FAUQUIER COUNTY GROUNDWATER RESOURCE ASSESSMENT AND MONITORING PROPOSAL
FOR LONG-TERM MANAGEMENT OF WATER RESOURCES

Prepared For:

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I. INTRODUCTION

Fauquier County, Virginia, a rapidly growing suburban area near Washington, D.C., includes parts of three distinct geologic provinces: (1) the Blue Ridge, (2) the Culpeper Basin, and (3) the Piedmont (fig. 1). The County is underlain by fractured-rock aquifers in each of these geologic provinces that are currently relied upon to supply about 3.9 Mgal/day of groundwater for public supply and domestic use (Maupin and others, 2014).

Sustainability of groundwater resources in Fauquier County is a concern for water managers and planners. Suburban development has increased water-supply demands, added impervious surfaces that may reduce groundwater recharge, and possibly caused transfers of water between basins through water-distribution and sewer systems. This is an area with an expanding economy and a growing population, and, to meet future water needs, these aquifers are likely to be developed to supplement current withdrawals. As urban and rural growth continues, water-resources management requires a long-term view toward assessment, characterization, and monitoring of the County's aquifer systems.

Fauquier County is located on the drainage divide between the Potomac and Rappahannock River Basins and surface drainage flows out of the county (fig. 1). The hydrogeology of Fauquier County is characterized by groundwater flow through a complex network of interconnected openings along joints, bedding-plane partings, and faults that have varying hydrologic properties.

II. PROBLEM

Regional- and local-scale data and interpretations are needed by County and State agencies to manage groundwater resources in Fauquier County. The additional information must be easily translated into tools that policy makers can use to address land-use decisions and aquifer withdrawals in context of long-term monitoring of groundwater resources. To be practical for managing sustainable ground-water development, resource assessments need to produce applicable spatial datasets and publically available archives of hydrologic monitoring data to facilitate their present and future use by decision makers.

III. OBJECTIVES

The objective of this proposed study is to develop an assessment of groundwater availability that is useful for active management of the fractured-rock aquifers in Fauquier County. Because of the wide range of geologic features in the County, it is expected the approach developed for the Fauquier County will have broad perspective on groundwater resources at the County-wide scale. Specific objectives of the study are:

- Develop a county-wide water-budget model to adequately characterize the range of past and current hydrologic conditions affecting aquifers;
- Couple groundwater and surface-water monitoring to permit assessment of the relationships between groundwater withdrawals and base flow in stream reaches, and the effects of new or increased groundwater withdrawals;
- Initiate development of tools and collect data, including geophysical logs, to help estimate the impacts of the overall trends in development and population growth on the water resources. These data would ultimately contribute to a future decision-support mechanism for allocation of water resources based on a physically-based, technical flow model.

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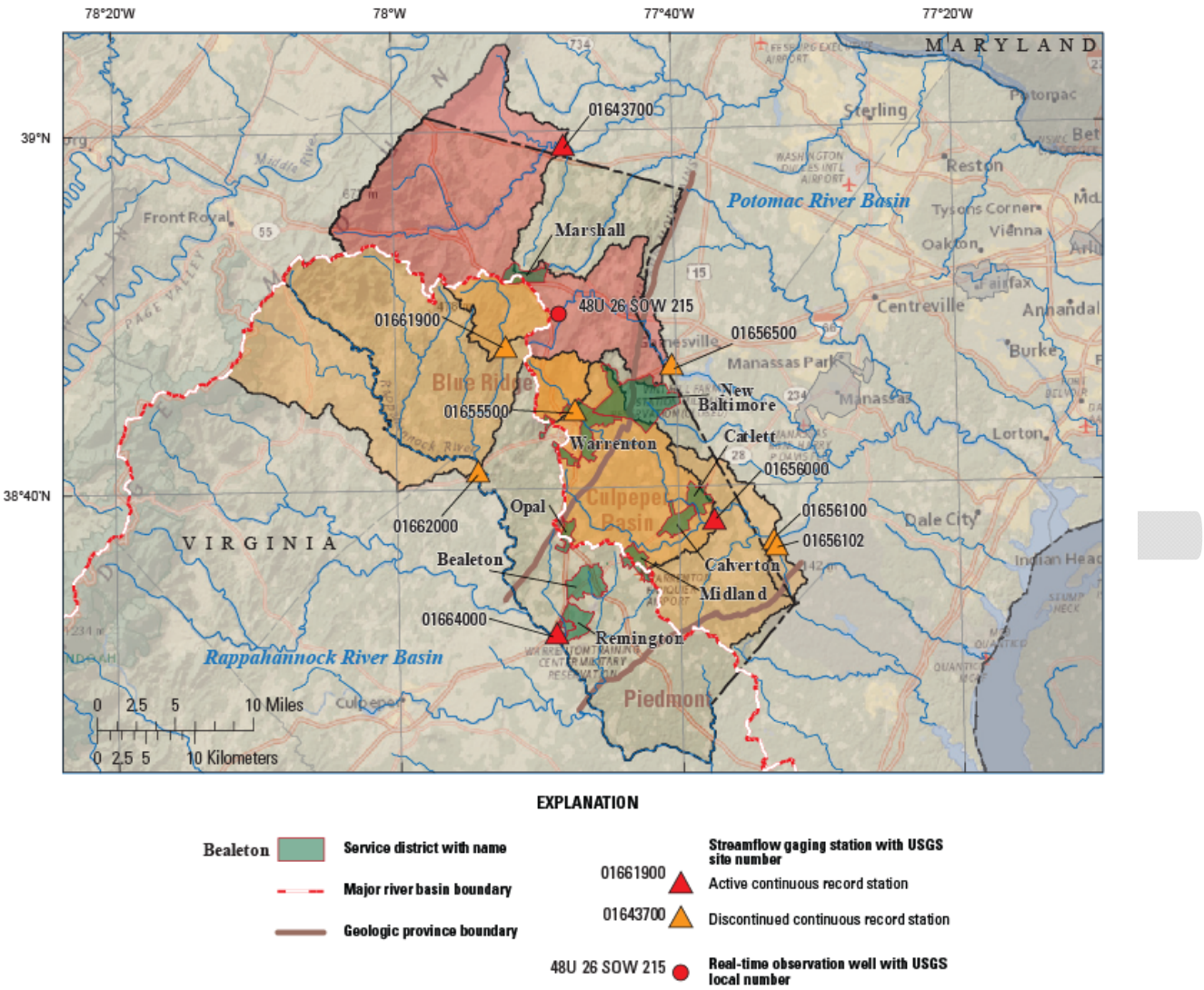

Figure 1. Location of study area, service districts, and hydrologic data-collection sites with drainage basins.

IV. APPROACH

In order to address the issues related to water-supply availability, a region-wide view is necessary. Adequate characterization of important hydrogeologic targets for drilling, however, requires very local-scale knowledge that is best addressed by the private sector. The proposed solution is the use of a regional-scale water-budget model with GIS output that can be easily downscaled to facilitate local-scale investigations (eg. EGGI, 2014). Because the regional-scale water availability issues focus on land-use changes and major water-budget components, we propose that a Soil-Water-Balance watershed model be employed for that purpose. To address questions regarding water-level declines, contributing areas to wells, and interactions with streams, we propose to establish surface-water and groundwater monitoring networks in an effort to assess current conditions and facilitate future investigations. Thus, as part of this project, Fauquier County personnel will provide technical support and guidance in the selection of monitoring network locations.

1. *Soil-Water-Balance modeling*

The magnitude and distribution of water-budget components in the Fauquier County will be computed using regionally available spatial datasets and the Soil-Water-Balance (SWB) model (Westenbroek and others, 2010). The SWB model calculates spatial and temporal variations in groundwater recharge based on climatological data, and soil and landscape properties. SWB is a deterministic model that uses gridded data and physically based parameters to apportion water derived from daily precipitation and snowmelt into surface runoff, evapotranspiration, recharge, and water storage in the soil column. Model output consists of gridded distributions of water-budget components, such as surface flow leaving grid cells, actual evapotranspiration (ET), soil moisture, and recharge at a specified cell size within the study area. Computation of water-budget components relies on relations between surface runoff, land cover, and hydrologic soil group (Cronshey and others, 1986) and estimated values of ET and temperature (Hargreaves and Samani, 1985). Water storage in the soil column is estimated using a modified Thornwaite-Mather accounting method on a daily basis (Westenbroek and others, 2010).

TASK 1 PRODUCT: Draft versions of the SWB data will be presented within 12 months of project initiation. The SWB output datasets of annual recharge and evapotranspiration for a normal year, wet year, and drought year will be published at ≥100 square meter resolution and available in downloadable GIS format from ScienceBase (www.sciencebase.gov) within 24 months of project initiation. The actual years of simulation will be determined by available climate data at the time of project initiation.

Based on growth scenarios from management agencies, existing land use and climate prediction models may be employed in future SWB simulations to assess areas where changes in streamflow and other deleterious hydrologic effects are likely. In year two, the USGS and Fauquier County personnel will assess the potential benefit of conducting SWB forecast simulations.

2. *Continuous Monitoring of Streams and Wells*

Continuous data are are currently being collected at two existing stream gages and one monitoring well in and adjacent to the County (fig. 1). The USGS will operate and maintain one new continuous-record stream-gaging station within 12 months of the project initiation. An additional stream-gaging station will be established in year two of the project. Previous discontinued gaging station locations in the County (figs. 1,2) will be evaluated in regards to their suitability for the proposed project. Up to 4 existing groundwater wells will also be selected for continuous monitoring within 12 months of project initiation. The USGS will provide all of the continuous and real-time equipment to install the streamflow and groundwater monitoring sites established within 24 months of project initiation. Two additional stream-gaging stations may be installed if sufficient USGS funds are available to purchase equipment in years 3 and 4 of the project.

These gaging stations and monitoring wells are intended to be operated for a minimum of ten years to establish long-term trends that can be used to continuously evaluate aquifer conditions and the effects of pumping, land-use change, and varying climate conditions in the County. The monitoring network will initially focus on areas near and within the following service district areas: Remington, Bealeton, Opal, Midland, Calverton, Catlett, New Baltimore, Marshall, and Warrenton.

TASK 2 PRODUCT: All surface and groundwater-level data collected will undergo quality assurance checks, be uploaded to the online NWIS database. All data will be publicly available for access from the USGS National Water Information System (NWIS - http://waterdata.usgs.gov/nwis) online database. A project website will be created within 12 months of project initiation to provide project updates, status, and additional portals to hydrologic data in Fauquier County.

3. *Aquifer Resource Assessment*

Beginning in year three, a synoptic survey of water levels in selected wells distributed across the County will be conducted quarterly to (1) establish the seasonal water-table fluctuations and (2) provide a

comparison with water level-surveys from the mid-1980s (Laczniak and Zenone, 1984) to assess changes, if any, in aquifer storage. Permission from owners of existing domestic and public-supply wells used in the survey will be sought and the appropriate well information inventoried. The network of well monitoring locations will be maintained for a minimum period of 24 months, afterwhich a county-wide water level map will be published as a USGS Scientific Investigations Map.

Existing unused wells located in Fauquier County will be used for collection of optical televiewer, fluid temperature, gamma, resistivity, and electromagnetic induction borehole geophysical data. These logs will be used to determine the depth and orientation of water bearing zones in different aquifers within the County. The information collected will supplement existing geologic information (Laczniak and Zenone, 1984). The long-term goal of the database is to construct a county-wide hydrogeologic framework from which future maps of groundwater availability can be developed and revised based on the local-scale investigations conducted by others. The number of wells to be logged will vary by year and cannot be determined until unused wells have been located.

TASK 3 PRODUCT – A USGS Scientific Investigations Map of county-wide water levels will be published following 24 months of quarterly water-level data collection. The borehole log database in Fauquier County will be available for download to use in future characterization of the variability in aquifers and the associated water bearing properties in Fauquier County. Aquifer characteristics from all wells in the database will be summarized in presentations to the Fauquier County personnel.

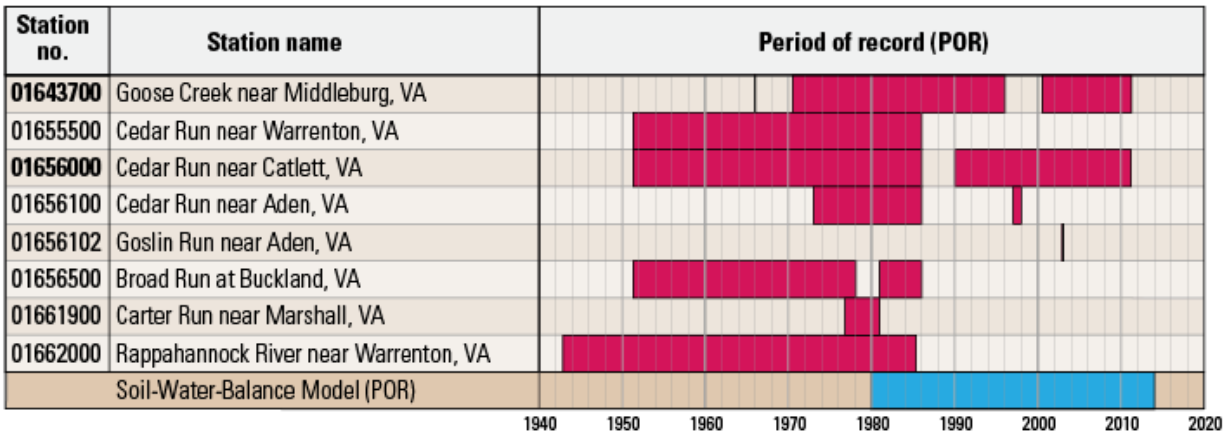

Figure 2. Period of record for streamflow gaging stations in and adjacent to Fauquier County, VA and selected period for soil-water-balance model. Station numbers in boldface are active continuous record stations.

V. REPORTS

Initial GIS datasets describing the water-budget components will be available for presentation to County personnel within 12 months of project start. An on-line USGS Scientific Investigations Report documenting the SWB model will be published within 2 years of project start. All monitoring data collected as part of the study will be stored in the publically accessible USGS National Water Information System web site (NWIS-Web). A Scientific Investigations Map of county-wide water levels will be published in year 5.

VI. BENEFITS AND FEDERAL ROLE

Completion of the proposed work will provide the USGS with additional groundwater and surface-water data. These data will add to the USGS national database and will assist in understanding and describing the Nation's water resources. This study aligns with the 2016 priorities for the Cooperative Water Program,

including "data collection--enhance hydrologic-data networks for improved hazards protection and forecasting and to support assessments of water sustainability for human and ecological needs" and "assessments and tracking of water use, consumptive use, and water availability (Water Availability and Use Science)." This investigation will establish a baseline of aquifer status for fractured-rock aquifers in Fauquier County, Virginia. Groundwater resources are a potential economic resource in the continued development of the area. Investigations in the mid-1980s (eg. Laczniak and Zenone, 1984) focused on the Culpeper basin and little data are available to support management decisions elsewhere in the County. The inventory of aquifer conditions in Fauquier County provided by this study will be important for assessment of source waters to public supplies where regional geologic structure may significantly influence the understanding of areas contributing to localized withdrawals. This study will build on the USGS research recently completed in the Shenandoah Valley (Nelms and Moberg, 2010), Bedford County, VA (McCoy and others, 2015a), and Appalachian Plateaus (McCoy and others, 2015b) by applying the concepts developed in those studies, to further research the complex hydrogeology of fractured-rock aquifers used as sources of public and domestic water supply in expanding suburban areas of Washington, DC.

VII. PERSONNEL

Two USGS groundwater hydrologists (GS-13, GS-12) will serve as project chiefs ¼ time and provide technical, interpretive, and report writing leadership. A GS-12 GIS specialist will assist project chiefs with processing spatial data and SWB modeling. A GS-11 Hydrologic Technician (¼ time) will lead monitoring and data-processing efforts. A Virginia Department of Environmental Quality hydrologist will provide additional technical and interpretive input and assist in various field-collection activities.

VIII. WORK PLAN

The timeframe for the proposed work is five years, beginning as early as April of 2016.

Project Tasks	Federal Fiscal Year and Quarter					
	2016	2017	2018	2019	2020	2021
	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
SWB model development	x x	x x				
Presentation of water-budget datasets		x				
Prepare draft Scientific Investigations Report		x x				
Report editorial and technical reviews		x				
Address review comments		x x				
Prepare and send report for Director's approval		x	x			
Publish report and SWB datasets			x x			
Define stream-gage and well locations	x x					
Instrument continuous monitoring stations	x x	x x x x	x x			
Continuous monitoring of streams and wells	x x	x x x x	x x x x	x x x x	x x x x	x x
Geophysical borehole logging			x x x x	x x x x	x x x x	x x
Establish quarterly monitoring-well network				x x		
Collect quarterly water-level data				x x x x	x x x x	x x
Preparation of Scientific Investigations Map					x x	
Report editorial and technical reviews					x x	x x
Publish Map						x x

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