areas.

A long tunnel exists in the City of Fall Church on the upper section of Tripps Run where survey data were limited. The analysis indicates that the capacity of the tunnel is exceeded during the 10-year flood event. As a result, water spills over the embankment and flows overland. Where the overflow goes and how much reenters the main channel is unknown. An analysis of this kind would require a much more sophisticated model. For this study, no floodplain output is presented over the tunnel.

Figure 3-4. 100-year flood event in the Lower Backlick Run

Velocities for 1- and 2-year flood events for current and future conditions generally are less than 10 feet per second (fps) throughout the watershed (Figures 3-5 through 3-8). Areas of higher velocities (higher than 10 fps) include Holmes Run just below Fairview Lake, and Holmes Run from Lake Barcroft to its confluence with Backlick Run. Middle and lower sections of Backlick Run have some areas of high velocities as does Cameron Run downstream of Eisenhower Avenue. Figures 3-9 and 3-10 illustrate stream segments where velocities are greater than 5 fps for the 1- and 2-year design storms, indicating where erosion is more likely to occur. Table 3-2 lists the percentage of each stream reach that exceeds a peak velocity of 5 fps, grouped by subwatershed.

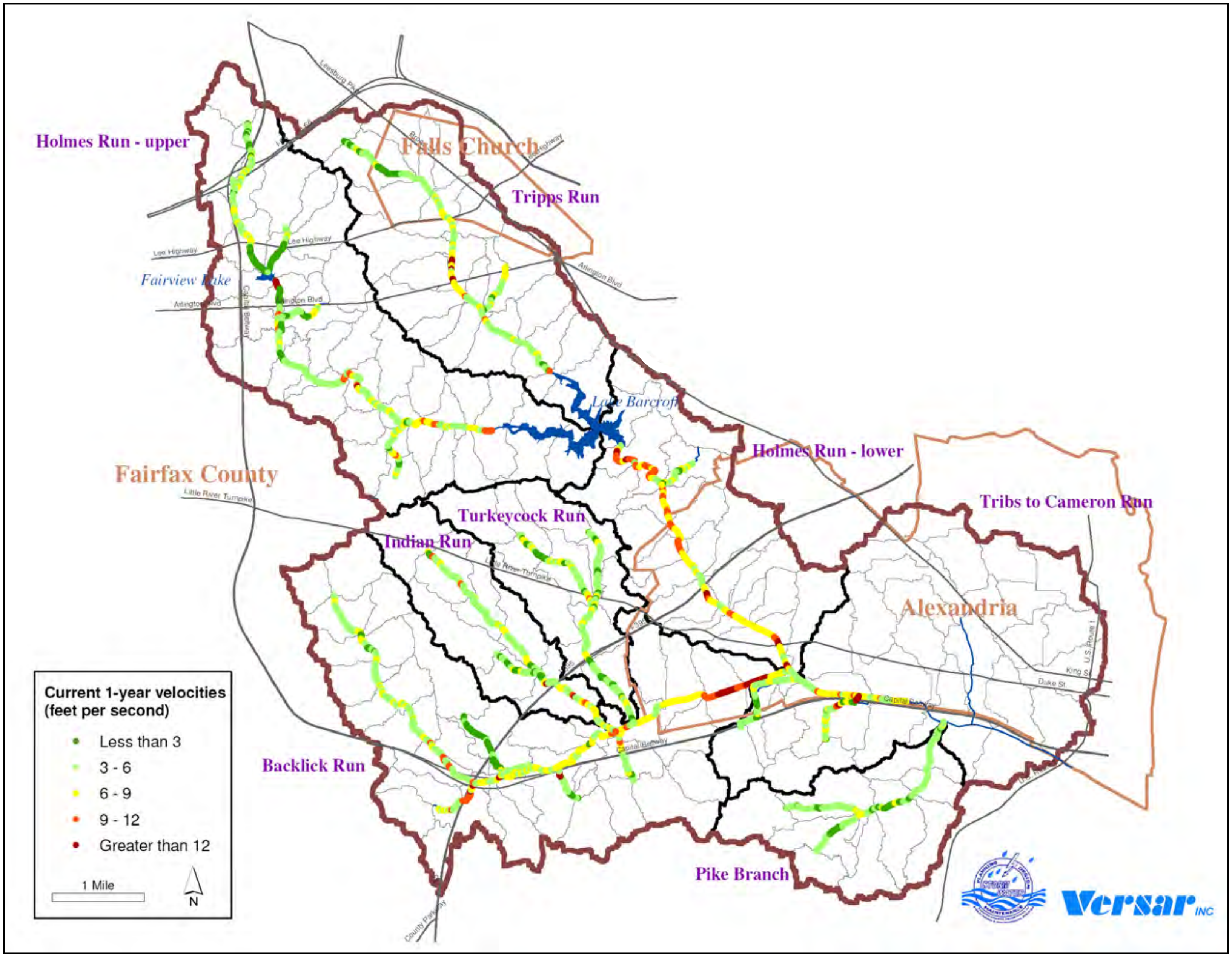

Figure 3-5. Peak stream velocities in the Cameron Run watershed for current conditions for a storm with a 1-year recurrence interval

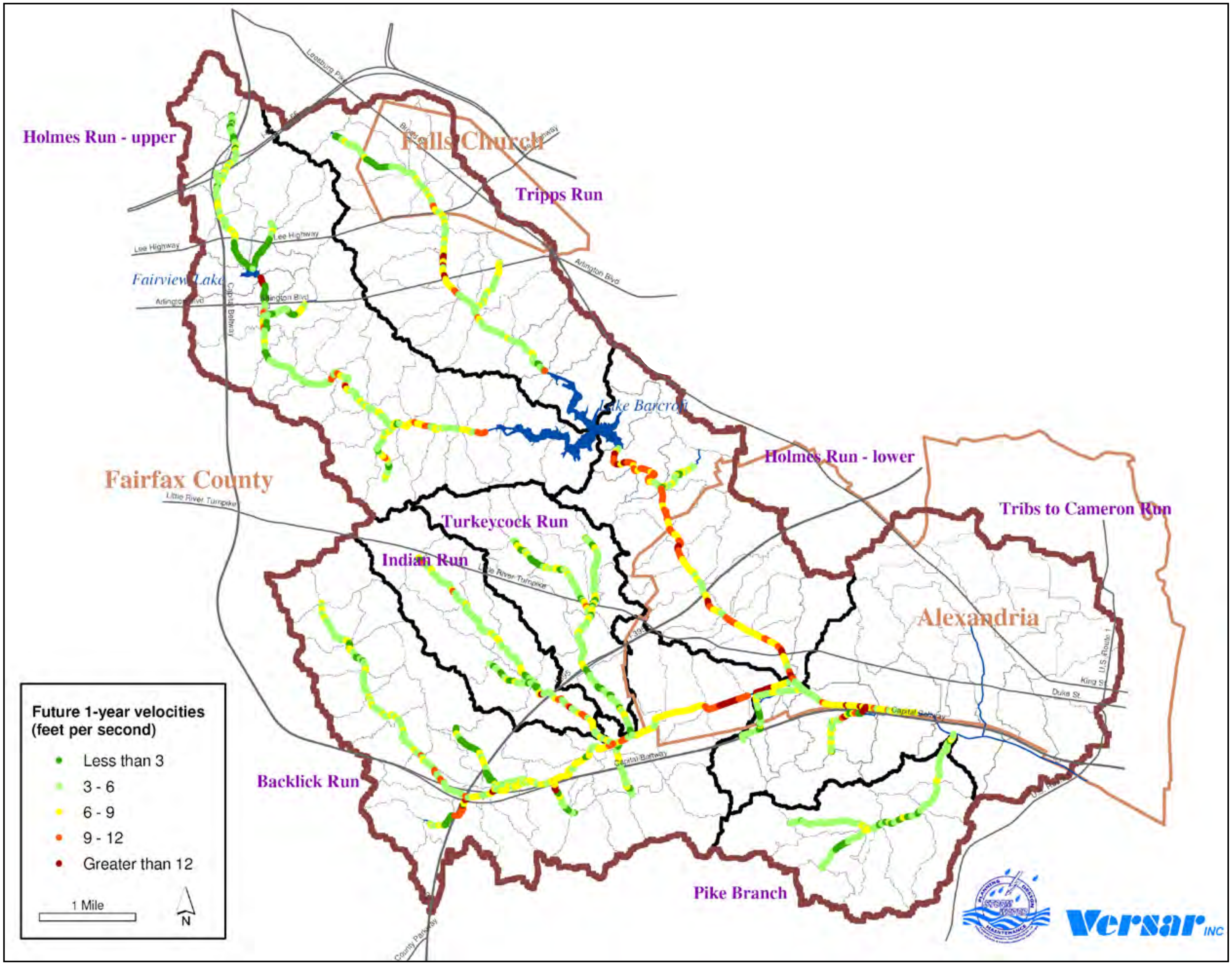

Figure 3-6. Peak stream velocities in the Cameron Run watershed for future conditions for a storm with a 1-year recurrence interval

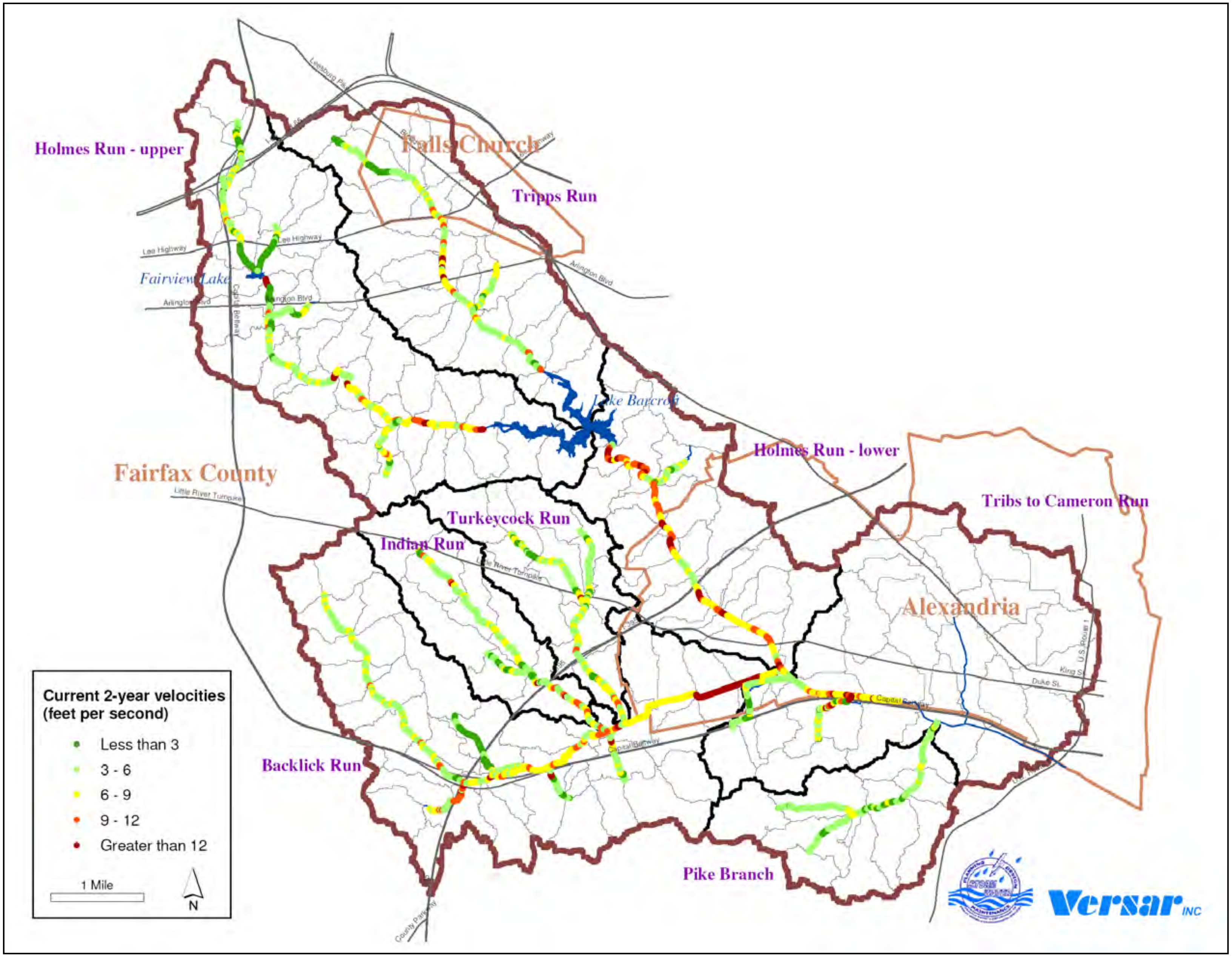

Figure 3-7. Peak stream velocities in the Cameron Run watershed for current conditions for a storm within a 2-year recurrence interval

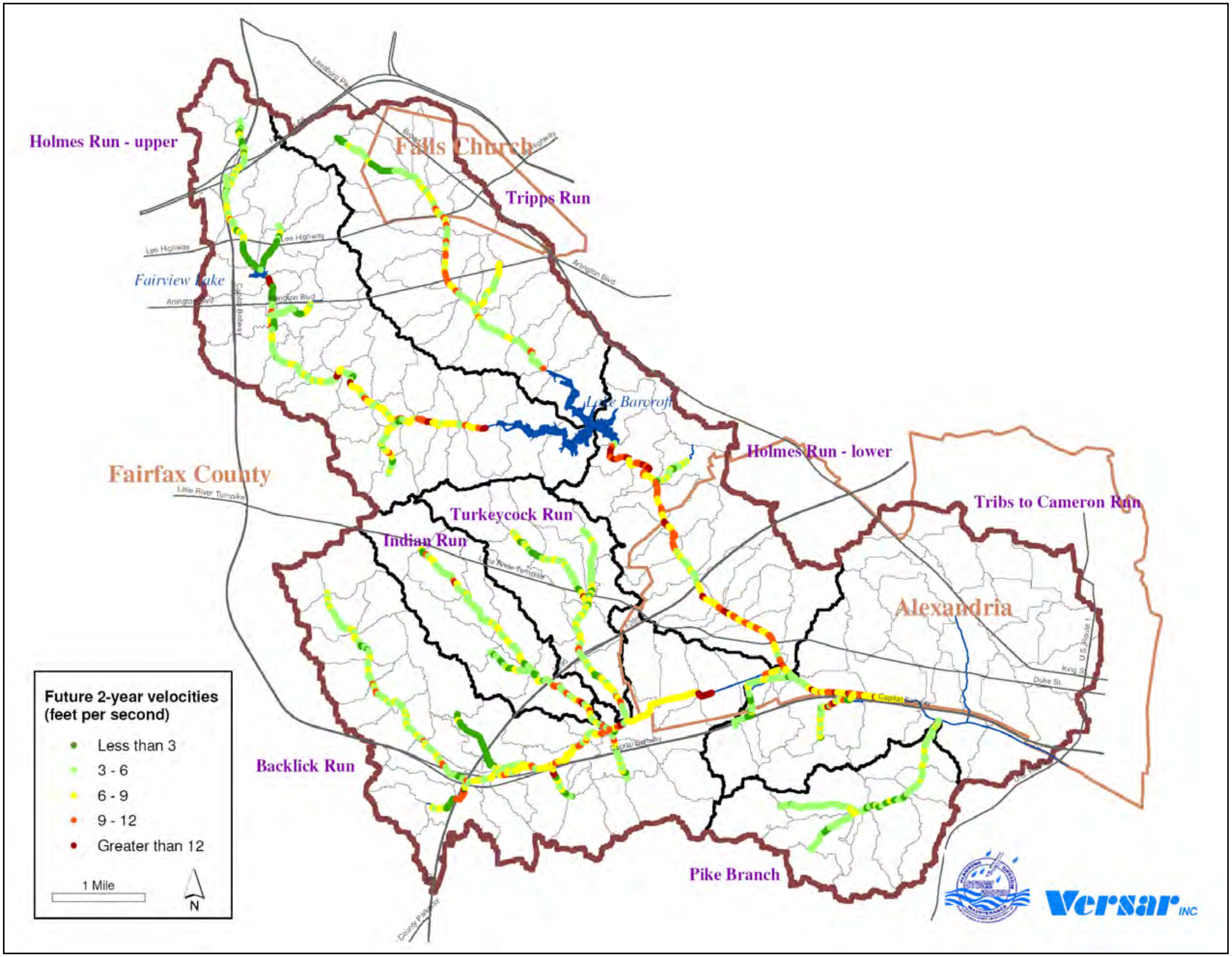

Figure 3-8. Peak stream velocities in the Cameron Run watershed for future conditions for a storm with a 2-year recurrence interval

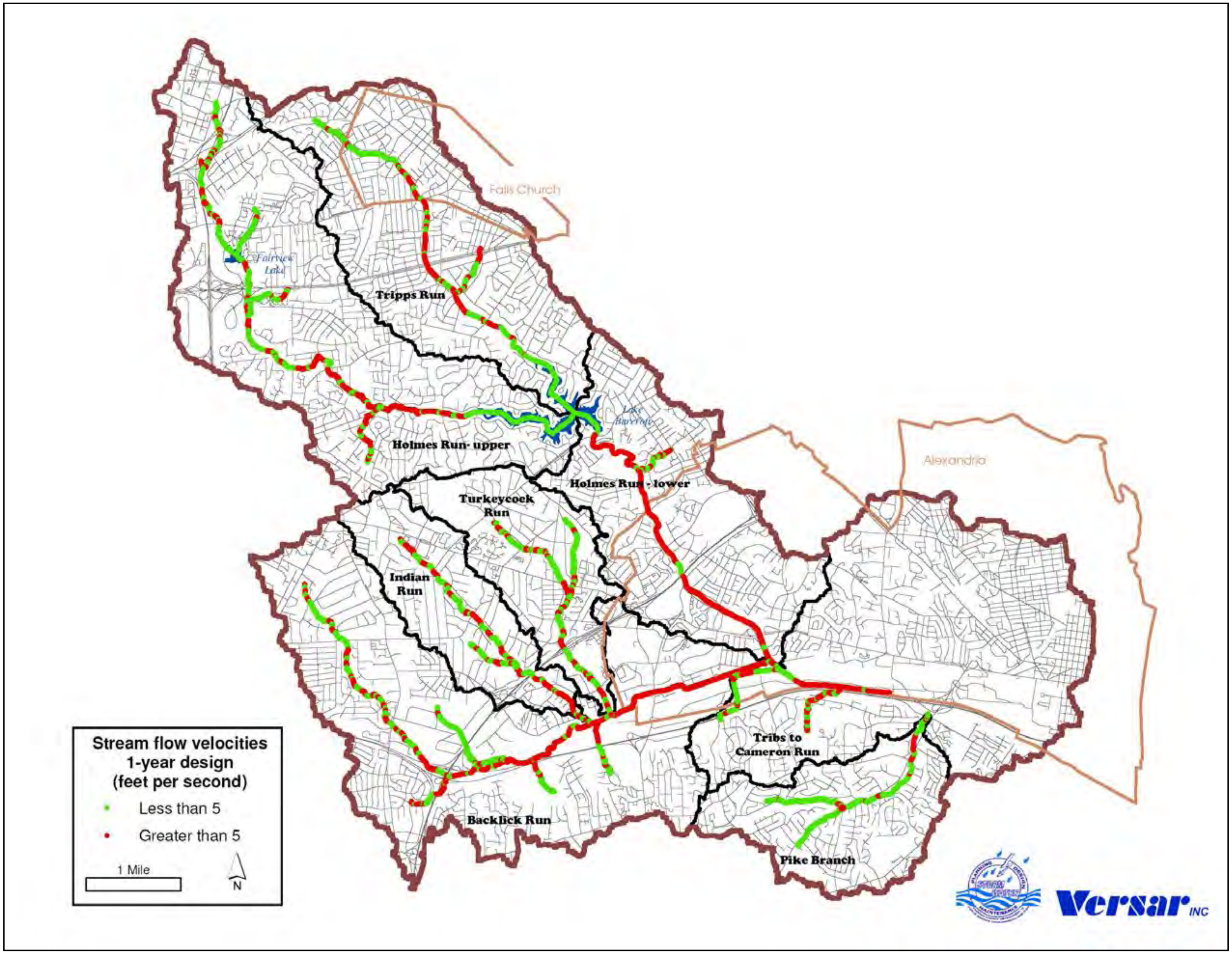

Figure 3-9. Peak stream velocities greater than 5 feet per second (fps) in the Cameron Run watershed for current conditions, for a storm with a 1-year recurrence interval

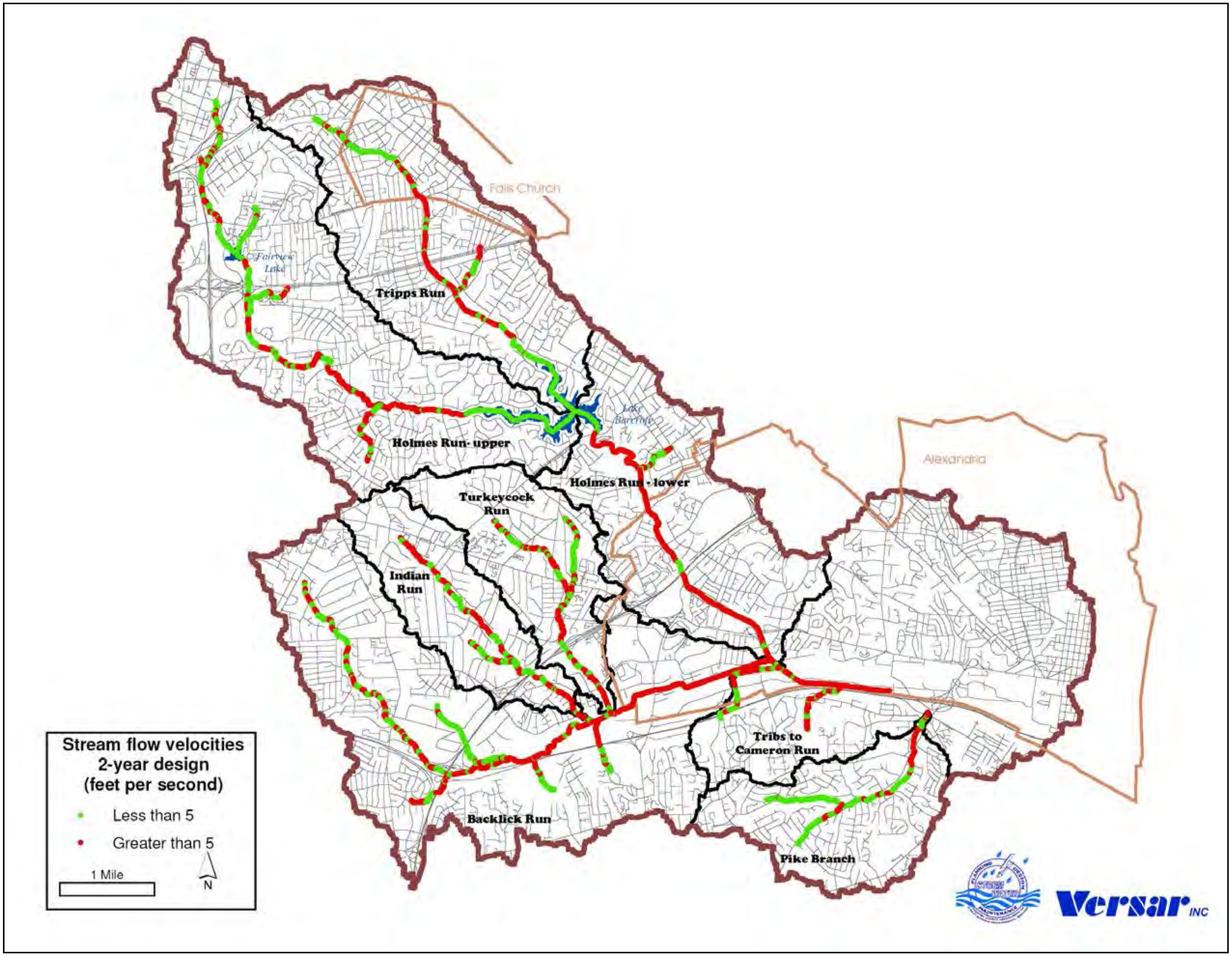

Figure 3-10. Peak stream velocities greater than 5 feet per second (fps) in the Cameron Run watershed for current conditions, for a storm with a 2-year recurrence interval

Table 3-2. HEC-RAS model stream reaches showing percentage of cross-sections exceeding a peak velocity of 5 feet per second (fps) for 1- and 2-year design storms

Subwatershed	Reach	Design Storm 1-year	Design Storm 2-year
		Percent > 5 fps	
Pike Branch	CA008	0	100
	PK001	0	14
	PK002	24	80
	PK003	2	2
	PK004	5	18
	PK005	15	48
	PK006	0	0
	PK007	9	23
	PK008	34	100
	PK009	64	100
	PK010	0	32
	PK011	17	17
	PK012	26	68
	PK017	0	0
	PK018	0	0
	PK019	9	10
Pike Branch Average		13	38
Tribs to Cameron Run	CA001	62	67
	CA002	0	100
	CA003	39	81
	CA004	100	100
	CA005	92	100
	CA006	100	100
	CA027	0	0
	CA028	30	30
	CA029	38	38
	CA030	0	0
	CA031	0	35
	CA032	37	78
	CA033	38	71
	CA039	79	79
	CA040	54	76
	CA041	59	59
	CA043	100	100
	CA044	81	81
Tribs Average		50	66

Table 3-2. (Continued)			
Subwatershed	**Reach**	**Design Storm**	
		1-year	**2-year**
		Percent > 5 fps	
Backlick Run	BA001	56	68
	BA002	0	45
	BA003	0	0
	BA004	51	51
	BA005	0	0
	BA006	63	63
	BA007	0	0
	BA008	9	9
	BA009	100	100
	BA010	59	59
	BA011	41	41
	BA012	0	0
	BA013	53	53
	BA014	59	59
	BA015	57	57
	BA016	39	60
	BA017	78	37
	BA018	0	0
	BA019	40	40
	BA020	71	71
	BA021	47	47
	BA022	20	68
	BA023	61	71
	BA024	100	100
	BA025	68	49
	BA026	80	80
	BA027	83	83
	BA028	67	100
	BA029	93	93
	BA030	87	87
	BA031	99	99
	BA032	100	100
	BA033	90	90
	BA034	83	83
	BA035	80	80
	BA036	100	100
	BA037	65	65
	BA038	99	99

Table 3-2. (Continued)			
Subwatershed	**Reach**	**Design Storm**	
		1-year	**2-year**
		Percent > 5 fps	
Backlick Run (Continued)	BA039	100	100
	BA040	100	100
	BA041	86	89
	BA042	57	71
	BA043	17	17
	BA044	100	100
	BA045	63	63
	BA046	98	98
	BA048	31	31
	BA049	0	0
	BA050	0	0
	BA051	0	0
	BA052	0	0
	BA053	0	0
	BA054	11	11
	BA059	0	0
	BA060	0	0
	BA061	60	60
	BA062	75	75
	BA066	13	13
	BA067	0	43
	BA068	86	100
Backlick Average		52	55
Holmes Run - Upper	HR003	0	0
	HR004	27	27
	HR005	13	13
	HR006	86	86
	HR007	49	49
	HR008	15	15
	HR009	47	47
	HR010	44	44
	HR011	32	32
	HR012	0	0
	HR013	0	0
	HR014	0	0
	HR015	27	27
	HR016	67	67
	HR017	43	43

Table 3-2. (Continued)			
Subwatershed	**Reach**	**Design Storm**	
		1-year	**2-year**
		Percent > 5 fps	
Holmes Run – Upper (Continued)	HR018	68	68
	HR019	85	85
	HR020	27	27
	HR021	68	68
	HR022	17	17
	HR023	0	0
	HR024	0	0
	HR025	0	0
	HR026	0	0
	HR027	0	0
	HR028	0	0
	HR029	75	75
	HR030	51	51
	HR031	50	50
	HR032	95	95
	HR033	14	73
	HR034	100	100
	HR035	43	69
	HR036	0	0
	HR037	0	0
	HR038	0	28
	HR039	34	68
	HR040	26	26
	HR041	41	46
	HR042	0	100
	HR043	0	60
	HR044	0	23
	HR045	97	97
	HR046	16	16
	HR047	66	66
	HR048	100	100
	HR049	74	52
	HR050	0	0
	HR051	98	98
	HR052	100	100
	HR053	39	100
	HR054	75	100
	HR055	70	100

Table 3-2. (Continued)			
Subwatershed	**Reach**	**Design Storm**	
		1-year	**2-year**
		Percent > 5 fps	
Holmes Run – Upper (Continued)	HR056	46	62
	HR057	100	100
	HR058	67	100
	HR059	70	100
	HR060	100	100
	HR061	100	100
	HR062	100	100
	HR063	80	96
	HR064	97	97
	HR065	25	25
	HR066	100	100
	HR067	79	73
	HR068	100	44
	HR069	72	100
	HR070	11	11
	HR100	72	72
	HR106	15	15
	HR107	0	0
	HR108	0	0
	HR109	0	0
	HR110	0	0
	HR113	26	89
	HR114	44	44
	HR115	37	37
	HR116	6	28
	HR117	0	0
	HR118	0	0
	HR120	61	60
Holmes Run - Upper Average		42	49
Holmes Run - Lower	HR071	53	53
	HR072	100	100
	HR073	100	100
	HR074	100	100
	HR075	100	100
	HR076	100	100
	HR077	100	100
	HR078	41	100
	HR079	69	100

Table 3-2. (Continued)			
Subwatershed	**Reach**	**Design Storm**	
		1-year	**2-year**
		Percent > 5 fps	
Holmes Run – Lower (Continued)	HR080	100	100
	HR081	100	100
	HR082	100	100
	HR083	100	100
	HR084	100	100
	HR085	100	100
	HR086	100	100
	HR087	100	100
	HR088	100	100
	HR089	100	100
	HR090	100	100
	HR091	37	37
	HR092	0	0
	HR093	93	93
	HR094	100	100
	HR095	83	83
	HR096	91	91
	HR123	46	38
Holmes Run - Lower Average		86	89
Indian Run	IR004	52	80
	IR005	100	100
	IR006	17	100
	IR007	62	100
	IR008	100	100
	IR009	12	12
	IR010	65	65
	IR011	23	89
	IR012	21	21
	IR013	28	28
	IR014	0	0
	IR015	0	0
	IR016	63	63
	IR017	100	100
	IR018	100	100
	IR019	33	53
	IR020	38	38
	IR021	89	89
	IR022	68	68

Table 3-2. (Continued)			
Subwatershed	**Reach**	**Design Storm**	
		1-year	**2-year**
		Percent > 5 fps	
Indian Run (Continued)	IR023	0	0
	IR024	0	0
	IR025	82	56
	IR026	48	69
	IR027	92	92
	IR028	52	69
	PR003	16	29
	PR004	70	70
	PR005	32	32
Indian Run Average		49	58
Turkeycock Run	TK002	16	23
	TK003	54	54
	TK004	44	44
	TK005	42	69
	TK006	0	100
	TK007	34	59
	TK008	48	85
	TK009	37	45
	TK014	38	38
	TK015	46	62
	TK016	13	65
	TK017	61	61
Turkeycock Run Average		36	59
Tripps Run	TR001	0	0
	TR002	0	0
	TR003	19	24
	TR004	35	48
	TR005	100	100
	TR006	52	52
	TR007	17	17
	TR008	89	89
	TR009	50	50
	TR010	68	91
	TR011	100	88
	TR012	100	100
	TR013	26	66
	TR014	99	99
	TR015	23	34

Table 3-2. (Continued)			
Subwatershed	**Reach**	**Design Storm**	
		1-year	**2-year**
		Percent > 5 fps	
Tripps Run (Continued)	TR016	0	100
	TR017	61	80
	TR018	0	0
	TR019	0	0
	TR020	2	2
	TR021	89	89
	TR022	32	49
Tripps Run Average		44	54

Results presented in the form of ArcView shapefile polygons and lines were generated in the steady flow version of HEC-RAS, which is a one-dimensional model. Because the steady flow version of HEC-RAS was used, no time-dependant hydrodynamic effects were captured in calculated water surface profiles, such as flow attenuation and lag times; however, flow attenuation was simulated by manually including lateral inflows throughout the watershed based on the results from the SWMM model, which does provide a method for estimating flow attenuation and lag time. The SWMM model results were calibrated to a gage at the downstream end of the watershed, which provides some confidence in both overall magnitudes and peak flow timing.

Being a one-dimensional model, HEC-RAS computes single water surface elevations for each cross-section. In other words, water surface elevation presented in the HEC-RAS results will not vary along the length of a cross-section because overbanks and the main channel will have the same water surface elevation. In reality, overbanks typically have a higher water surface elevation than the main channel. As a result, model flow will come out of bank earlier than in reality and water surface elevation in overbanks will be slightly lower than in reality. Errors due to the one-dimensionality of HEC-RAS are typically inconsequential for watershed-level analyses, and the results are generally accepted for use in planning and design.

Complete floodplain maps for each of the design storm simulations for current and future conditions in the watershed are shown in Figures 3-11 through 3-15. Figure 3-15 shows the 100-year design storm simulations for current and future conditions along with the buildings which are within or touching the peak water level resulting from this size storm. Table 3-3 lists the number of buildings in each subwatershed within or touching the 100-year floodplain for current conditions. There is little difference between current and future conditions since this watershed is already mostly built-out. Table 3-4 lists all crossings included in the model, their locations, and which are impacted or overtopped at various recurrence intervals. Crossings that may be overtopped are illustrated in Figures 3-16 and 3-17 for current and future conditions; Figures 3-18 and 3-19 list roadway bridges that may be overtopped by various design storms. Table 3-5 summarizes the number of roadway bridges that may be overtopped by various design storms. Table 3-6 lists crossings that were surveyed but not included in the model.

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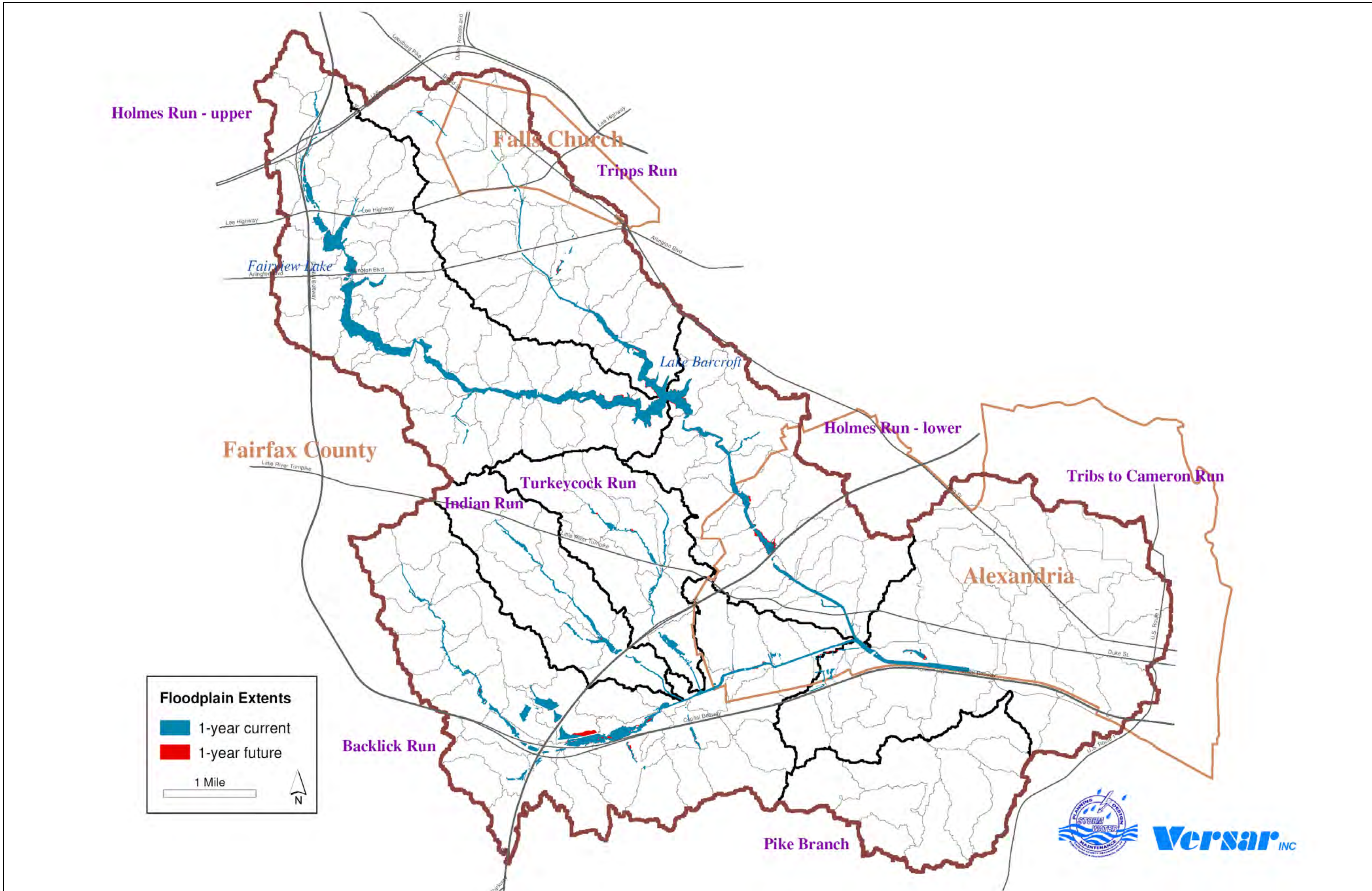

Figure 3-11. 1-year floodplain for Cameron Run watershed for current and future land use conditions

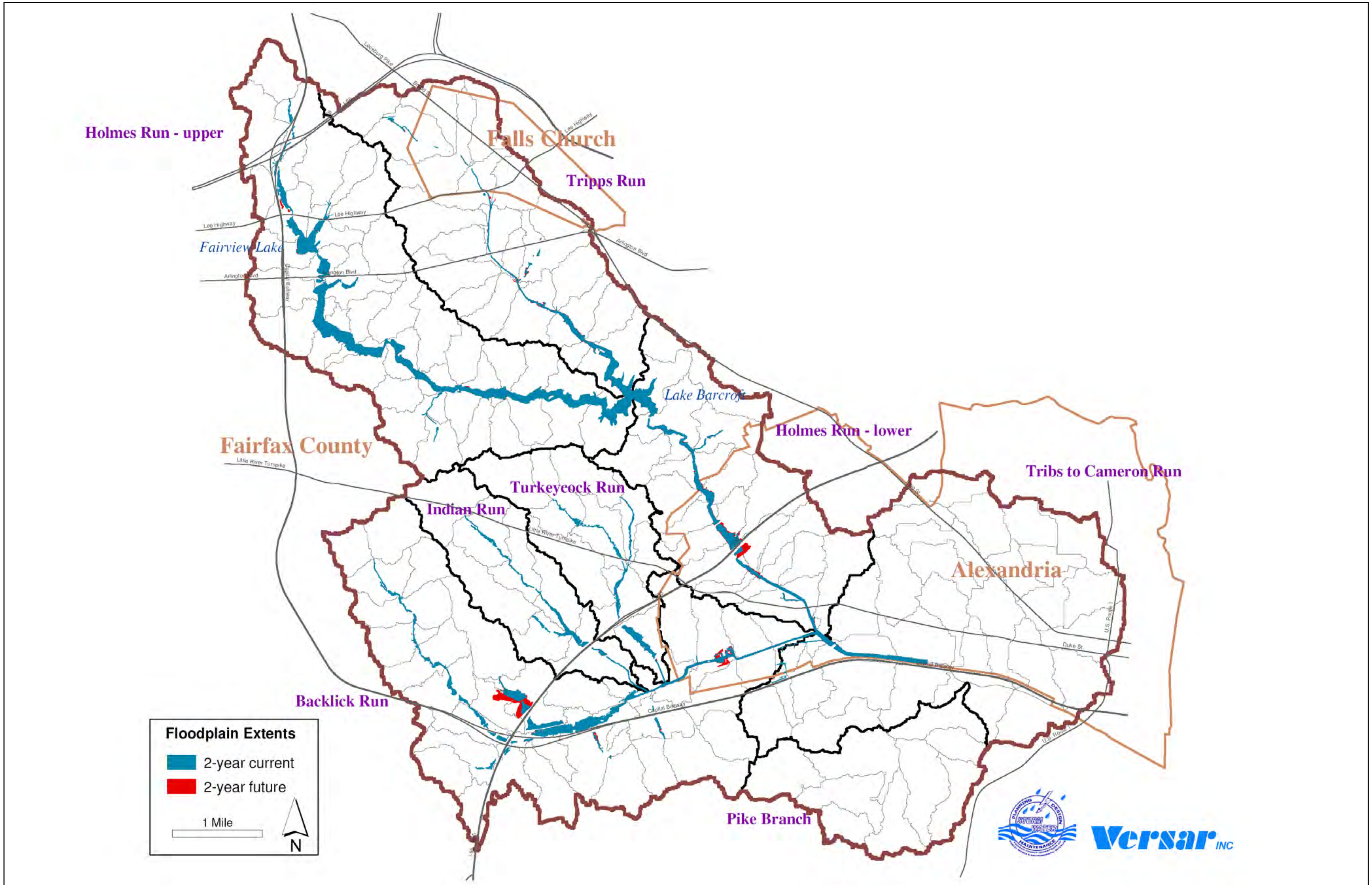

Figure 3-12. 2-year floodplain for Cameron Run watershed for current and future land use conditions

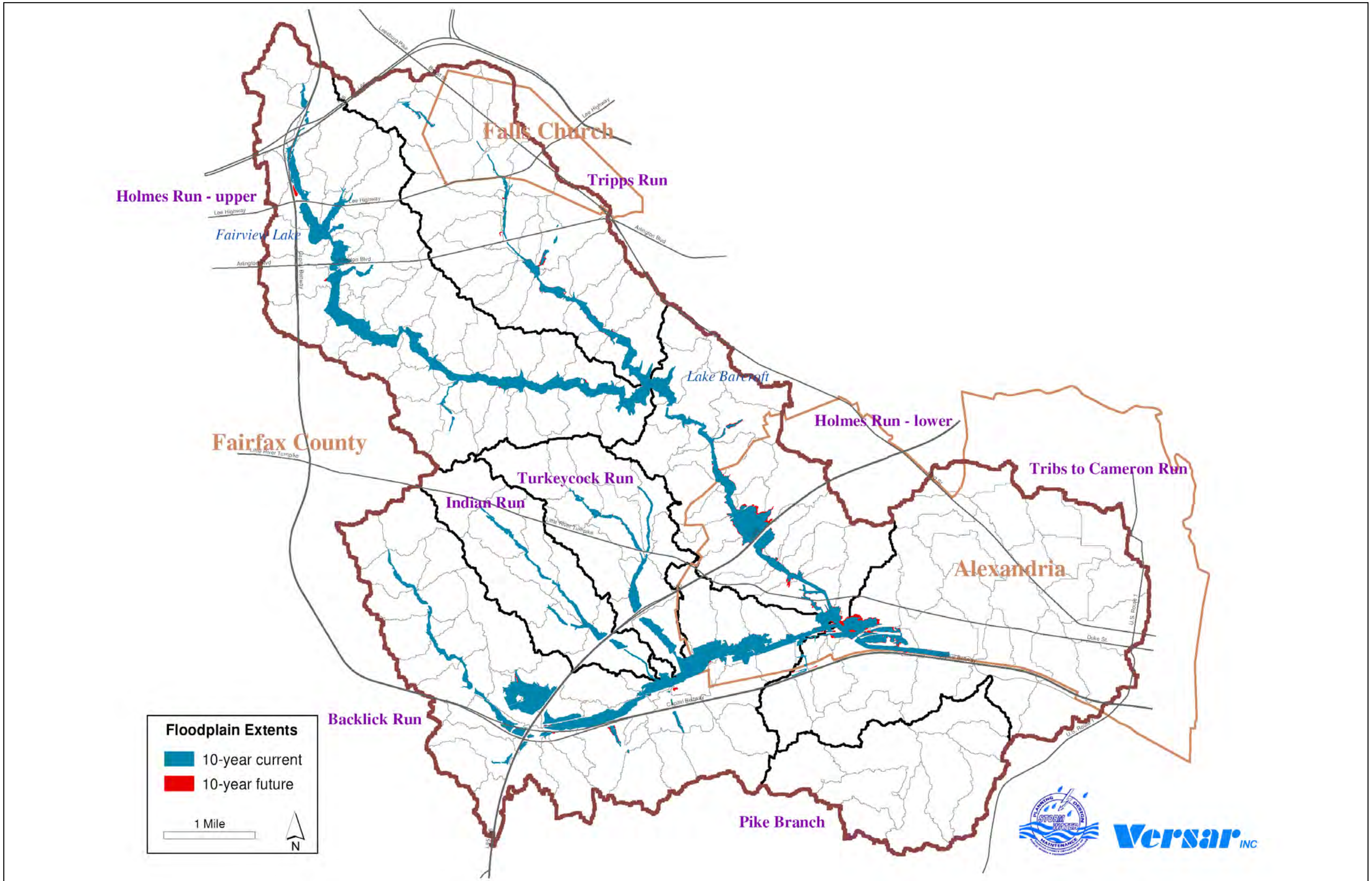

Figure 3-13. 10-year floodplain for Cameron Run watershed for current and future land use conditions

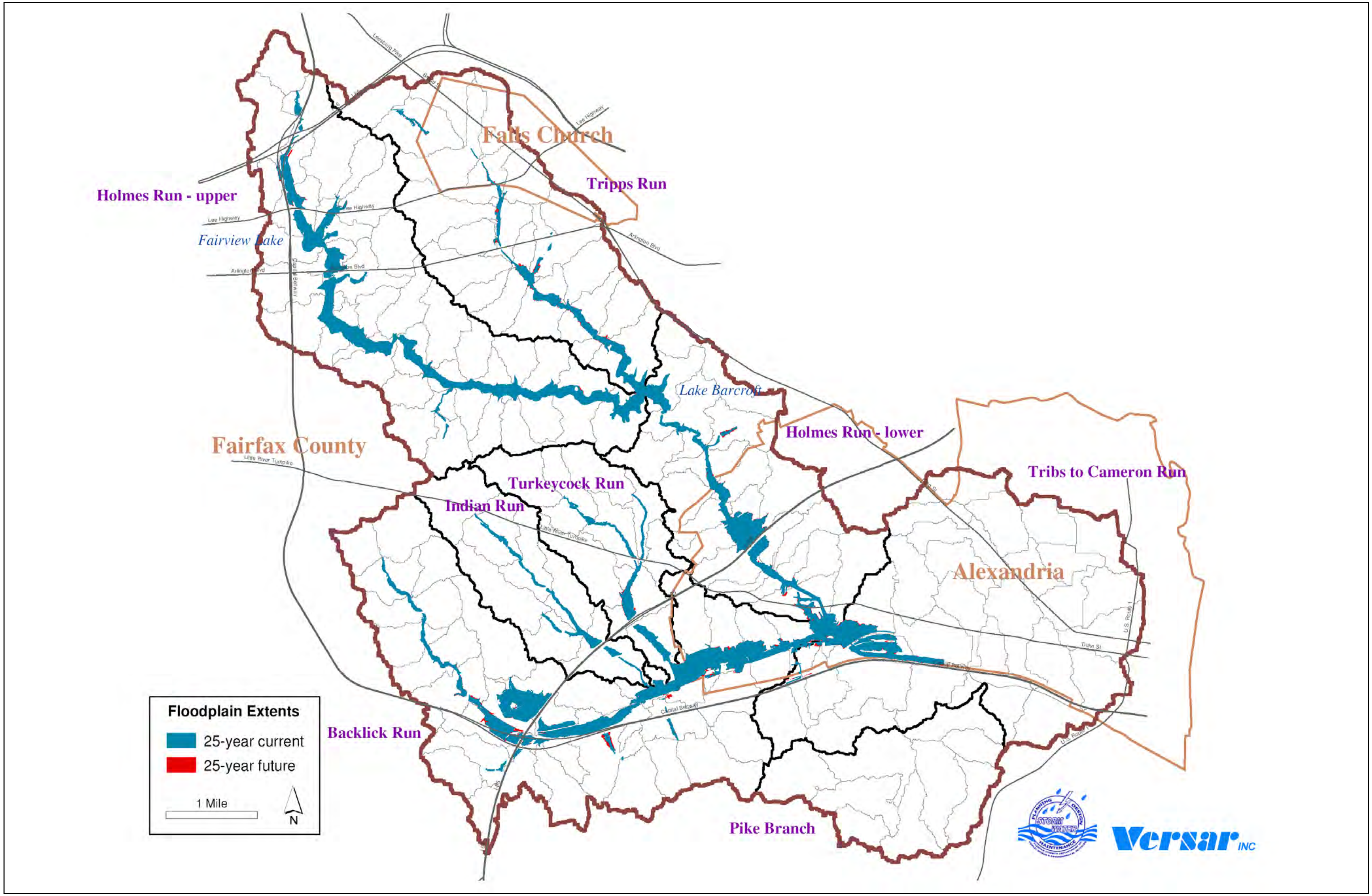

Figure 3-14. 25-year floodplain for Cameron Run watershed for current and future land use conditions

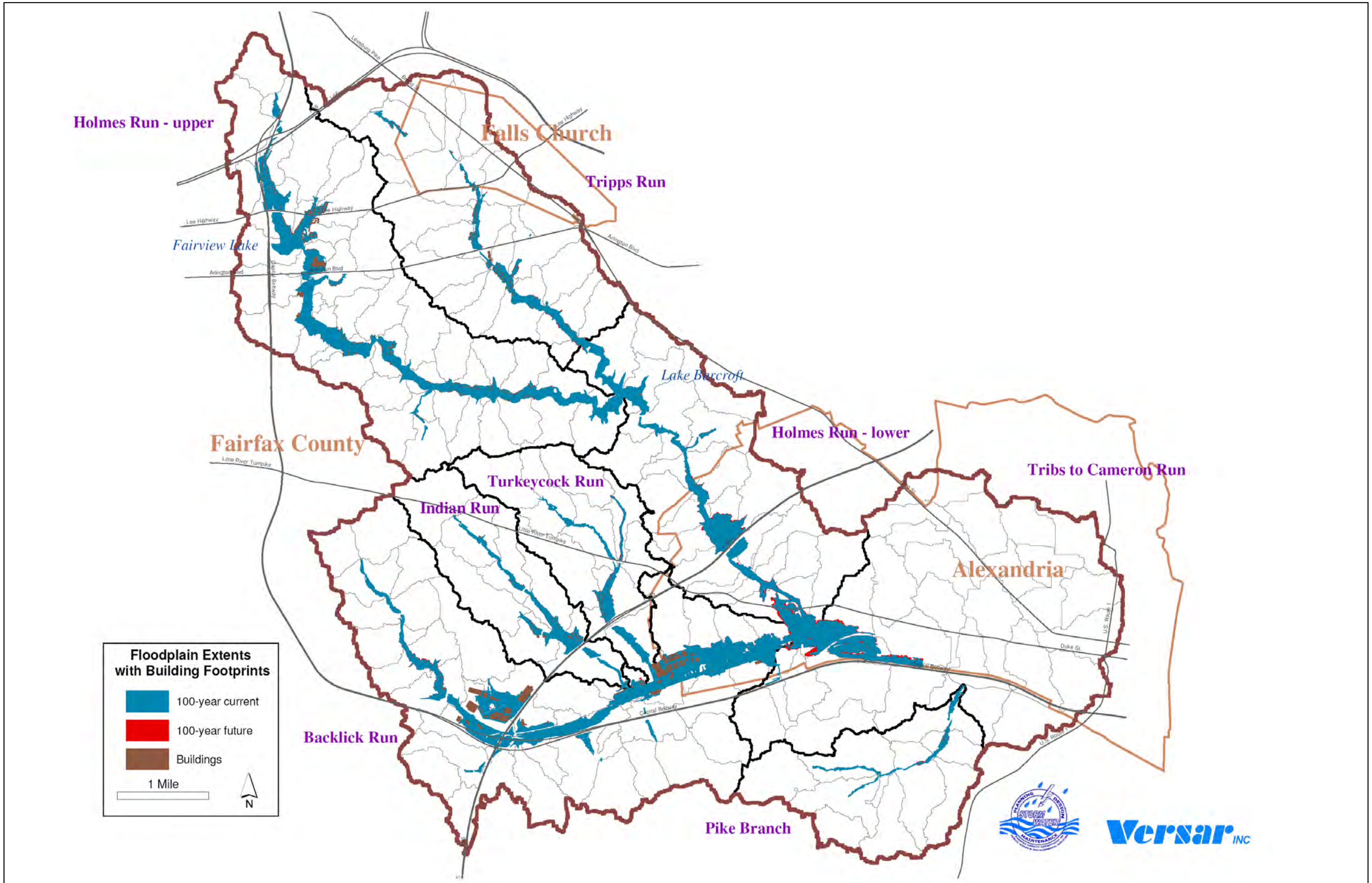

Figure 3-15. 100-year floodplain for Cameron Run watershed for current and future land use conditions; buildings in or adjacent to the 100-year floodplain are also shown

Table 3-3. Number of buildings intersecting the 100-year floodplain for current conditions in the Fairfax County areas of Cameron Run watershed

Subwatershed	Buildings in Floodplain	Buildings in Subwatershed
Backlick Run	108	7554
Cameron Run Tributaries and Mainstem	8	2477
Holmes Run - Upper	280	9329
Holmes Run - Lower	16	3362
Indian Run	60	2488
Pike Branch	22	3936
Turkeycock Run	46	2297
Tripps Run	208	9040

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Table 3-4. Crossings in Cameron Run HEC-RAS model, including IDs, location information, type, and flood impact and overtopping results

Crossing ID	Map ID	X Coordinate	Y Coordinate	Stream Name	Reach	Station	Description	Subtype	Present Impacted	Present Overtopped	Future Impacted	Future Overtopped	Street Location Detail	ADC Map and Grid #
BACKLICK RUN														
CABA010.C001	1	11854874.2	6981307.9	BackLick Run	BA001	32400	Culvert	3 concrete box	100-Year	N/A	100-Year	N/A	Braddock nr. Ferndale	19 F-4
CABA007.C003	2	11857061.3	6977666.4	BackLick Run	BA001	27100	Culvert	concrete arch	100-Year	100-Year	N/A	100-Year	Leesville nr. Backlick Rd.	19 G-6
CABA007.C002	3	11857541.5	6976572.3	BackLick Run	BA001	25600	Culvert	3 concrete box	25-Year	100-Year	25-Year	100-Year	Backlick nr. Wimsatt	19 G-6
CABA007.C001	4	11858220.0	6975870.3	BackLick Run	BA001	24600	Bridge	0 pier rr bridge	25-Year	100-Year	25-Year	100-Year	Hechinger nr. Backlick Rd.	19 H-7
CABA005.C008	5	11859118.8	6974818.4	BackLick Run	BA001	23100	Bridge	0 pier roadway bridge	10-Year	10-Year	N/A	10-Year	Versar Center Drive	19 H-7
CABA005.C007	6	11859412.6	6974423.1	BackLick Run	BA001	22600	Culvert	4 concrete box	10-Year	10-Year	N/A	10-Year	I-495 WB west of I-395	19 H-7
CABA005.C006	7	11859788.6	6974126.0	BackLick Run	BA001	22000	Culvert	3 concrete box	10-Year	10-Year	N/A	10-Year	I-495 WB to I-395 SB ramp	19 H-7
CABA005.C005	8	11860115.9	6974029.7	BackLick Run	BA001	21700	Culvert	3 corrugated plastic pipe	1-Year	1-Year	N/A	1-Year	between I-495 EB and WB lanes, west of I-395	19 J-8
CABA005.C004	9	11860533.3	6973809.9	BackLick Run	BA001	21200	Culvert	2 concrete box	10-Year	10-Year	N/A	10-Year	I-395 between I-495 EB and WB lanes	19 J-8
CABA005.C002	10	11861151.1	6973798.6	BackLick Run	BA026	20500	Culvert	4 concrete box	10-Year	100-Year	10-Year	100-Year	I-495 EB to I-395 NB ramp	19 J-8
CABA005.C001	11	11862061.1	6974095.5	BackLick Run	BA026	19600	Culvert	4 concrete box	10-Year	10-Year	N/A	10-Year	I-495 WB to I-395 NB ramp	19 K-8
CABA030.C002	12	11861309.7	6976216.2	BA Unnamed2	BA048	4500	Culvert	2 RCP	1-Year	1-Year	N/A	1-Year	Industrial @ Electronic	19 J-6
CABA030.C001	13	11861613.5	6975486.7	BA Unnamed2	BA048	3500	Culvert	drop culvert inlet; 1 chamber concrete box outlet	10-Year	10-Year	2-Year	10-Year	I-395 between Exit 1 and Exit 2	19 J-7
CABA028.C001	14	11862136.0	6974485.9	BA Unnamed2	BA048	2200	Culvert	1 stone/concrete arch/box	1-Year	1-Year	N/A	1-Year	railroad bed nr I-495 WB to I-395 NB ramp	19 K-7
CABA035.C002	15	11865518.3	6974166.9	BA Unnamed3	BA059	600	Culvert	1 concrete box	25-Year	100-Year	10-Year	25-Year	I-495 east of I-395 jct.	20 B-7
CABA035.C001	16	11865429.9	6974562.4	BA Unnamed3	BA059	300	Culvert	2 concrete box	25-Year	N/A	10-Year	N/A	I-495 east of I-395 jct.	20 A-7
CABA002.C001	17	11867352.7	6976117.3	BackLick Run	BA032	12900	Bridge	1 pier rr bridge	10-Year	10-Year	N/A	10-Year	Rear Shirley Edsall Indus. Park.	20 B-6
CABA001.C002	18	11869822.1	6977167.1	BackLick Run	BA038	9860	Bridge	3 pier rr bridge	10-Year	10-Year	N/A	10-Year	Rear office park on Pickett	20 D-6
CABA001.C001	19	11872233.7	6978474.0	BackLick Run	BA038	6800	Culvert	4 concrete box	1-Year	1-Year	N/A	1-Year	S. Van Dorn nr. Pickett	20 E-5
CABA118.C001	20	11877028.1	6979704.7	BackLick Run	BA038	1730	Bridge	0 pier footbridge	100-Year	100-Year	N/A	100-year	Somerville St. end	20 H-5
CABA118.C002	21	11878163.7	6980079.2	BackLick Run	BA038	532	Bridge	0 pier footbridge	10-Year	10-Year	10-Year	25-Year	Holmes Run Parkway nr Backlick Run & Holmes Run confluence	20 H-4
CAMERON RUN TRIBUTARIES AND MAINSTEM														
CACA118.C002	1	11876756.2	6977713.2	CA Unnamed1	CA027	4400	Culvert	1 RCP inlet; 1 CMP outlet	2-Year	2-Year	N/A	2-Year	railroad bed nr I-495 west of Exit 174	20 G-6
CACA118.C001	2	11876767.8	6977882.1	CA Unnamed1	CA027	4090	Culvert	1 concrete box	10-Year	10-Year	N/A	10-Year	Driveway south of Eisenhower west of Connector	20 G-5
CACA118.C003	3	11876621.2	6978680.0	CA Unnamed1	CA027	3250	Culvert	1 concrete box inlet; 1 RCP outlet	1-Year	1-Year	N/A	1-Year	Eisenhower Ave west of Connector	20 G-5
CACA003.C017	4	11879088.1	6979750.5	Cameron Run	CA001	6500	Bridge	8 pier rr bridge	25-Year	25-Year	N/A	10-Year	railroad bridge downstream of Backlick Run & Holmes Run confluence, upstream of Eisenhower Ave. crossing	20 J-5
CACA003.C018	5	11879592.0	6979394.2	Cameron Run	CA003	5800	Culvert	7 RCP + brick/concrete arch	25-Year	N/A	10-Year	N/A	railroad bridge downstream of Backlick Run & Holmes Run confluence, upstream of Eisenhower Ave. crossing	20 J-5
CACA002.C001	6	11880642.3	6976288.0	CA Unnamed2	CA039	4200	Culvert	1 CMP	1-Year	2-Year	1-Year	2-Year	Paved pedestrian path nr. Marjoram Ct.	20 K-6
CACA001.C004	7	11880736.4	6977971.0	CA Unnamed2	CA039	2160	Culvert	1 CMP	1-Year	1-Year	N/A	1-Year	Dirt drive off Elmwood Dr. nr Peaceful Terr.	20 K-6
CACA001.C003	8	11881181.8	6978062.3	CA Unnamed2	CA039	1700	Culvert	1 concrete box	1-Year	1-Year	N/A	1-Year	Elmwood Dr. nr Peaceful Terr.	20 K-6
CACA001.C001	9	11882349.3	6978440.9	CA Unnamed2	CA039	300	Culvert	4 concrete box	N/A	N/A	N/A	N/A	I-495 between Exit 174 & 176	21 A-6
HOLMES RUN UPPER														
CAHR021.C001	1	11847672.1	7010882.3	Holmes Run	HR003	60200	Culvert	2 concrete box	10-Year	10-Year	N/A	10-Year	Idylwood nr. Shreve Hill Rd.	13 B-2
CAHR038.C001	2	11847887.0	7009436.0	Holmes Run	HR003	58500	Culvert	3 concrete box	100-Year	N/A	100-Year	N/A	I-495 NB to I-66 WB ramp	13 B-3
CAHR037.C002	3	11847843.4	7008954.4	Holmes Run	HR003	58000	Culvert	3 concrete box	25-Year	N/A	25-Year	N/A	I-66 WB east of I-495 interchange	13 B-3
CAHR037.C001	4	11847041.7	7007726.8	Holmes Run	HR003	56500	Culvert	3 concrete box	10-Year	100-Year	25-Year	100-Year	I 495 NB south of I-66 interchange	13 B-4
CAHR020.C004	5	11846895.9	7006852.2	Holmes Run	HR012	55000	Culvert	3 concrete box	10-Year	25-Year	10-Year	25-Year	I 495 NB south of I-66 interchange	13 B-4
CAHR020.C003	6	11847106.5	7005757.5	Holmes Run	HR012	54300	Culvert	2 concrete box	10-Year	10-Year	N/A	10-Year	Shreve 0.5 mi. n of US 29	13 B-5
CAHR020.C002	7	11847823.8	7004835.3	Holmes Run	HR012	52950	Bridge	0 pier footbridge	1-Year	1-Year	N/A	1-Year	Jefferson Dist. Park nr. US 29 at Shreve	13 B-5
CAHR020.C001	8	11847864.8	7004562.0	Holmes Run	HR012	52600	Culvert	2 concrete box	25-Year	N/A	25-Year	N/A	US 29 nr Shreve	13 B-5
CAHR022.C002	9	11849674.9	7004289.5	HR Unnamed2	HR106	1800	Culvert	4 concrete box	1-Year	10-Year	1-Year	10-Year	US 29 nr Mary St.	13 C-5
CAHR022.C001	10	11849170.6	7003689.0	HR Unnamed2	HR106	900	Culvert	3 concrete box	1-Year	10-Year	1-Year	2-Year	New Providence Drive	13 C-6
CAHR017.C002	11	11849473.5	7001589.1	Holmes Run	HR017	48860	Culvert	3 concrete box	1-Year	1-Year	N/A	1-Year	US 50 WB ramp to Fairview Park Dr.	13 C-7
CAHR017.C001	12	11849505.0	7000964.2	Holmes Run	HR017	48000	Culvert	3 concrete box	1-Year	1-Year	N/A	1-Year	US 50 east of Fairview Park Dr.	13 C-7
HOLMES RUN UPPER (Cont'd)														

Table 3-4. Crossings in Cameron Run HEC-RAS model, including IDs, location information, type, and flood impact and overtopping results

Crossing ID	Map ID	X Coordinate	Y Coordinate	Stream Name	Reach	Station	Description	Subtype	Present Impacted	Present Overtopped	Future Impacted	Future Overtopped	Street Location Detail	ADC Map and Grid #
CAHR016.C003	13	11849461.9	7000544.9	Holmes Run	HR017	47500	Culvert	3 concrete box	1-Year	10-Year	1-Year	10-Year	Fairview Park to US 50 EB ramp	13 C-7
CAHR053.C002	14	11851537.9	7000669.4	HR Unnamed3	HR112	3400	Bridge	0 pier footbridge	1-Year	2-Year	N/A	1-Year	Lakeside Village Dr. end	13 D-7
CAHR053.C001	15	11850739.0	7000612.2	HR Unnamed3	HR112	2400	Culvert	3 concrete box	100-Year	N/A	100-Year	N/A	Jaguar Terr	13 D-7
CAHR016.C002	16	11849497.6	6999132.6	Holmes Run	HR033	46130	Bridge	0 pier footbridge	1-Year	1-Year	N/A	1-Year	Fairview Park Drive S, rear of office building	13 C-8
CAHR016.C001	17	11849737.9	6997894.2	Holmes Run	HR033	44720	Bridge	0 pier footbridge	10-Year	10-Year	N/A	10-Year	Holly Berry Ct. in apartment complex	13 C-9
CAHR005.C002	18	11850983.3	6997225.2	Holmes Run	HR033	43140	Bridge	0 pier footbridge	1-Year	1-Year	N/A	1-Year	Hartwell Ct. end	13 D-9
CAHR005.C001	19	11851794.2	6996578.1	Holmes Run	HR033	41950	Bridge	0 pier footbridge	1-Year	1-Year	N/A	1-Year	Arnold La. end, s. side of stream	13 E-9
CAHR004.C001	20	11853923.9	6996454.2	Holmes Run	HR033	38500	Bridge	0 pier roadway bridge	1-Year	2-Year	1-Year	2-Year	Annandale Rd. nr. Sheffield	13 F-9
CAHR002.C001	21	11857708.9	6994437.6	Holmes Run	HR063	32710	Bridge	0 pier footbridge	10-Year	10-Year	N/A	10-Year	Rose La. end, s. side Slade Run	13 H-10
CAHR001.C002	22	11859335.3	6994126.1	Holmes Run	HR063	30990	Bridge	0 pier footbridge	1-Year	1-Year	N/A	1-Year	Devon Dr. s. side Valley Brook, behind health spa	13 H-10
CAHR001.C001	23	11860355.8	6994033.7	Holmes Run	HR063	29800	Bridge	2 pier roadway bridge	2-Year	2-Year	N/A	2-Year	Sleepy Hollow near Dearborn	13 J-11
HOLMES RUN LOWER														
CAHR201.C001	1	11868778.4	6992734.3	Holmes Run	HR072	18900	Culvert	1 concrete arch	N/A	N/A	N/A	N/A	Columbia Pike at Lake Barcroft Dam	14 C-11
CAHR204.C001	2	11872125.1	6991532.3	HR Unnamed5	HR122	1400	Culvert	2 RCP	N/A	N/A	N/A	10-Year	Colfax Ave. nr Reservoir Heights	14 E-12
CAHR087.C008	3	11872495.3	6986837.5	Holmes Run	HR080	9680	Culvert	2 plastic pipes under ford	1-Year	1-Year	N/A	1-Year	Beauregard nr North Morgan St.	20 E-1
CAHR087.C009	4	11872726.2	6986496.7	Holmes Run	HR080	9270	Culvert	3 CM arches on concrete piers	10-Year	10-Year	N/A	10-Year	Beauregard nr North Morgan St.	20 E-1
CAHR093.C010	5	11873716.7	6984944.8	Holmes Run	HR080	7360	Culvert	2 concrete arches + 1 CMP	10-Year	10-Year	N/A	10-Year	I-395 between Exit 3 and Exit 4	20 F-2
CAHR093.C011	6	11873839.5	6984626.9	Holmes Run	HR080	7000	Culvert	4 concrete box + 1 CMP inlet; 3 concrete box outlet	2-Year	10-Year	N/A	2-Year	Van Dorn north of Landmark Mall	20 F-2
CAHR093.C012	7	11874091.1	6984175.3	Holmes Run	HR080	6460	Culvert	3 RCP under ford	1-Year	1-Year	N/A	1-Year	Holmes Run Parkway nr Ripley St.	20 F-2
INDIAN RUN														
CAIR013.C001	1	11858280.0	6986651.3	Indian Run	IR004	16917	Bridge	1 pier footbridge	10-Year	25-Year	10-Year	25-Year	Morning Wind Ct. end	19 H-1
CAIR010.C003	2	11859836.6	6985146.7	Indian Run	IR004	14416	Culvert	2 CMP on concrete base	10-Year	25-Year	10-Year	25-Year	Columbia Rd. between Braddock & Little River	19 J-2
CAIR010.C001	3	11862057.5	6982744.6	Indian Run	IR004	10490	Culvert	2 concrete box	100-Year	100-Year	N/A	100-Year	Braddock Rd. nr Randolph Dr.	19 K-3
CAIR004.C003	4	11862615.8	6980488.5	Poplar Run	PR003	2160	Culvert	1 RCP	1-Year	1-Year	N/A	1-Year	Under Clinton, outlet at Mitchell	19 K-4
CAIR004.C002	5	11862826.1	6980268.4	Poplar Run	PR003	1958	Bridge	2 pier footbridge	10-Year	10-Year	N/A	10-Year	Between Shawnee and Mitchell	19 K-4
CAIR004.C001	6	11863058.7	6980179.3	Poplar Run	PR003	1698	Culvert	3 RCP	10-Year	100-Year	10-Year	100-Year	Shawnee Rd. end	19 K-4
CAIR002.C002	7	11864942.7	6979515.4	Indian Run	IR024	5166	Bridge	0 pier roadway bridge	1-Year	1-Year	N/A	1-Year	Cherokee Ave. nr I 395 Exit 2	20 A-5
CAIR002.C001	8	11865287.5	6979416.9	Indian Run	IR024	4718	Culvert	2 concrete box	10-Year	100-Year	10-Year	100-Year	I 395 between Exit 2 and Exit 3	20 A-5
CAIR001.C003	9	11866214.1	6978790.1	Indian Run	IR024	3486	Culvert	2 concrete box	10-Year	10-Year	N/A	10-Year	Edsall @ Indian Run Pkwy	20 B-5
CAIR001.C002	10	11866627.7	6978497.9	Indian Run	IR024	2951	Bridge	2 pier footbridge	100-Year	100-Year	N/A	100-Year	Indian Run Pkwy nr Sheldon Dr.	20 B-5
CAIR001.C001	11	11867892.5	6977120.7	Indian Run	IR024	924	Bridge	1 pier roadway bridge	N/A	10-Year	N/A	10-Year	Bren Mar nr Indian Run Pkwy	20 C-6
PIKE BRANCH														
CAPK007.C001	1	11879064.7	6972440.2	PK Unnamed1	PK017	4143	Bridge	0 pier footbridge	N/A	N/A	N/A	N/A	Eaton Pl. end nr Lillian Dr.	20 J-8
CAPK006.C001	2	11882571.8	6972086.9	PK Unnamed1	PK017	158	Culvert	2 RCP	10-Year	10-Year	N/A	10-Year	Old Telegraph nr Pine Brook Rd.	21 A-9
CAPK003.C005	3	11883886.0	6972349.0	Pike Branch	PK003	7000	Culvert	2 concrete box	N/A	N/A	N/A	N/A	Telegraph nr Pike Rd.	21 A-8
CAPK003.C004	4	11884926.5	6972694.1	Pike Branch	PK003	5853	Bridge	0 pier roadway bridge	10-Year	100-Year	10-Year	100-Year	Wilton Rd. nr Telegraph	21 B-8
CAPK003.C003	5	11884961.7	6972697.5	Pike Branch	PK003	5817	Bridge	0 pier roadway bridge	10-Year	N/A	10-Year	N/A	nr Wilton Rd. nr Telegraph	21 B-8
CAPK003.C002	6	11885550.4	6973034.2	Pike Branch	PK003	5092	Bridge	3 concrete box	25-Year	100-Year	25-Year	100-Year	Florence La. nr Telegraph	21 B-8
CAPK003.C001	7	11885782.1	6973283.6	Pike Branch	PK003	4747	Bridge	0 pier roadway bridge	10-Year	100-Year	10-Year	100-Year	Driveway off Telegraph near Florence	21 B-8
CAPK002.C002	8	11886318.1	6973784.8	Pike Branch	PK003	3982	Culvert	0 pier roadway bridge	10-Year	10-Year	N/A	10-Year	Otley Dr. nr Telegraph	21 B-8
CAPK002.C001	9	11886487.7	6974243.6	Pike Branch	PK003	3487	Culvert	0 pier roadway bridge	10-Year	100-Year	10-Year	100-Year	Marl-Pat Dr. nr Telegraph	21 C-8
CAPK001.C003	10	11886579.2	6975093.8	Pike Branch	PK003	2234	Culvert	5 concrete box	N/A	N/A	N/A	N/A	Telegraph nr Franconia	21 C-7
CAPK001.C002	11	11887165.4	6976841.0	Pike Branch	PK003	478	Culvert	4 concrete box	100-Year	100-Year	N/A	100-Year	Burgundy Rd. nr Telegraph	21 C-6
CAPK001.C001	12	11887341.5	6977067.9	Pike Branch	PK003	186	Culvert	4 concrete box	100-Year	100-Year	N/A	100-Year	I 495 EB ramp to Telegraph/Huntington jct.	21 C-6

Table 3-4. Continued

Crossing ID	Map ID	X Coordinate	Y Coordinate	Stream Name	Reach	Station	Description	Subtype	Present Impacted	Present Overtopped	Future Impacted	Future Overtopped	Street Location Detail	ADC Map and Grid #
TURKEYCOCK RUN														
CATK013.C004	1	11863332.7	6987850.8	TK Unnamed1	TK014	6780	Bridge	0 pier footbridge	N/A	N/A	N/A	N/A	Elmdale between Emory and Old Columbia Pike	20 A-1
CATK013.C003	2	11863840.8	6987288.9	TK Unnamed1	TK014	6000	Culvert	2 CMP	10-Year	10-Year	N/A	10-Year	Golf course nr Elmdale & Emory	20 A-1
CATK013.C002	3	11864004.3	6987071.9	TK Unnamed1	TK014	5440	Culvert	2 RCP	1-Year	1-Year	N/A	1-Year	Golf course nr Elmdale & Emory	20 A-1
CATK012.C004	4	11864790.1	6986495.7	TK Unnamed1	TK014	4720	Bridge	0 pier footbridge	1-Year	1-Year	N/A	1-Year	Braddock nr Elmdale	20 A-1
CATK013.C001	5	11864726.3	6986541.2	TK Unnamed1	TK014	4800	Culvert	2 CMP	1-Year	2-Year	1-Year	2-Year	Golf course nr Braddock & Elmdale	20 A-1
CATK012.C003	6	11864818.5	6986465.4	TK Unnamed1	TK014	4650	Culvert	3 RCP	1-Year	2-Year	1-Year	2-Year	Braddock nr Elmdale	20 A-1
CATK012.C002	7	11865256.4	6986375.9	TK Unnamed1	TK014	4100	Culvert	2 CMP on concrete base	10-Year	10-Year	N/A	10-Year	Green Spring Gardens, nr Elmdale & Braddock	20 A-1
CATK012.C001	8	11866033.1	6986303.0	TK Unnamed1	TK014	3050	Bridge	0 pier footbridge	10-Year	10-Year	N/A	10-Year	Merritt Rd. end	20 B-1
CATK006.C001	9	11867147.1	6984398.5	TK Unnamed1	TK014	700	Culvert	1 concrete box	N/A	N/A	N/A	N/A	Little River nr Chowan	20 B-2
CATK008.C001	10	11867160.3	6988053.8	Turkey Cock Run	TK002	14320	Culvert	1 concrete box	10-Year	10-Year	N/A	10-Year	Brookside Dr. nr Braddock	20 B-1
CATK004.C001	11	11867541.6	6984308.2	Turkey Cock Run	TK002	9300	Culvert	1 concrete box	10-Year	N/A	25-Year	N/A	Little River nr Brookside Dr.	20 C-2
CATK003.C001	12	11867268.2	6980660.3	Turkey Cock Run	TK003	5000	Culvert	2 concrete box	10-Year	100-Year	10-Year	100-Year	I 395 between Exit 2 and Exit 3	20 B-4
CATK002.C001	13	11868066.6	6979740.4	Turkey Cock Run	TK003	3280	Bridge	0 pier footbridge	10-Year	10-Year	N/A	10-Year	Colliers La. End	20 C-5
CATK001.C001	14	11869066.5	6978603.9	Turkey Cock Run	TK003	1600	Culvert	4 concrete box	10-Year	10-Year	N/A	10-Year	Edsall nr Winter View	20 C-5
TRIPPS RUN														
CATR014.C004	1	11853409.6	7010229.7	Tripps Run	TR001	24700	Culvert	1 stone/concrete arch/box	1-Year	2-Year	1-Year	1-Year	railroad bed nr Shreve Rd. & Buckelew	13 F-2
CATR014.C003	2	11853405.5	7010206.6	Tripps Run	TR001	24700	Culvert	1 RCP	1-Year	2-Year	1-Year	1-Year	Shreve Rd. nr Buckelew	13 F-2
CATR014.C002	3	11853645.5	7010103.5	Tripps Run	TR001	24442	Bridge	0 pier footbridge	1-Year	1-Year	N/A	1-Year	Buckelew Dr. nr Shreve	13 F-2
CATR014.C001	4	11853741.1	7010030.8	Tripps Run	TR001	24280	Culvert	1 CMP	2-Year	2-Year	N/A	1-Year	Buckelew Dr. nr Shreve	13 F-2
CAFC000.C001	5	11856763.7	7008505.9	Tripps Run	TR001	20840	Culvert	2 CMP on concrete base inlet; 0 pier roadway bridge outlet	25-Year	25-Year	N/A	10-Year	West nr Randolph inlet; Oak St. outlet	13 G-3
CAFC000.C007	6	11858240.7	7007368.7	Tripps Run	TR001	18510	Culvert	4 CMP on concrete base	N/A	N/A	N/A	N/A	Sherrow Ave. nr Cameron Rd.	13 H-4
CATR006.C002	7	11858512.1	7006959.3	Tripps Run	TR001	18020	Bridge	0 pier footbridge	100-Year	100-Year	N/A	100-Year	Westmoreland Rd. end	13 H-4
CATR006.C001	8	11858678.4	7006670.5	Tripps Run	TR001	17700	Brigde	0 pier footbridge	100-Year	100-Year	N/A	100-Year	Westmoreland Rd. end	13 H-4
CATR005.C001	9	11859369.9	7005647.1	Tripps Run	TR001	16380	Culvert	2 concrete box	10-Year	10-Year	N/A	10-Year	off US 29 nr Maple Ave. (landscaping co.)	13 H-5
CATR004.C002	10	11859303.8	7002971.5	Tripps Run	TR001	13690	Bridge	0 pier roadway bridge	100-Year	100-Year	N/A	100-Year	Adams @ Jefferson	13 H-6
CATR004.C001	11	11859452.5	7002321.3	Tripps Run	TR001	13000	Culvert	4 concrete box	100-Year	100-Year	25-Year	100-Year	US 50 nr Tripps Run Rd.	13 J-6
CATR003.C002	12	11860232.7	7001424.4	Tripps Run	TR001	11800	Bridge	0 pier roadway bridge	100-Year	N/A	100-Year	N/A	Annandale Rd. nr Barrett	13 J-7
CATR010.C001	13	11861385.0	7000919.4	TR Unnamed1	TR021	350	Culvert	2 concrete box	10-Year	25-Year	N/A	10-Year	Holmes Run Rd. nr Cedarwood	13 K-7
CATR003.C001	14	11861187.4	7000253.8	Tripps Run	TR011	10230	Bridge	0 pier roadway bridge	10-Year	10-Year	2-Year	10-Year	Holloway Rd. @ Barrett	13 J-7
CATR001.C002	15	11862772.0	6999113.4	Tripps Run	TR011	8140	Bridge	0 pier roadway bridge	10-Year	25-Year	N/A	10-Year	Sleepy Hollow nr Holmes Run Rd.	13 K-8
CATR001.C001	16	11864890.9	6997277.5	Tripps Run	TR011	4950	Bridge	1 pier roadway bridge	1-Year	1-Year	N/A	1-Year	Potterton Dr. nr Waterway Dr.	14 A-9

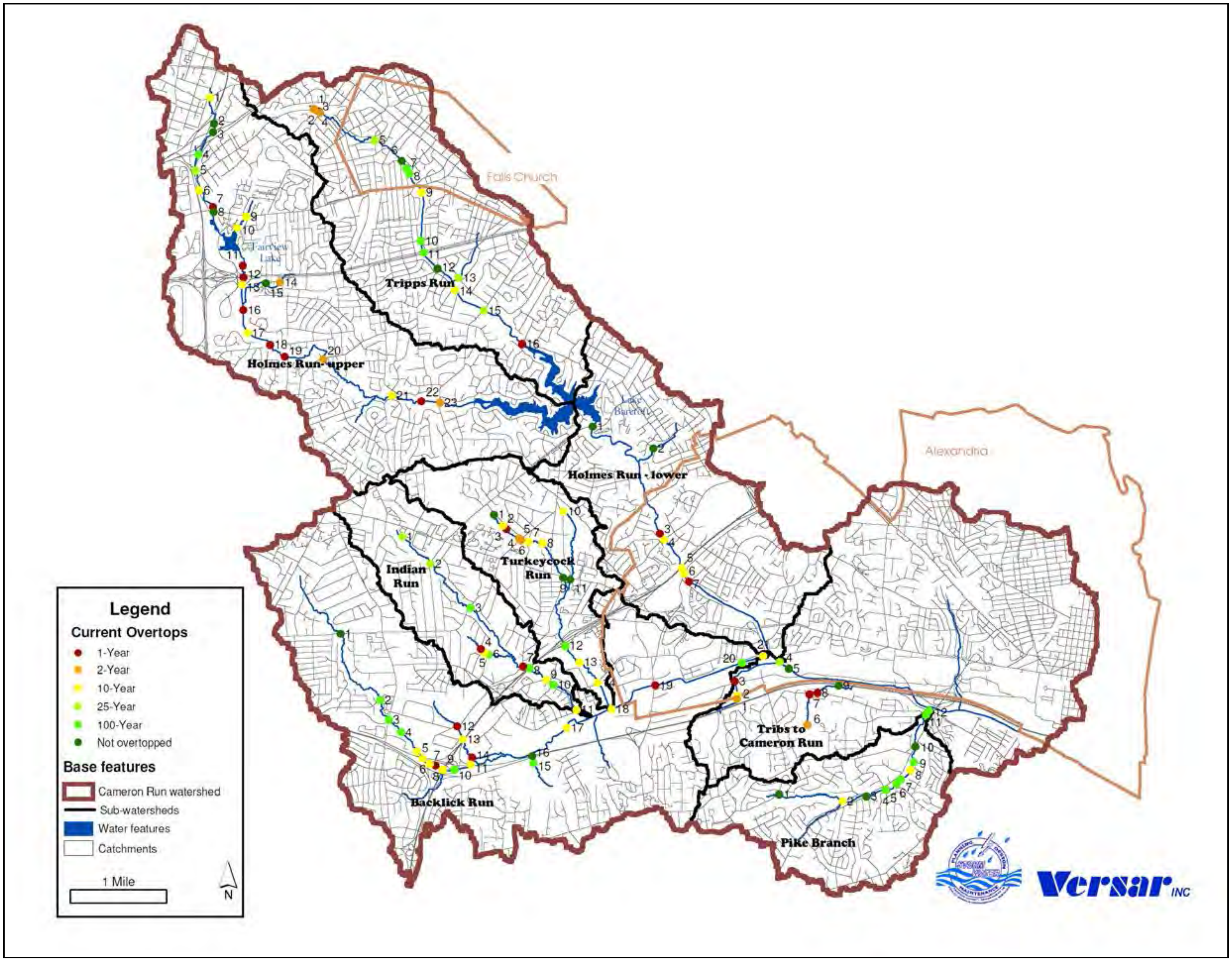

Figure 3-16. Stream crossings in Cameron Run which may be overtopped under current conditions. Crossings are labeled with a Map ID number by subwatershed as listed in Table 3-4.

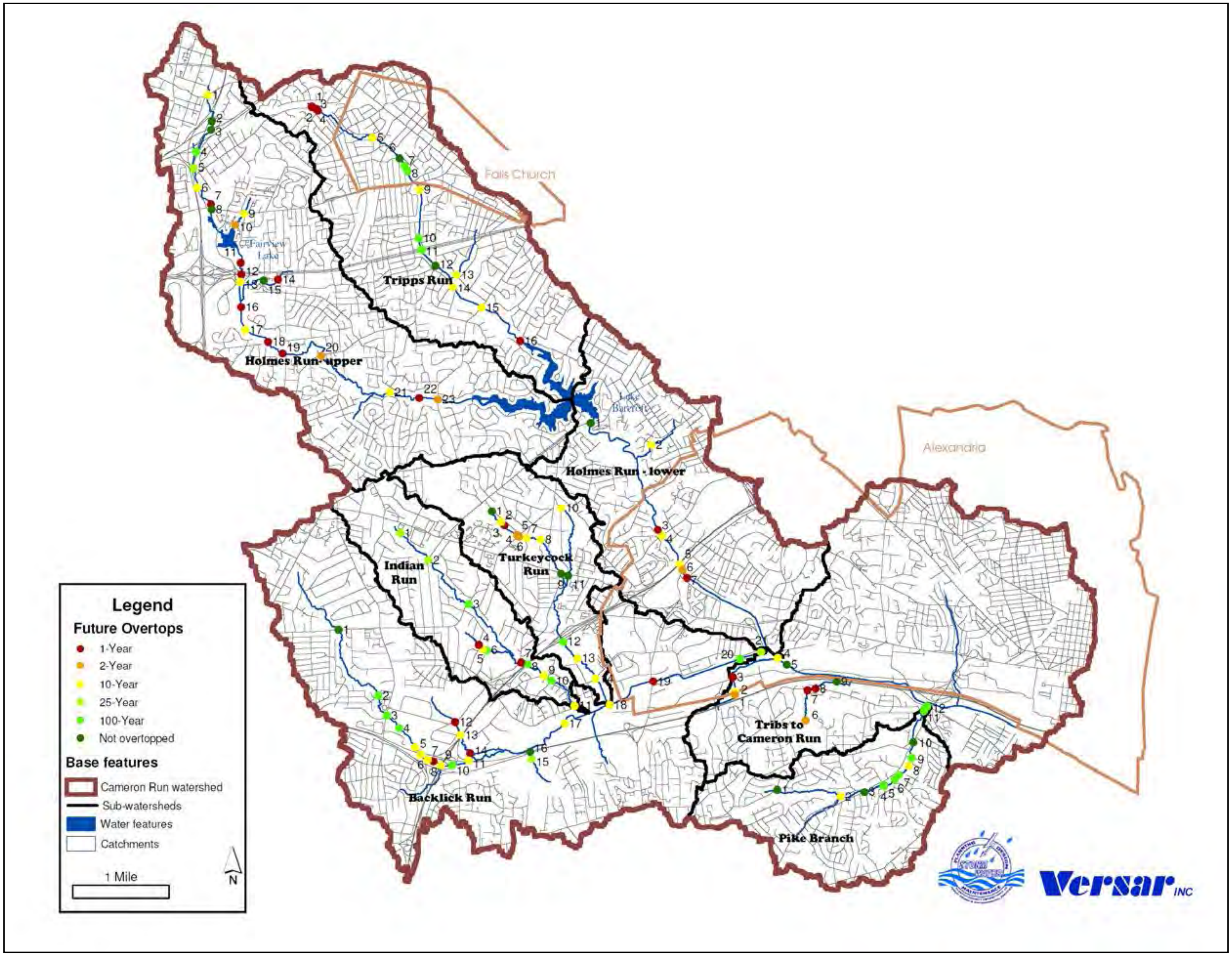

Figure 3-17. Stream crossings in Cameron Run which may be overtopped under future conditions. Crossings are labeled with a Map ID number by subwatershed as listed in Table 3-4.

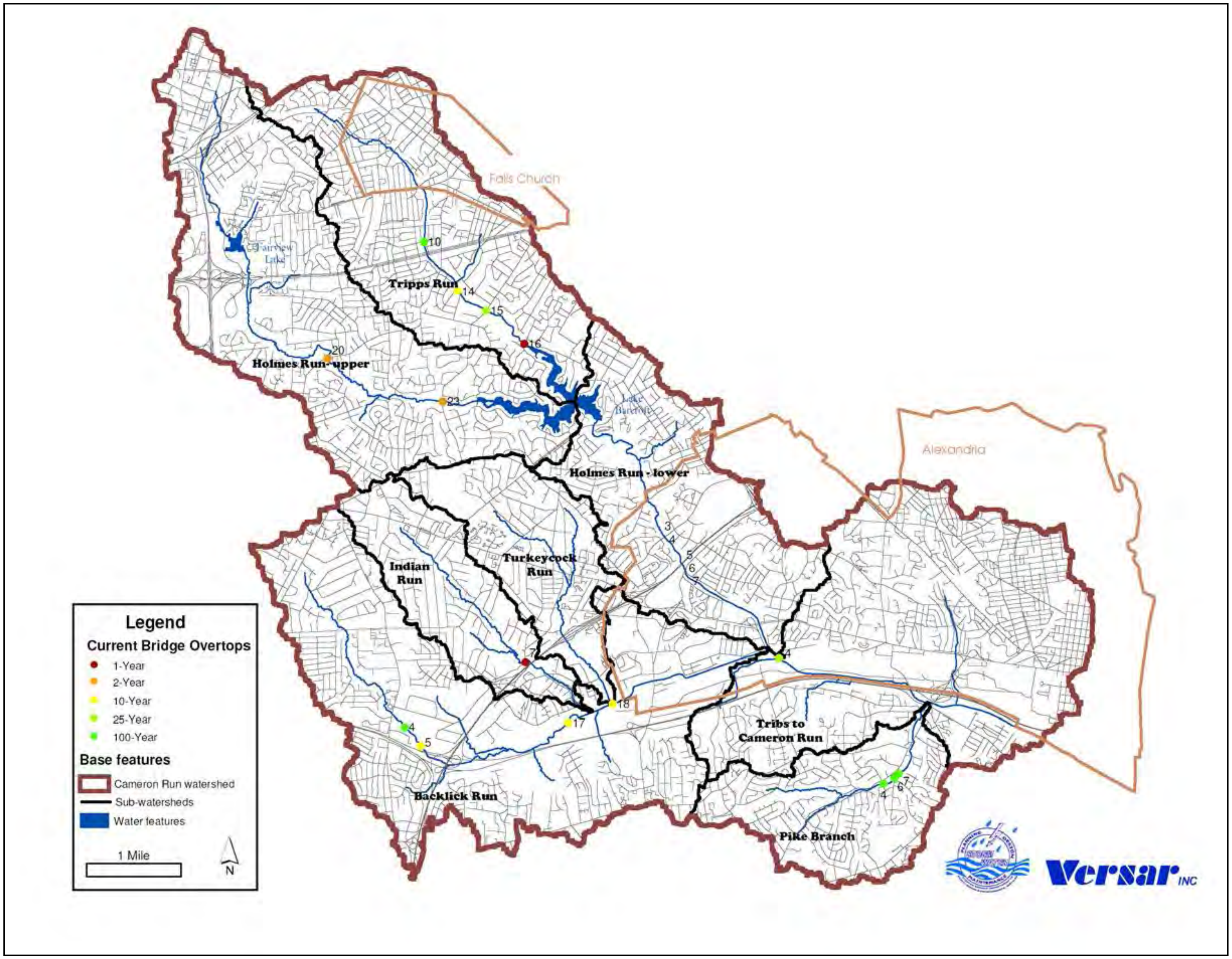

Figure 3-18. Roadway bridges in the Fairfax County portion upstream of the USGS gage in Cameron Run and in Pike Branch, which may be overtopped under current conditions for various design storms. Bridges are labeled with a Map ID number by subwatershed as listed in Table 3-4.

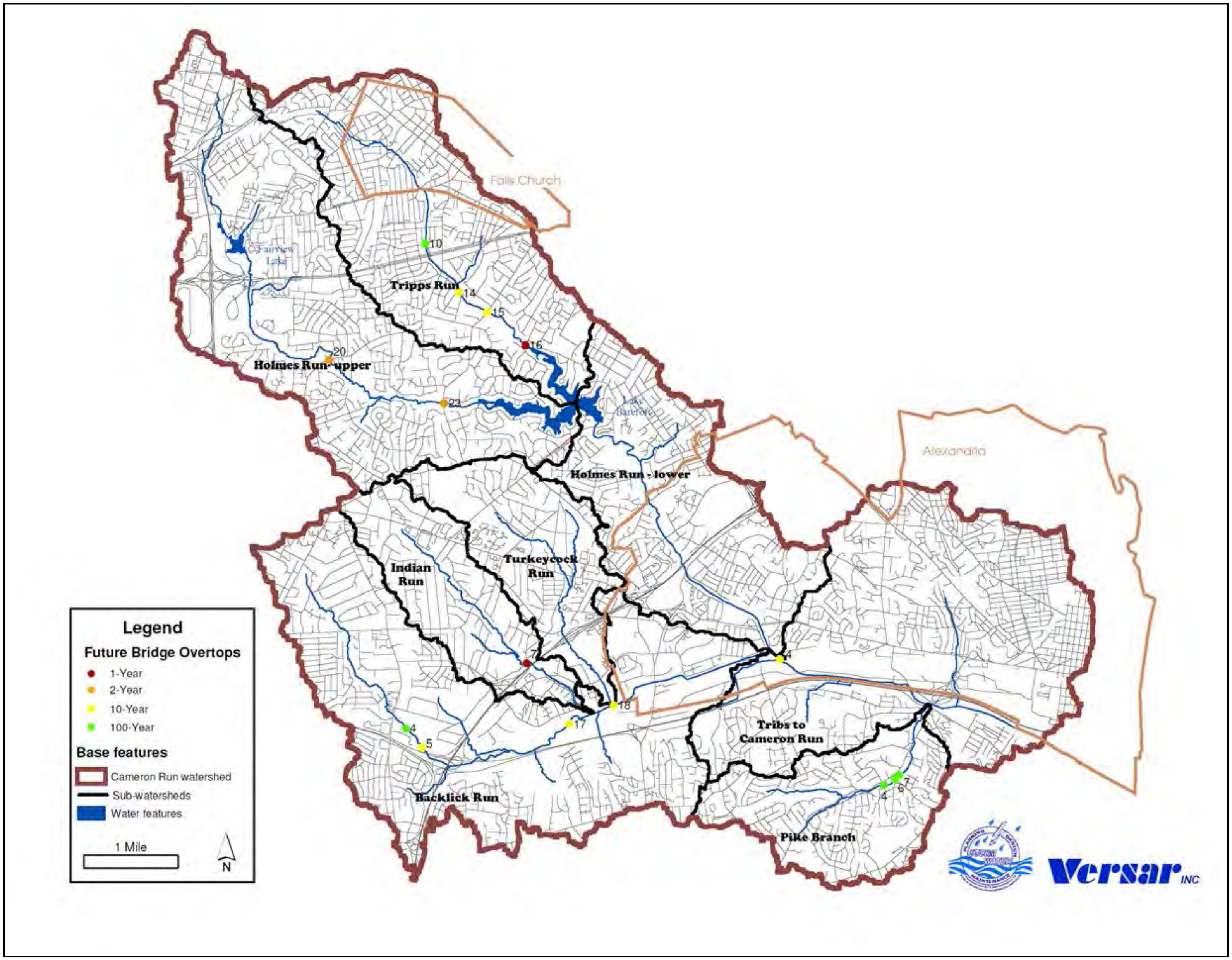

Figure 3-19. Roadway bridges in the Fairfax County portion upstream of the USGS gage in Cameron Run and in Pike Branch, which may be overtopped under future conditions for various design storms. Bridges are labeled with a Map ID number by subwatershed as listed in Table 3-4.

Table 3-5. Number of roadway crossings (bridges) overtopped by design flows for subwatersheds in Cameron Run

Subwatershed	**Present**				
	1-year	**2-year**	**10-year**	**25-year**	**100-year**
Backlick Run	0	0	3	3	4
Cameron Run Tributaries and Mainstem	0	0	0	1	1
Holmes Run - Upper	0	2	2	2	2
Holmes Run - Lower	0	0	0	0	0
Indian Run	1	1	2	2	2
Pike Branch	0	0	0	0	3
Turkeycock Run	0	0	0	0	0
Tripps Run	1	1	2	3	4
Subwatershed	**Future**				
	1-year	**2-year**	**10-year**	**25-year**	**100-year**
Backlick Run	0	0	3	3	4
Cameron Run Tributaries and Mainstem	0	0	1	1	1
Holmes Run - Upper	0	2	2	2	2
Holmes Run - Lower	0	0	0	0	0
Indian Run	1	1	2	2	2
Pike Branch	0	0	0	0	3
Turkeycock Run	0	0	0	0	0
Tripps Run	1	1	3	3	4

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Table 3-6. Crossings surveyed but not included in model

Crossing ID	X Coordinate	Y Coordinate	Stream Name	Reach	Station	Description	Subtype	Reason Not Included	Street Location Detail	ADC Map and Grid #
CABA005.C003	11860820.4	6973762.0	BackLick Run	N/A	N/A	Ford	concrete slab	Ford modeled as cross-section	Downstream of I-395 crossing of I-495	19 J-8
CABA010.C002	11855312.3	6979178.4	BackLick Run	N/A	N/A		not located	small footbridge	Between Atlee and Homestead	19 F-5
CACA001.C002	11881548.5	6978327.9	CA unnamed2	N/A	N/A		crossing removed	no crossing here	Peaceful Terr. end	20 K-5
CACA001.C016	11879023.9	6979800.2	Cameron Run	N/A	N/A	Bridge	8 pier rr bridge	combined with CA003.017	railroad bridge downstream of Backlick Run & Holmes Run confluence, upstream of Eisenhower Ave. crossing	20 J-5
CAHR001.C003	11859144.0	6994109.4	Holmes Run Upper	N/A	N/A	Ford	concrete slab	Ford modeled as cross-section	Devon Dr. s. side Valley Brook, behind health spa	13 H-10
CAHR003.C001	11855381.4	6995187.4	Holmes Run Upper	N/A	N/A	Ford	concrete slab	Ford modeled as cross-section	Valleycrest Blvd end	13 F-10
CAHR030.C001	11856638.8	6994236.2	HR Unnamed	N/A	N/A	Ford	broken concrete chunk	Ford modeled as cross-section	Raleigh Rd. end	13 G-10
CAHR038.C002	11847807.8	7009633.5	HR Unnamed	N/A	N/A	Culvert	2 concrete box	Combined with CA038.C001	I 495 NB north of I 66 interchange	13 B-3
CAHR038.C003	11847732.3	7009860.1	HR Unnamed	N/A	N/A	Culvert	2 concrete box	Combined with CA038.C001	I 495 SB north of I 66 interchange	13 B-3
CAHR055.C001	11846876.3	7008007.3	HR Unamed	N/A	N/A	Culvert	2 concrete box	no distinguishable stream above crossing	I 66 EB amid I 495 lanes	13 B-3
CAHR093.C013	11876437.3	6982765.6	Holmes Run Lower	N/A	N/A	Bridge	1 pier footbridge	in Alexandria	Pickett St. @ Holmes Run Pkwy	20 G-3
CAHR095.C014	11877988.0	6981638.4	Holmes Run Lower	N/A	N/A	Bridge	2 pier roadway bridge	in Alexandria	Duke St. nr Holmes Run Pkwy	20 H-4
CAHR096.C015	11878379.6	6980645.9	Holmes Run Lower	N/A	N/A	Bridge	0 pier footbridge	in Alexandria	Holmes Run Pkwy nr Jordan St.	20 H-4
CAIR010.C002	11860646.8	6984301.7	Indian Run	N/A	N/A	Bridge	0 pier footbridge (half-crossing)	half a footbridge	Randolph Dr. nr Locust Way	19 J-2
CATK003.C002	11867049.8	6980974.2	Turkey Cock Run	N/A	N/A		upstream end of CATK003.C001	Combined with CATK003.C001	I395 between Exit 2 and Exit 3	20 B-4
CATR005.C002	11859169.8	7005970.8	Tripps Run	N/A	N/A	Culvert	2 concrete box	Combined with CATR005.C001	US 29 nr Maple Ave.	13 H-5
CATR005.C003	11859065.4	7006023.0	Tripps Run	N/A	N/A	Culvert	Retail furniture store	Combined with CATR005.C001	Between US 29 @ Maple Ave.	13 H-5
CATR005.C004	11858986.1	7006052.0	Tripps Run	N/A	N/A	Culvert	2 concrete box	Combined with CATR005.C001	Maple Ave. nr US 29	13 H-5
CATR005.C005	11859315.2	7005785.4	Tripps Run	N/A	N/A	Bridge	0 pier footbridge	Same as TR008.C001	off US 29 nr Maple Ave. (landscaping co.)	13 H-5

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