Date of Meeting: May 19, 2010

BOARD OF SUPERVISORS
TRANSPORTATION AND LAND USE COMMITTEE
INFORMATION ONLY ITEM

IO-B

SUBJECT: Completion of County Grant #970153 from U. S. EPA to Establish the Water Resources Monitoring Program and a Summary of Work Accomplished

STAFF CONTACT: Glen Rubis – Department of Building & Development
Dennis Cumbie - Department of Building & Development
Terrance Wharton - Department of Building & Development, Director

ELECTION DISTRICT: Countywide

BACKGROUND: At the request of the Board, work was initiated in 2001 by the Department of Building & Development (B&D) to begin establishment of the Loudoun County Water Resources Monitoring Program (WRMP). The purpose of the WRMP was long-term monitoring of the quantity and quality of the county's surface water and groundwater resources. Establishing the WRMP and exploring alternatives for its funding were in accordance with recommendations of the Board-appointed Groundwater Advisory Committee in December 1999. The WRMP has been consistently supported by the Board's Water Resources Technical Advisory Committees (2001 to present), and supports policies of Chapter 5 of the County's General Plan.

Through initiatives by B&D staff, assistance was received from Congressman Frank Wolf (R-10th District) in the form of federal appropriation funds for a grant, managed through the U.S. EPA, to help the County establish the WRMP. The purpose of the WRMP is coincident with those of the EPA in that it will provide the basic water quantity and water quality data needed to better understand and manage the water resources of the county. With sufficient data, the County, through the Board of Supervisors, will have sound, science-based information needed to make informed policy and regulatory decisions about the long term use, protection, and restoration of the water resources for drinking, agricultural, commercial, recreational, and natural habitat purposes.

The County's original WRMP grant application was submitted to EPA in 2002 with expectations by both the EPA grant manager and the County that it would be approved without delay. However, unexpected changes to EPA's funding account and a revision of their strategic goals delayed award of the grant until April 2006 (EPA Grant # XP-97310401). EPA approved a two year extension to the original grant period because of delays in their award process and the grant ended in September 2009.

SUMMARY OF WORK:
Major accomplishments of the Water Resources Monitoring Program at the conclusion of the grant included the following:

- Establishment, operation, and maintenance through a cooperative agreement with the U.S. Geological Survey (USGS) of eight real-time stream gauges;
- Establishment of 19 dedicated groundwater monitoring wells, including 5 wells constructed specifically for the WRMP. (Some of the other wells were obtained through a program where a property owner donated the use of an inactive well on his or her property to the County's WRMP for monitoring groundwater levels);
- Development of an EPA-approved quality assurance and quality control (QA/QC) program for data collected or compiled for use in the WRMP;
- Compilation of existing water resources data and development of WRMP databases;
- Adding and filling a Water Resources Data Manager position;
- Compilation and statistical analysis of WRMP data;
- Installation of stream water level recording equipment and procurement of groundwater level monitoring equipment, two rain gauges, groundwater sampling equipment, and surface water sampling equipment (chemical and biological);
- Collection of stream assessment data, precipitation data, and ground-water quality data from outside sources for addition into the WRMP databases;
- Establishment of two real-time rain gauges;
- Use of real-time precipitation and stream water level data provides Emergency Management Services in the county with vital and timely information on potentially hazardous flooding conditions to help protect life and property.
- County-wide probabilistic and targeted sampling of water quality from domestic wells;
- Completion of a county-wide Stream Assessment for biotic health, habitat, and perenniality;
- Developing the *2008 Water Resources Monitoring Data Summary* report.

Four maps depicting some of the accomplishments listed above are provided at the end of this document. The maps are:

Figure 1. Long-Term Monitoring Sites used for the Loudoun County Water Resources Monitoring Program

Figure 2. Probabilistic Groundwater Sampling Sites, Summer 2009.

Figure 3. Locations of Benthic Stream Assessment Sites, 2009.

Figure 4. Locations of Stream Habitat Assessment Sites, 2009.

A general expectation of granting agencies is that the grant recipient will continue to conduct activities into the future that were initially established with the grant funds. Although the WRMP was initially established as a long-term program even without any guarantees of a grant, the additional monitoring capabilities that were established with the EPA grant will continue to be conducted as funds allow, but are expected to continue for many years. These future activities include continued collection of data from WRMP monitoring wells and stream gauges, expanded water quality sampling of surface and groundwater using probabilistic site selection methods, expansion of the groundwater monitoring network through establishment of additional donated wells, and installation of real-time precipitation gauges to expand coverage and allow for advanced warning of potential flooding conditions in the County.

FISCAL IMPACT:
The grant award from EPA was based on the project work plan submitted with the County's grant application to EPA which was for a proposed $1,576,920 in potential total project costs. In February 2007, the Board approved a Budget Adjustment (#700621), which recognized and appropriated an aggregate amount of $1,576,920 in multi-year (FY 03 through FY 11) revenue and expenditures in B&D for the County's WRMP work plan. As part of the grant award, EPA agreed to a 55 percent cost share of all approved budget expenditures. At the completion of the grant on September 30, 2009, the County had received a total benefit of $1,547,826.80 in completed workplan tasks (based on EPA-approved grant expenditures) for a total net cost of $696,522.06.

SUMMARY:
With the assistance of this EPA grant, Loudoun County was able to develop, at a significant saving in costs, the majority of the WRMP infrastructure, in the form of stream flow stations, rainfall gauges, and monitoring wells, including the equipment for continuous data monitoring and recording. These sites will form the backbone of hydrologic monitoring in Loudoun for many years to come although additional sites will be added if available and helpful, such as donated monitoring wells. To maintain the monitoring program will require annual funding commitments for support of the real-time stream flow and rain gauges operated by the USGS. Water quality sampling, for both groundwater and surface water, will also require some annual funding to continue monitoring. Conducting stream assessments are not an inexpensive commitment and are typically not repeated for a number of years. Fortunately, sampling by stream monitoring volunteer groups will help fill part of the data void in the interim. Although longer periods of data records are generally more useful for many types of analyses, data collected from this program have already been applied to several projects, including the 2008 CH2M Hill, Inc. *Comprehensive Watershed Management Program* report and the *2008 Water Resources Monitoring Data Summary*

report. Continued operation of the WRMP will provide essential data for future policy and land management decisions as well as for watershed management planning and assessment of implementation measures that the County will likely need to implement in the years ahead as improvements in water quality at the local level are required as anticipated.

ATTACHMENTS:

A. Project Completion Report – Loudoun County Water Resources Monitoring Program
B. 2008 Water Resources Monitoring Data Summary

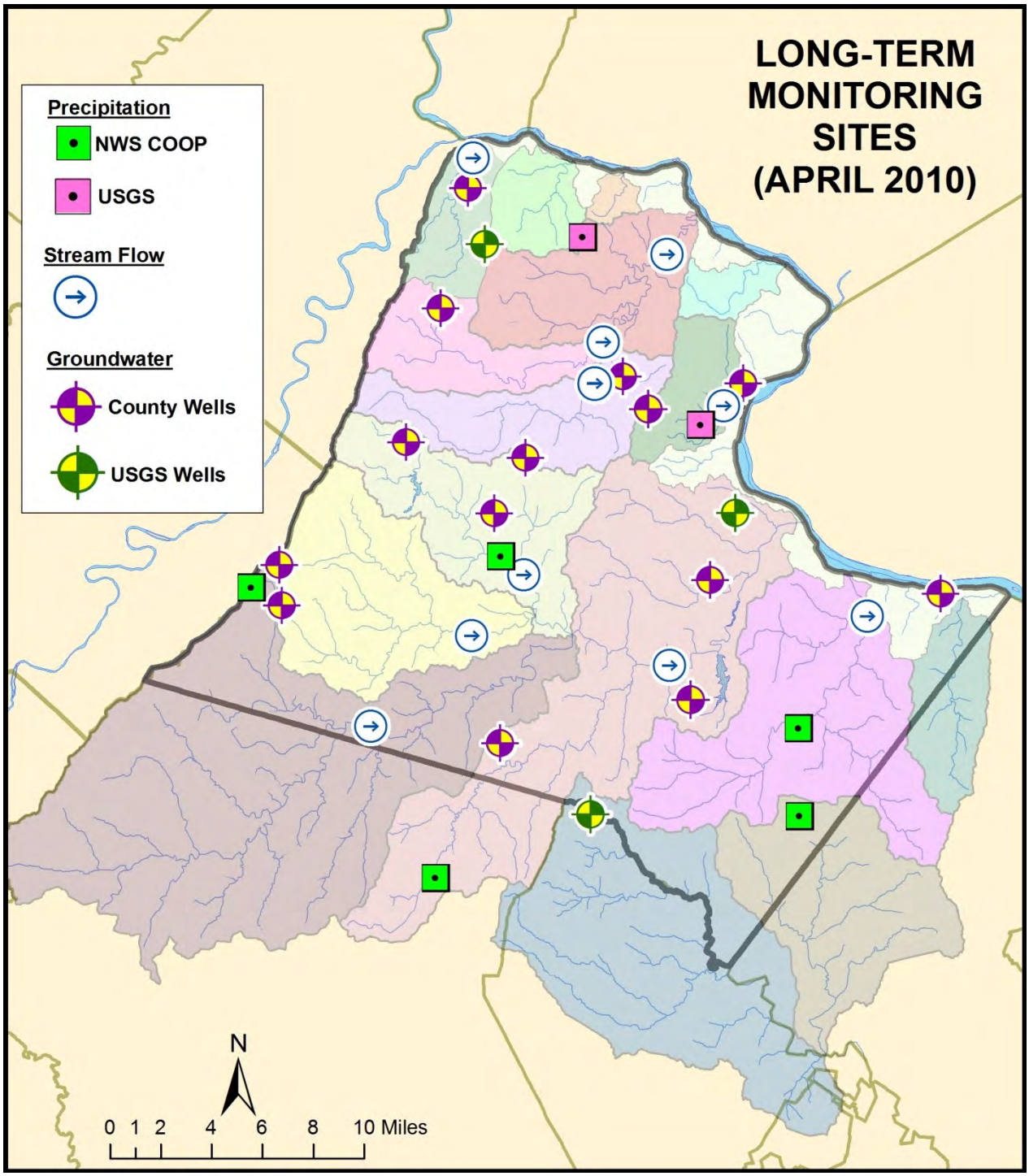

Figure 1. Long-Term Monitoring Sites used for the Loudoun County Water Resources Monitoring Program.

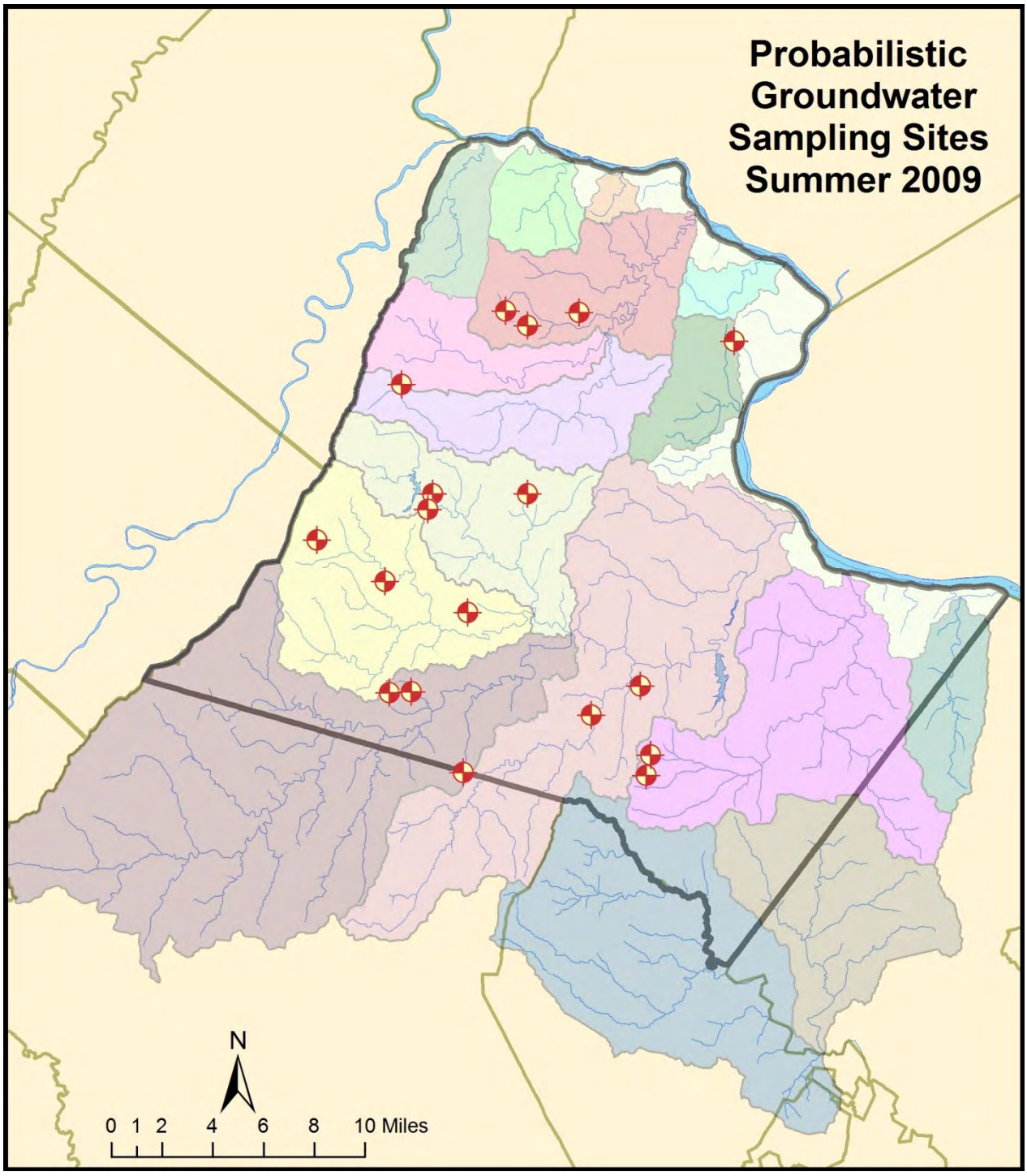

Figure 2. Probabilistic Groundwater Quality Sampling Sites, Summer 2009.

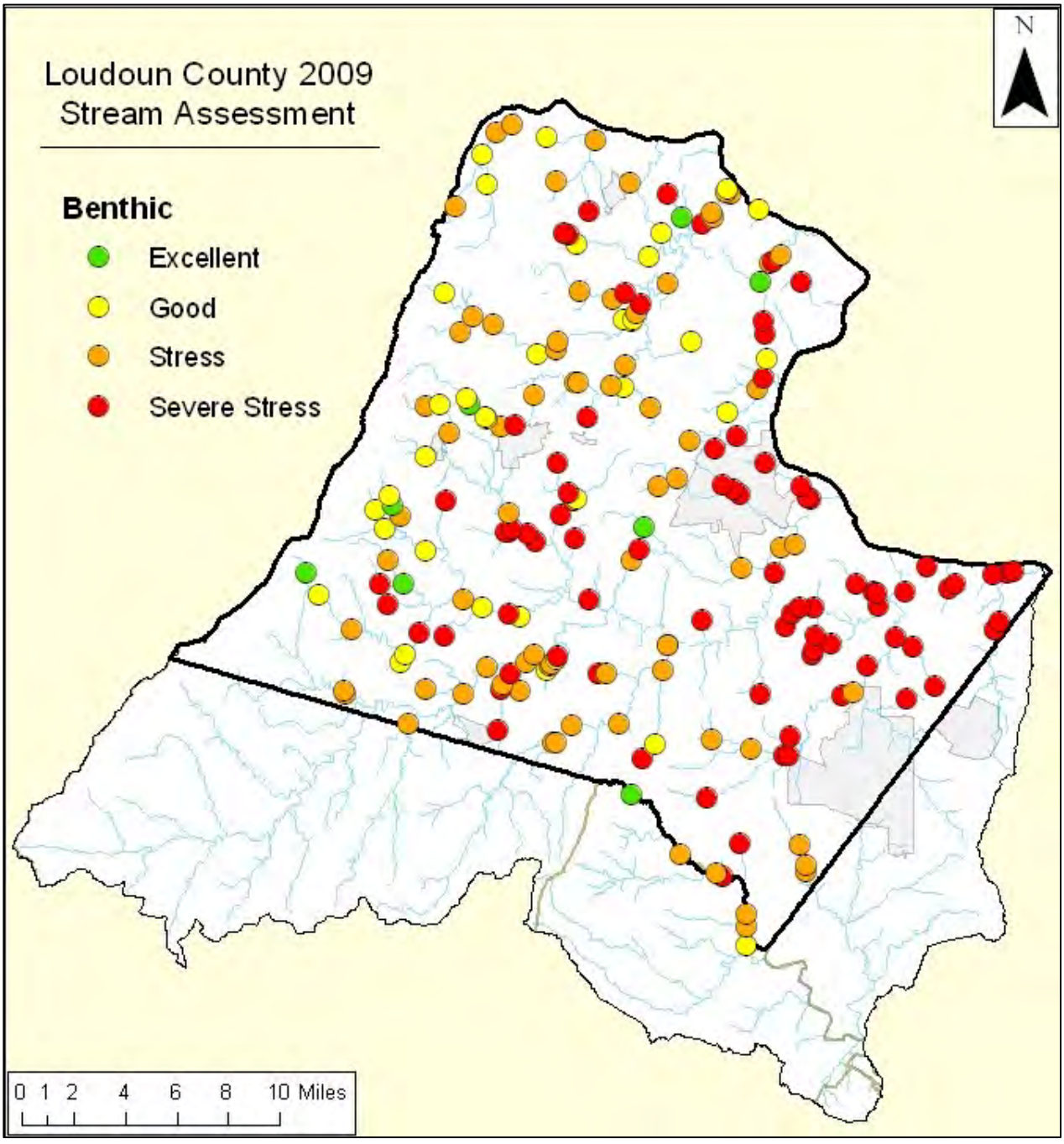

Figure 3. Locations of Benthic Stream Assessment Sites, 2009.

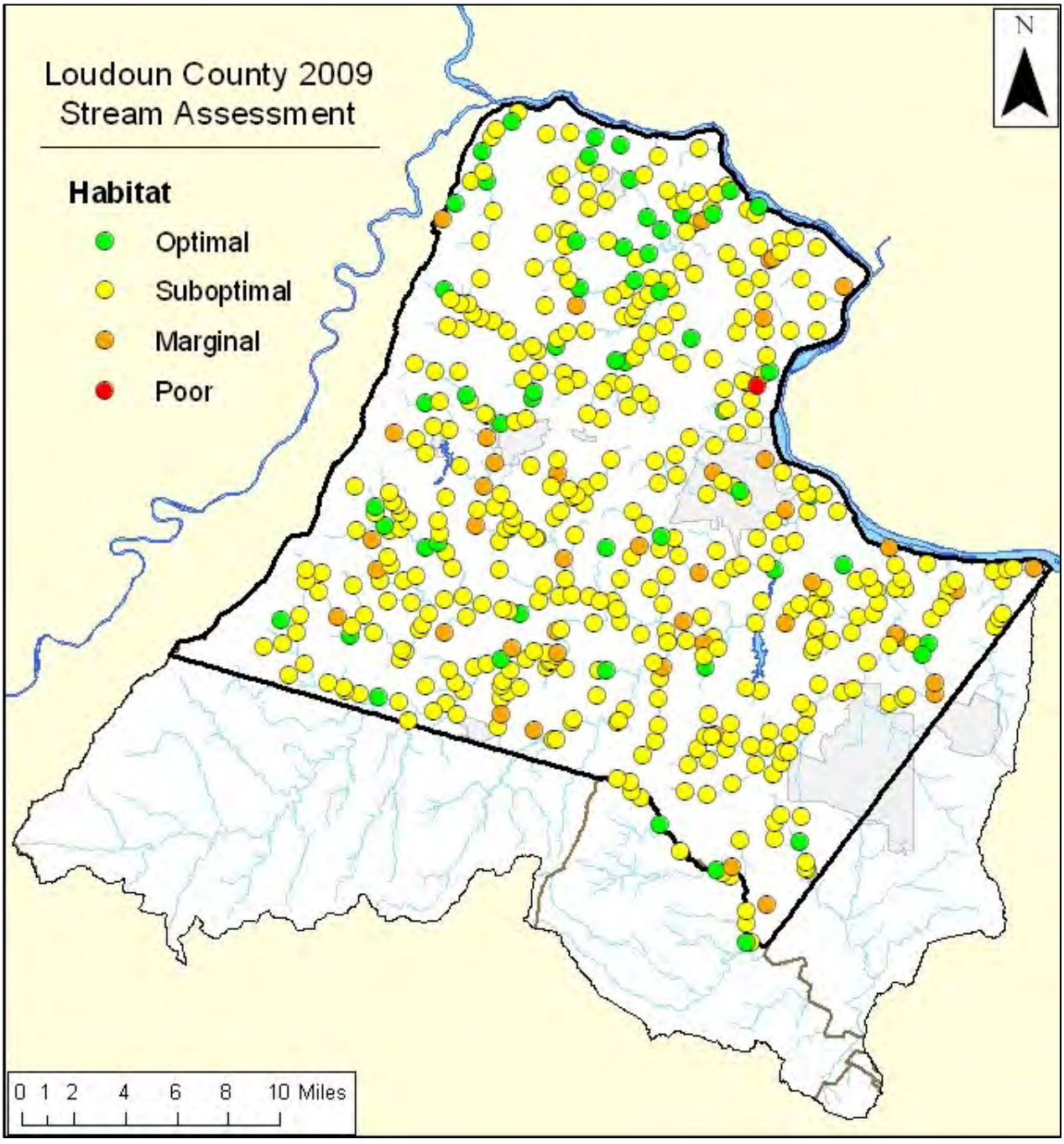

Figure 4. Locations of Stream Habitat Assessment Sites, 2009.

PROJECT COMPLETION REPORT

Loudoun County, Virginia
Water Resources
Monitoring Program

Prepared by
County of Loudoun
Department of Building and Development
1 Harrison St. S.E., Leesburg, VA 20177
703-777-0397

December 2, 2009

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PROJECT COMPLETION REPORT
LOUDOUN COUNTY WATER RESOURCES MONITORING PROGRAM
October 2002 - September 2009

Grant Title 66.606 – Surveys, Studies, and Special Purpose Grants
Assistance # XP- 97310401
Budget/Project Period 10/01/2002 to 09/30/2009
Grantee's Project Loudoun County, VA Water Resources Monitoring Program (WRMP)
EPA Project Officer's US EPA Project officer Frank Ciambrano, (215) 814-5746,
US EPA QA officer, Terry Simpson (410) 305-2739
Loudoun County, VA Project Officers: Dennis Cumbie (703) 771-5529
Wm. Kelly Baty, (703) 771-5390
Susan Breen, (703) 737-8341 (contract admin)

Federal Funding:	**$ 867,300.00**
Federal Funds Expended:	**$ 851,304.74**
Federal Funds Remaining:	**$ 15,995.26**

GOALS/OBJECTIVES:

The general goal of the Water Resources Monitoring Program is to monitor water quality and quantity in Loudoun County. Through these monitoring activities, the County will have the data needed to help promote: (1) clean and safe water through watershed management activities, and (2) healthy communities and ecosystems locally, ultimately affecting the Chesapeake Bay ecosystem.

Specifically, the program proposes to:

- Monitor, assess and delineate, on a countywide watershed basis, baseline conditions and changes to water resources.
- Maintain a database for water resources and related environmental data, much of it in the County's GIS database.
- Assess streams to ascertain their overall condition. Healthy watersheds and streams are more effective in attenuating point and non-point pollution (part of the goal of the Chesapeake Bay Program) and minimizing damage to life and property from flooding.

The program will provide information to assist the County Board of Supervisors in better planning related to utilizing and protecting the County's water resources.

Project Summary:

Purpose

The WRMP has been initiated to monitor water quality and quantity in Loudoun County. The purpose of the WRMP is coincident with those of the US Environmental Protection Agency (USEPA) in that it will provide the basic quantitative data needed to better understand and manage the County's water resources and thus help protect human health and the environment by assuring adequate, sustainable, clean, and safe water. Program outputs described in the approved Work Plan are to install a monitoring infrastructure and begin collecting water quality and quantity data that, although beyond the scope of the WRMP Work Plan, will continue into the future. From this foundation of basic data, trends in quantity and quality can be identified and, with other incorporated information, be used to help evaluate the effects on water resources of climatic variability, increasing use of groundwater, land use changes, and the efficacy of best management practices. The County, through the Board of Supervisors, will then have sound, scientific-based information needed to make informed policy and regulatory decisions about the long-term use, protection, and restoration of water resources for drinking, recreation, and natural habitat. In addition, real-time monitoring of precipitation and stream water levels will provide the County's emergency management services with vital and timely information on hazardous flooding conditions to help protect life and property.

Approach

The objective of the WRMP is to comprehensively monitor the quantity and quality of the County's groundwater and surface water resources so that informed decisions can be made regarding the long-term use and protection of these resources for drinking, recreation, and natural habitat purposes and to ensure healthy communities and ecosystems for all species. Comprehensive hydrologic data are being and/or will need to be continually collected to accomplish this objective. Data collection (including some real-time data) includes the basic hydrologic parameters of precipitation, surface water flow, groundwater levels, the quality of surface water and groundwater, and the general condition of the county's streams through stream assessments.

Precipitation is monitored because of its fundamental influence on all other forms of water resources. Monitoring sites will include real-time stations recording rainfall as well as the

inclusion of previously established stations that have substantial historical data records. Continuous monitoring of stream stage (water level) allows calculations of stream flow. Along with water quantity, stream water quality parameters such as sediment load, temperature, pH, bacteria, and dissolved oxygen will be useful to quantify water quality and the biotic health of the stream. Assessments in selected segments of streams in the major watersheds of the county will incorporate the aforementioned quantity and quality inputs of stream water along with channel morphology, biotic diversity, determination of pereniality and evaluation of riparian borders to integrate an overall measurement of stream health. In addition to basic data useful for evaluating the health and sustainability of surface water, real-time precipitation and stream stage data will be important from a flooding/emergency management consideration and help protect life and property.

Groundwater is the sole source of water for many county residents and is also vital to stream health as the source of stream baseflow. Both the quantity and quality of groundwater is important and will be monitored to provide the basic data for evaluating both baseline conditions and potential trends due to increasing withdrawals and quality affects from various types of land use activities. This information is needed to help examine the relationships between groundwater recharge and discharge areas, pollution sources (both point and non-point), and impacts from withdrawals.

The county's approach with the WRMP has been to develop and incorporate, where possible, cooperative agreements and partnerships with other organizations, including state and federal agencies that have similar environmental goals. This will benefit all of the participating organizations by avoiding duplication of efforts and targeting common issues such as regulatory Total Maximum Daily Loads (TMDLs), and/or statutory Clean Water Act (CWA), Safe Drinking Water Act (SDWA), etc. The WRMP complies with USEPA Strategic Goals of the Government Performance Results Act (GPRA). Data collected as part of the WRMP will be made available to the public.

PLANNED VS ACTUAL ACCOMPLISHMENTS:

TASKS

This section provides a list of tasks associated with the aforementioned goals of the WRMP. Some of these tasks have been partially completed.

Task 1 – Install Stream Gages

In a joint funding agreement between the County and the US Geological Survey (USGS), eight stream gages have been installed in the County and are located as shown in Figure 1. Another two stream gages are also located in the County (also in Figure 1), but have been installed in a joint funding agreement between the Virginia Department of Environmental Quality (VADEQ) and the USGS. Installation of stream gages was completed prior to this reporting period, with no anticipated need for further stream gauging capability.

- **Subtask 1.1 – Collect Stream Data**

  Stage data and the corresponding flow data are collected continuously at each of the stations established through cooperative agreements between USGS/Loudoun County, USGS/VADEQ, and USGS/Interstate Commission on the Potomac River Basin (ICPRB). All data are available through the USGS web site, but are considered provisional until published in the yearly USGS stream flow reports for each state. Data has continued to be received via an automated web query tool that accesses the USGS gage data, and downloads the data into pre-defined formats for easy integration into County databases and various analysis programs. USGS Quality Assurance/Quality Control (QA/QC) protocols have not been completed until the data sets are released by the USGS as part of their statewide yearly water resources publications. The County WRMP Work Plan dictates that these data will be clearly marked as provisional until published by the USGS.

  Water quality sampling is currently conducted at several of the USGS Loudoun County stream gauging sites by the VADEQ. These data are available from the VADEQ web site. The most recent update of the VADEQ data was in March, 2009, with updates to be completed on an annual basis. These data are downloaded and transferred into a County database and incorporated into the WRMP database and the County GIS.

In addition to sampling at USGS stream flow stations, the VADEQ data includes samples collected during previous water quality monitoring projects, from stream monitoring sites that are no longer in service, and as part of VADEQ's probabilistic stream monitoring program. Several of the discontinued monitoring sites have many years of data, whereas the special water quality monitoring projects may have several months of data, and the probabilistic sites may have only one sample collection date. Some of the sites are located outside of the county boundaries, but are integral to the WRMP because they are in headwaters of watersheds that flow into the County, or are downstream of in-County headwaters. Three other sites are located in the main stem of the Potomac River along the northern border of the County.

VADEQ water quality data include over 98,000 individual analyses from more than 140 sampling sites either within Loudoun County or within contributing watersheds. Of these sites, 86 sites had multiple sample events, and 19 sites are long-term sites, with most recent sampling events occurring within the 2009 federal fiscal year. VADEQ data consists of aqueous chemical analyses, biological sampling (data incorporated into VADEQ TMDL reports), field data, and sediment analysis.

Several stream sampling sites within the County have been added to VADEQ's trend monitoring sites through the VADEQ monitoring site nomination process, wherein results from citizen monitoring efforts that have identified sites in need of continued high value data collection. The County has also, through the WRMP EPA grant, performed countywide probabilistic chemical, habitat and biological sampling.

Task 2 – Install Rain Gages

Two real-time (provisional data) rain gages have been installed in the County in a joint funding agreement between the County and the USGS. Four other precipitation gages that previously existed in the County and have long-term historic data records continue to report precipitation through the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC). The locations of the rain and precipitation monitoring sites are shown in Figure 1. A fifth NOAA precipitation gage is located outside

Loudoun County, but is included in the data set since the location is within a large watershed that drains into the County.

The County has also purchased two additional rain gages that will be installed at sites underrepresented by current rain gages. The additional sites have been selected, however, installation has not occurred while awaiting completion of current site construction activities.

- **Subtask 2.1 – Collect Rain Data**

Rain gage data collected at the USGS sites will be provisional until final QA/QC is conducted and the data are published by the USGS. Precipitation data collected at the other five sites are subject to the data QA/QC procedures of NOAA and the National Weather Service (NWS) and are provisional until published. Data from County-owned rain gages will be collected on a monthly basis and added to the County database. Data from the NWS cooperative stations are acquired through the NCDC, but can only be used for analysis, and cannot be re-distributed as raw data. The County is also exploring the possibility of utilizing data collected at various Weatherbug© stations throughout the County.

Task 3 – Install Groundwater Monitoring Wells

The Loudoun County WRMP currently monitors 19 wells for water levels (see Figure 1). Of those 19, three wells were installed and are maintained by the USGS, and provide real-time water level data. The other 16 are wells that were drilled by the County, other agencies, or by private individuals and businesses who have subsequently donated use of the wells to the County for groundwater monitoring purposes. The County has procured 34 electronic water-level logging devices, with 16 devices currently installed in monitoring wells. By the end of calendar year 2010, it is anticipated that the groundwater monitoring network will have 20 active wells. Additional wells may be added as the County continues to pursue donations of inactive wells.

During the current contract period, the County sited and drilled 5 groundwater wells in accordance with criteria established in the WRMP work plan. One well, located at Mickie Gordon Park near Middleburg, was drilled to a depth of 400’ with a tested yield of 3.5 gallons per minute (gpm). Another well, located at the Blue Ridge Center for Environmental Stewardship near Neersville, was drilled to 360’, and had an airlift yield of

12 gpm. Both wells have been sampled for water quality, and are equipped with downhole pressure transducers for long-term water level monitoring.

Three additional wells were drilled on properties owned by the Northern Virginia Regional Park Authority. One is located at Algonkian Regional Park in Sterling, and was drilled to a depth of 240' with an estimated yield of 20 gpm. Another is located at the Temple Hall Farm Regional Park located northeast of Leesburg, and was drilled to 280' with a yield of 5 gpm. The third well was drilled at the Blue Ridge Regional Park near the top of the Blue Ridge southwest of Bluemont. This well was finished at 660' with a yield of 4 gpm. Each well has been instrumented with downhole water level recording devices.

- **Subtask 3.1 – Collect Groundwater Data**

Groundwater level data are currently collected by both the County and by the USGS in cooperation with the VADEQ and the ICPRB. Groundwater level data collected through these agencies follow QA/QC procedures established by those agencies. Level data collected by the County from established and future monitoring wells follow Standard Operating Procedures established by the County and approved as part of the WRMP combined Quality Management Plan/Quality Assurance Project Plan (QMP/QAPP).

Although some groundwater quality data are available from previous work by others, the primary source of data will be generated by the WRMP and collected through the same contract awarded for drilling of monitoring wells. Monitoring wells established by the County for water level monitoring may become permanent groundwater quality sample sites, depending on the accessibility of each site.

A large source of data collected through the County Department of Health domestic well permitting process will be used to augment the data collected from the dedicated monitoring wells installed for the WRMP. Although the sample analysis protocols use standard approved methods, collection of these samples is not performed using approved standard operating procedures. Thus, results from these samples do not meet decision-making criteria, and will be used only for screening of possible water-quality trends or identification of water contamination problems. Health Department permitting data also includes well construction and water level data that can also be used as screening tools.

Water level, water quality, and aquifer testing data are also collected through the County's hydrogeologic testing requirements for subdivision applications. These data are collected under the supervision of professional groundwater geologists using standard protocols. All groundwater data are provisional until a final QA/QC check is conducted to determine the validity of the data. During the contract period, a major effort was initiated and completed to create a digital database of each hydrogeologic study report submitted to the County. These reports, dating back to the mid 1980's, existed mostly in paper copies in the Health Department archives. Funding secured by B&D, through a recommendation by the Water Resources Technical Advisory Committee (WRTAC), was used to pay two groundwater contractors to compile and transmit electronic copies of datasets created by the hydrogeologic study reports. These two contractors were responsible for preparing approximately 85% of the 176 hydrogeologic study reports in the County's records. Approximately 15 other reports in the Health Department archives, studies performed by other contractors, were manually entered into the database by County staff. The result of this effort was a database with construction details, geologic, physical, chemical and spatial data for 176 hydrogeologic studies consisting of over 1850 test wells. Although most of the reports were performed for proposed residential subdivisions, some reports were prepared for industrial sites, resource extraction operations, commercial use and irrigation as required. Since this initial effort was completed, the Health Department has embarked on an effort to scan and archive all paper records of submitted hydrogeologic study reports, along with all well completion and water quality reports.

To augment the water quality database collected from Health Department sampling and hydrogeologic study reports, during the Summer of 2009, the County performed three separate sampling events using domestic water supply wells. The first sampling event consisted of 21 domestic wells selected using a probabilistic approach. The probabilistic design will allow the County to extrapolate results to other areas with more statistical certainty. The second sampling event was based on sampling domestic wells in 10 subdivisions, mostly in Western Loudoun, where County required hydrogeologic study reports had been submitted prior to approval and construction of those subdivisions. By collecting samples from wells in these subdivisions, County staff will be able to identify any changes in water quality between pre- and post-construction. The third domestic sampling

effort was performed in wells located within the Limestone Congolomerate area of the County, located generally north of Leesburg and east of the Bull Run Fault. This karst area is subject to a proposed Zoning Overlay District and had limited groundwater quality information.

Additional water quality data were collected in October, 2008 and March, 2009 by sampling seven of the existing WRMP groundwater monitoring wells. Continued sampling of WRMP wells is expected to continue periodically as funds are made available.

Task 4 – Stream Assessment

Subtask 4.1 – Collect Stream Assessment Data

In early 2009, Loudoun County contracted with an environmental consulting firm to have assessments conducted on streams in the county as part of the Water Resources Monitoring Program. The stream assessment project provided information on the general health of the streams and also identified the extent of perennial streams (those having flows all or most of the time versus intermittent streams that have flows only after rainfall or during wet periods).

The county's stream assessment strategy included review and incorporation, where possible, of information collected during previous stream assessments. Field investigations included analysis at 200 benthic macroinvertebrate monitoring sites and 500 stream habitat assessments. The data from this project compliments and will be used to integrate with other stream monitoring activities within the county to help provide a better understanding of the conditions of the county's streams.

Components of the Loudoun County stream assessment project include:
Benthic macroinvertebrates – The insects and other small creatures that live on the stream bottom. A rich and diverse community of these small animals indicates that the stream is generally in good to excellent condition. Conversely, finding only a few macroinvertebrates or only certain types that are tolerant of harsh conditions indicates generally poor stream conditions.

Water quality – Field measurements such as temperature, pH (how acidic or alkaline the water is), and specific conductivity (dependent on the concentration of dissolved solids in the water).

Physical characteristics of the stream - channel cross section, amount of sediment on the stream bed, obstructions, water depth and velocity, bank stability, and vegetation on the bank and adjacent to the stream.

The following reports were generated during the stream assessment project and are available at www.loudoun.gov/streamassessment:

- Stream Assessment – Results
- Stream Assessment - Strategic Plan
- Stream Assessment – Quality Assurance Project Plan
- Stream Assessment – Review of Previous Assessments
- Stream Assessment – Presentation of Findings to Water Resources Technical Advisory Committee

DATA COLLECTION AND MANAGEMENT

During the WRMP contract period, the County established and filled the position of Water Resources Data Manager. This position is charged with compiling all available County water resources data into efficient, manageable and user-friendly structures. The Data Manager has created a data model, where surface water, groundwater, soils, wetlands, and numerous other water-related data sources, can be identified, queried, and updated more efficiently. Another achievement of the Data Manager has been the completion of the first annual report for the 2008 calendar year. The report is based on data collected by the WRMP during 2008, and includes comparisons with data collected in previous years. A full text copy of the report is available at the Department of Building and Development web site at http://www.loudoun.gov/Default.aspx?tabid=640. These annual reports are expected to be developed each year as part of the on-going WRMP.

Extensive work was conducted during the contract period to compile, integrate, and evaluate all existing water resources data. County staff completed statistical analyses of stream flow, precipitation, surface water quality, groundwater quality, groundwater quantity, potential pollution sources, soils, wetlands, and has begun initial investigation into County-wide and

watershed-based water budgets. These analyses, along with a rather large compilation of water-related reports, GIS base maps, and spatial derivative maps, were provided to a private consulting firm for incorporation into a Comprehensive Watershed Management Plan (CWMP). The initial report establishing baseline water resources conditions was completed by the consultant in December of 2007, with the final CWMP report completed in March of 2008.

Education and outreach efforts have provided an explanation of the WRMP and other county environmental initiatives to the public by way of the Loudoun County Department of Building & Development web site at www.loudoun.gov/watersheds-hydrology. WRMP data collected by the County or other agencies are available to the public upon request, with the exception of precipitation data purchased from the NCDC (analysis of those data may be distributed, but the raw data can not). Any data that is not currently available on-line can be obtained by contacting the Department of Building and Development.

QMP/QAPP UPDATE:

Adherence to QA/QC procedures and Standard Operating procedures as outlined in the QAPP has been achieved with all data collected thus far by the WRMP. As water resources monitoring strategies progressed, some additional documents in the form of project specific QAPP and Standard Operating Procedures (SOP) were added to the project QMP/QAPP contract period. Appendix A is a summary of data sources and associated QA/QC protocols, along with a checklist showing that data collected has followed those protocols. Appendix A has been updated to include those project specific documents that have been added to the QMP/QAPP since its initial approval by EPA. Each data source is categorized by the minimum data quality criteria as specified in the QMP/QAPP document.

HIGHLIGHTS:

Since the inception of the Water Resources Monitoring Program, the major accomplishments as of the date of this report are:

- establishment of ten cooperative real-time stream gauges;

- establishment of 19 groundwater monitoring wells, including 5 wells drilled specifically for WRMP use;
- compilation and QA/QC of existing County water resources data and development of WRMP databases;
- Hiring of a Water Resources Data Manager;
- Compilation and statistical analysis of WRMP data;
- Collection of stream assessment data, precipitation data, and ground-water quality data from outside sources for addition into the WRMP databases;
- Establishment of additional rain gauges;
- County-wide probabilistic and targeted sampling of domestic groundwater wells;
- Completion of County-wide Stream Assessment.

Future activities include continued collection of data from WRMP monitoring wells and stream gauges, expanded water quality sampling of surface and groundwater using probabilistic site selection methods, expansion of the groundwater monitoring network through installation of additional wells, and installation of real-time precipitation gauges to expand the WRMP's coverage, and to allow for advanced warning of flood conditions throughout the County.

EQUIPMENT:

All equipment purchased in support of the WRMP has been associated with installation of groundwater monitoring wells, installation of water level recording equipment, installation of additional rain gauges, procurement of groundwater sampling equipment, and procurement of surface water sampling equipment (chemical and biological). Equipment procured under this contract will enable the County to continue to operate the WRMP well into the future.

DEFICIENCIES/CORRECTIVE ACTION:

None to report.

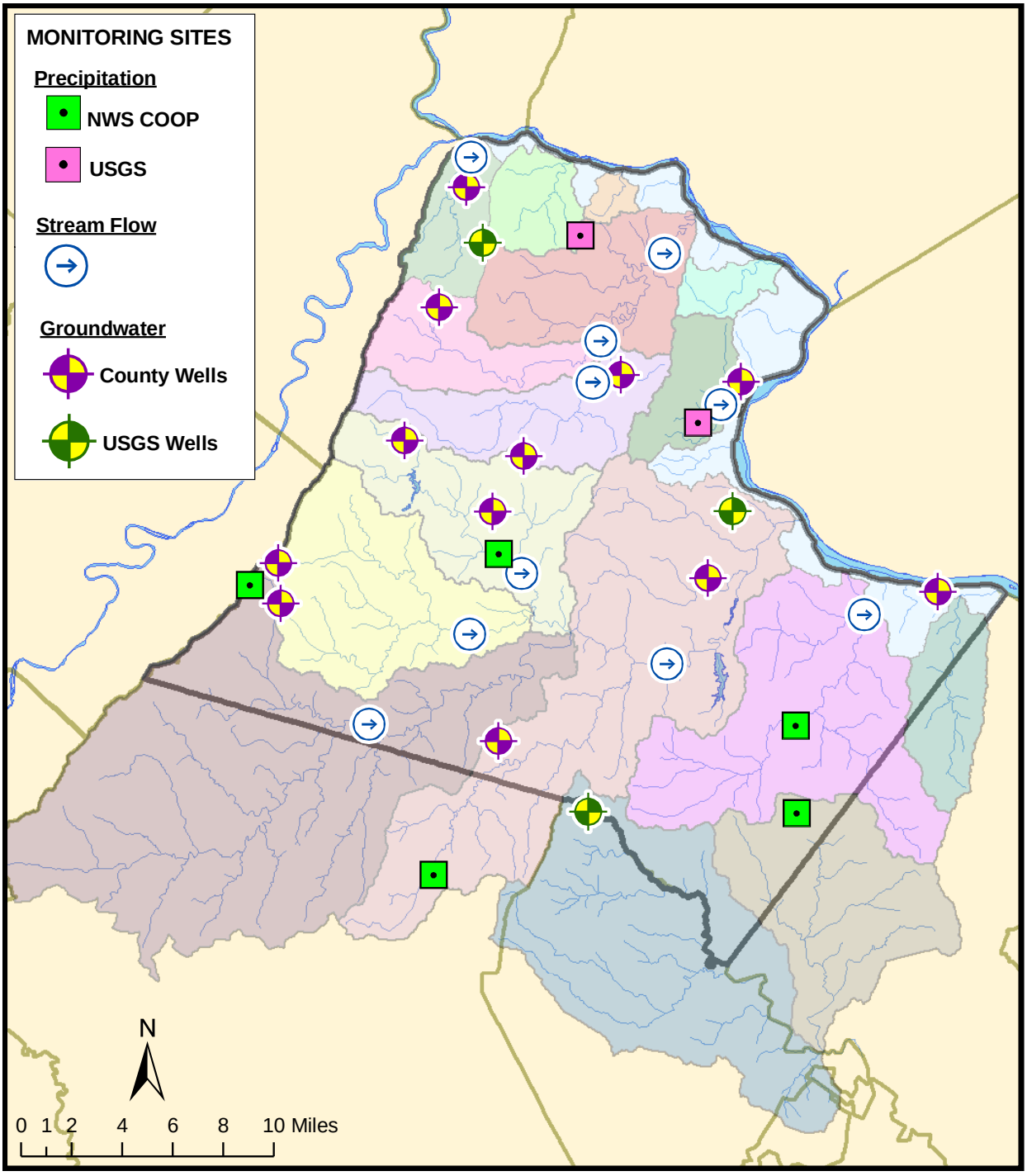
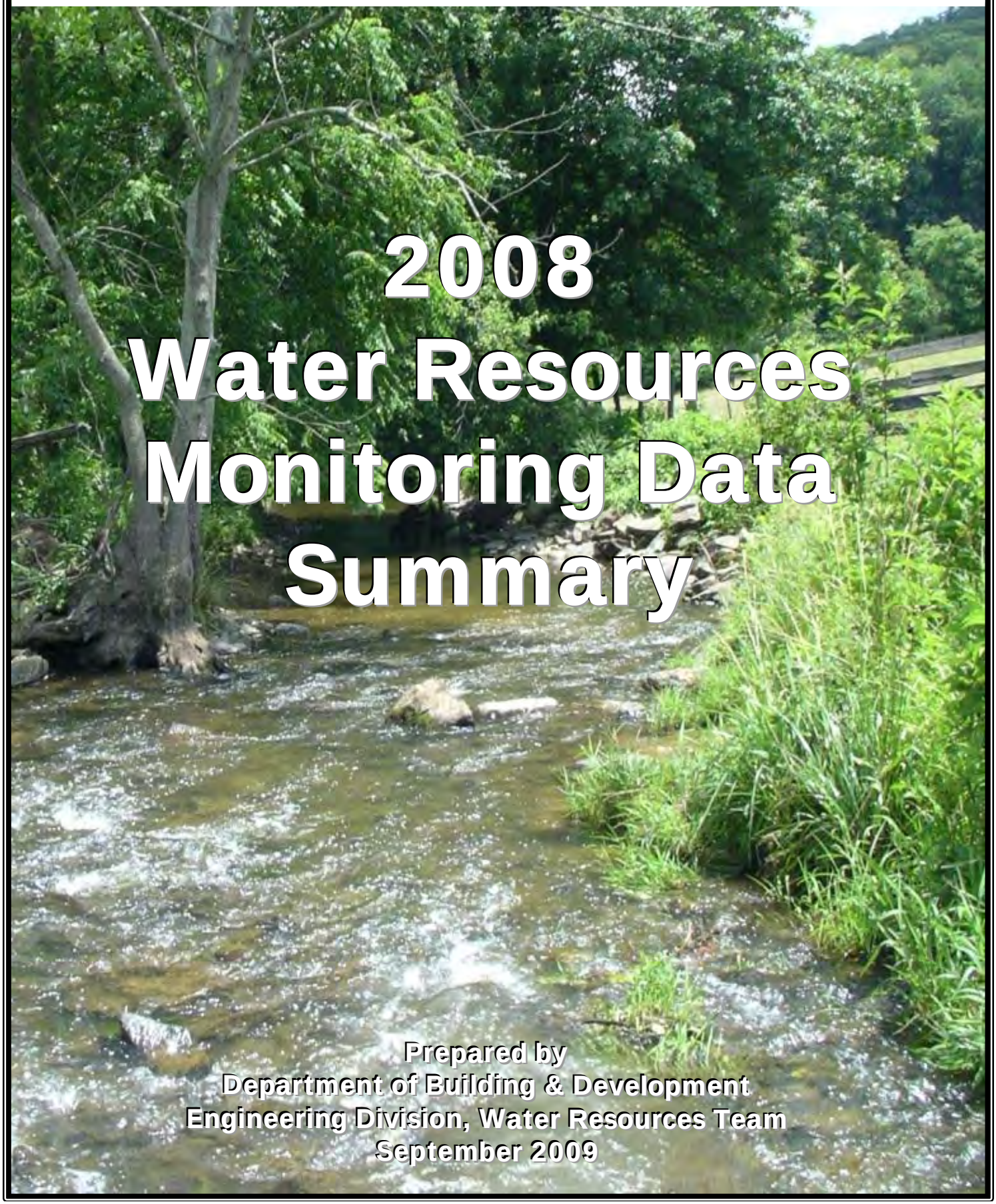


Figure 1. Locations of Water Resources Monitoring Program permanent monitoring sites.

Appendix A. Data quality matrix for data sources employed by the Water Resources Monitoring Program.

Data Quality Level	*Quality Assurance Plan*	*Project Data Collection*	*Standard*	*Standard Reference*	*Data Collected During Report Period*	*QA Performed*
A	Internal QAPP approved by QA officer	Groundwater Level Monitoring: Data collected by Loudoun County and/or County contractors.	Loudoun County SOP for Groundwater Monitoring.	ASTM D 4750-87	Groundwater level data collected from 10 monitoring wells. Field data sheets on file. Barometric compensation not completed for post 11/06 data due to logger failure.	✔
		Groundwater Quality Sampling: Data collected by Loudoun County and/or County contractors.	Loudoun County SOP for Groundwater Monitoring.	ASTM D 4448-85a USGS National Manual for the Collection of Water-Quality Data	County groundwater quality sampling on hold for completion of other tasks.	✔
	Project Specific QAPP and SOPs	Stream Assessment, including Water Quality, Biological Assessment, and determination of stream pereniallity.	External QAPP and SOP	Virginia DEQ "Guidelines for DEQ review and approval of biological monitoring QAPPs submitted by non-DEQ sources" (Guidance Memo No. 06-2010, DEQ 2006a).	County-wide Stream Assessment completed in 2009.	✔
B	External QAPP	Groundwater Quality Analysis: National Testing Laboratories	External QA and SOP	EPA analyitical techniques.	Over 2700 samples and 300,000 analyses received and entered into WRMP Access database.	✔
		Precipitation: National Weather Service	External SOP	NWS Observation Handbook No 2: Cooperative Station Observations	Long-term historical data from 5 NWS stations updated May, 2007.	✔
		Stream Flow: USGS, VDEQ	External SOP	Rantz, S.E., 1982, Measurement and Computation of Streamflow: Vol. 1, Measurement of Stage and Discharge. U.S. Geol. Survey Water-Supply Paper 2175, 284 p.	QA verified data from 10 stations approved through September 30, 2006. Data provisional from October 1, 2006 to present. All published data available from USGS. Provisional data available only from USGS web site.	✔
		Surface Water Quality: VDEQ	External SOP	Standard Operating Procedures Manual for the Dept. of Env. Quality Office of Water Quality Monitoring and Assessment.	Data from 146 stations within state HUCs covering Loudoun County. Nineteen stations current thrugh January, 2006. Data entered into County Access database.	✔
		Groundwater Level: VDEQ, ICPRB, USGS	External SOP	ASTM D 4750-87	Data from two monitoring wells available at USGS web site. Data approved through September 30, 2006.	✔
		Stream Assessment: VDEQ, Metropolitan COG	External SOP	Galli, John, 1992, Rapid Stream Assessment Technique (RAST). Metropolitan Washington Council of Governments.	No stream assessments perfomed. Other methodologies may be used.	NA
C	Minimum Data Acceptance Criteria met	Precipitation: USGS	No SOP (in development)		Provisional data available at USGS web site.	None
D	Minimum Data Acceptance Criteria not met	Groundwater quality: Data collected by LCDEH	No SOP	Sampling methods may be questionable	Data from County WellPoll database.	None
		Stream Assessment: Volunteer Program	Guidance manual		Annual reports through 2005 available.	NA

Loudoun County, Virginia



2008 Water Resources Monitoring Data Summary

Prepared by
Department of Building & Development
Engineering Division, Water Resources Team
September 2009

Loudoun County, VA
2008 Water Resources Monitoring Data Summary

ABBREVIATIONS AND ACRONYMS

cfs:	*cubic feet per second*
DEQ:	*Virginia Department of Environmental Quality*
EPA:	*U.S. Environmental Protection Agency*
MCL:	*maximum contaminant level*
mg/L:	*milligrams per Liter*
NWS-COOP:	*National Weather Service Cooperative monitoring station*
OWTS:	*On-site Wastewater Treatment System*
TDS:	*Total Dissolved Solids*
uS/cm:	*microSiemens per centimeter*
USGS:	*U.S. Geological Survey*
WRMP:	*Water Resources Monitoring Program (Loudoun County)*

DATA LIMITATIONS

While efforts have been made to insure the accuracy of the data presented in this report, Loudoun County does not assume any liability arising from the use of these data. Reliance on these data is at the risk of the user. The U.S. Geological Survey (USGS) and the National Climatic Data Center (who distribute National Weather Service data) have data quality assurance procedures in which data are considered "provisional" until they are checked and corrected as needed. Data used in this report that are provisional are:

- USGS rainfall site Limestone/Leesburg from 1/1/2004
- USGS rainfall site Catoctin/Lovettsville from 1/1/2005
- USGS well site Bull Run (USGS-03) from 10/15/2008
- USGS well site Leesburg (USGS-02) from 11/19/2008
- USGS well site Short Hill (USGS-01) from 11/18/2008
- USGS stream gauging station South Fork Catoctin Creek from 10/8/2008
- USGS stream gauging station Catoctin Creek (Taylorstown) from 10/1/2008
- USGS stream gauging station Piney Run from 12/9/2008
- USGS stream gauging station Beaverdam Creek from 10/9/2008
- USGS stream gauging station Goose Creek Middleburg from 10/9/2008
- USGS stream gauging station Goose Creek Leesburg from 10/1/2008
- NWS-COOP precipitation site The Plains 2NNE from 12/1/2008
- NWS-COOP precipitation site Sterling RCS from 12/1/2008
- NWS-COOP precipitation site Mount Weather from 12/1/2008
- NWS-COOP precipitation site Lincoln from 12/1/2008

ACKNOWLEDGMENTS

A grant from the U.S. Environmental Protection Agency supplemented County funds to establish portions of the monitoring sites and infrastructure identified in this report including some of the stream gauges, monitoring wells, and precipitation stations. The grant also reimbursed a portion of the cost associated with time County staff spent developing the Water Resources Monitoring Program including program planning and implementation, data collection, data management, and analyses.

This document was prepared by County staff members Glen Rubis, Scott Sandberg, David Ward, and Dennis Cumbie of the Water Resources Team in the Engineering Division of the Department of Building and Development.

INTRODUCTION AND SETTING

This document presents a summary of the data collected during various water resources monitoring activities in and adjacent to Loudoun County, Virginia, by government and volunteer organizations during calendar year 2008. More specifically, data characterizing precipitation, stream flow, groundwater levels, and surface water and groundwater quality are summarized. Loudoun County Department of Building and Development either collects these data or compiles them from other sources as part of the County's Water Resources Monitoring Program (WRMP). The data are presented and discussed in two sections: water quantity – measurements of precipitation, stream flows, and groundwater levels; and water quality – the chemical and biological characteristics of stream water and groundwater.

The WRMP was initiated in 2001 to help assess the conditions of water resources in Loudoun County which has been one of the fastest growing counties in the nation during the past 10 to 15 years. The current population of Loudoun is approximately 283,000 and is projected to nearly double by 2030.

General Characteristics of Loudoun County

Loudoun County is located in Northern Virginia approximately 30 miles west of Washington, D.C. The county covers an area of 520 square miles and is bordered on the north by the Potomac River and the west by the Blue Ridge Mountains (Figure 1).

Urban and suburban development is concentrated mostly in the eastern part of the county, generally from the Town of Leesburg to Washington Dulles International Airport and the border with Fairfax County. The western portion of the county is more rural, with crop farms, pastures, vineyards, several small towns, and numerous large-lot residential subdivisions.

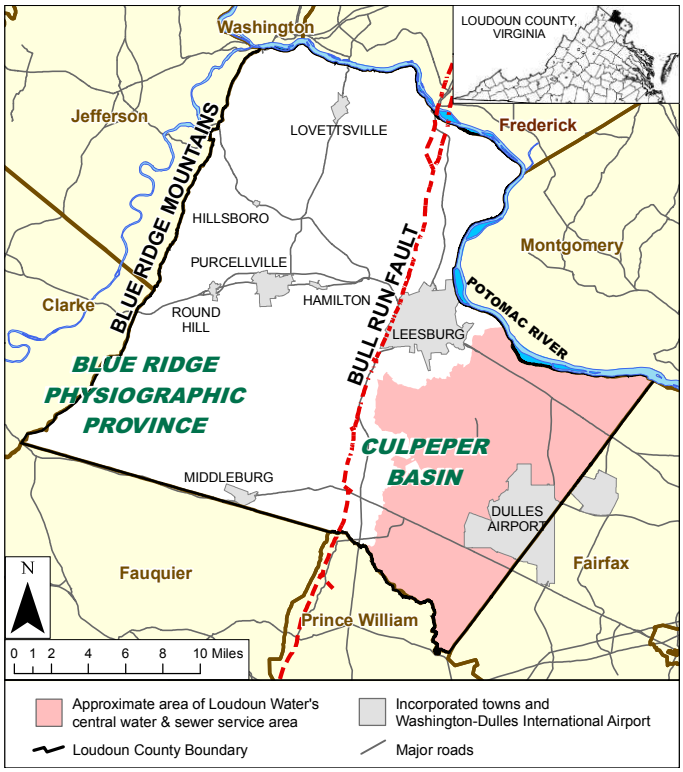


Figure 1. Major features of Loudoun County, VA.

Loudoun Water, an entity created by a resolution of the Loudoun Board of Supervisors in 1959 (see www.loudounwater.org), owns and operates a centralized water and sewer system that serves the developed area of eastern Loudoun as shown in Figure 1. Outside of Loudoun Water's central system area, county residents obtain water for drinking and other uses primarily from wells. In the rural towns and several of the subdivisions, sewage is treated in small wastewater treatment plants while the remaining single family homes and businesses have on-site individual wastewater treatment systems such as a septic tank with drain field.

Physiography and Geology

Loudoun County intersects two physiographic provinces which are separated by the Bull Run Fault (Figure 1). The fault separates the Culpeper Basin (a Triassic-age rift basin) of the Piedmont Province on the east from the Blue Ridge Province on the west. The Culpeper Basin is comprised of sedimentary rocks and sedimentary-derived metamorphic rocks, both which may include intrusions of dense, igneous diabase rock. The north-eastern area of the county, generally from the Town of Leesburg northward, is underlain by limestone conglomerate rock (the Leesburg Member of the Balls Bluff Siltstone) and has surface features and hydrogeology characteristic of karst areas. Western Loudoun is underlain by metamorphic rocks derived from both sedimentary and igneous parent material. Bedrock in the county is covered by regolith (unconsolidated sediments and soils) that is commonly between 20 and 50 feet thick, but ranges from 0 to more than 90 feet thick. Soils are generally less permeable in eastern Loudoun as compared to western Loudoun.

Watersheds

Watersheds are defined by topography and drain all of the surface water in an area to a single location such as a stream or lake. They are often used to delineate areas for monitoring, analyzing, and managing water resources. Watersheds can be defined at many different sizes and one of the watershed scales that is convenient for county-wide investigations in Loudoun is based on the 17 watershed areas shown in Figure 2. The majority of the county is covered by three major drainage areas that empty into the Potomac River by way of the following stream systems: Goose Creek, Catoctin Creek, and Broad Run.

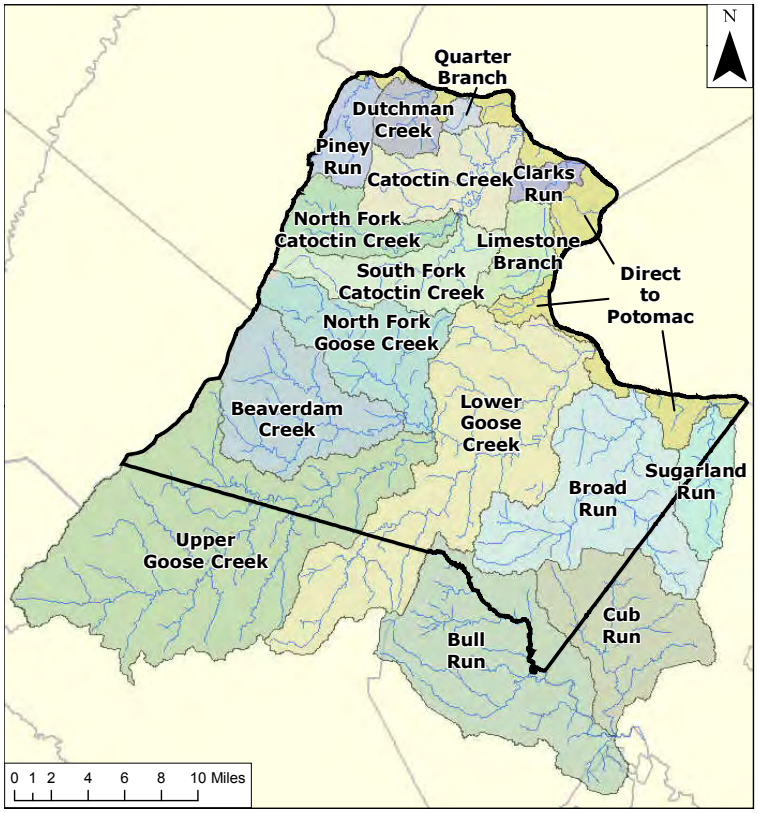


Figure 2. Watersheds and streams in and adjacent to Loudoun County, VA.

The eastern and southern borders of the county share watersheds with the neighboring counties of Fairfax, Prince William and Fauquier. The upper reaches of Broad Run and Sugarland Run watersheds lie to the east in Fairfax County and Goose Creek originates to the southwest in Fauquier County, but all three streams/watersheds drain into Loudoun County and, ultimately, the Potomac River.

The southeastern region of Loudoun includes the headwaters of Bull Run and Cub Run. These streams drain out of Loudoun County to the south and are tributaries to the Occoquan River which empties into the Potomac River.

WATER QUANTITY

This section presents information on the quantity of water resources with data on precipitation, stream flows, and groundwater levels in Loudoun County during calendar year 2008.

Precipitation

Total annual precipitation was above normal during 2008, with approximately 44 inches recorded at Dulles Airport. Precipitation data used in the WRMP are obtained from seven monitoring sites in or adjacent to the county (Figure 3). Five precipitation stations are part of the National Weather Service's cooperative monitoring network and two rain gauges are operated by the U.S. Geologic Survey (USGS). The National Weather Service sites have relatively long periods of record with one having nearly continuous data since 1930 (Table 1). The two USGS rain gauges have mostly continuous data records beginning in 2004.

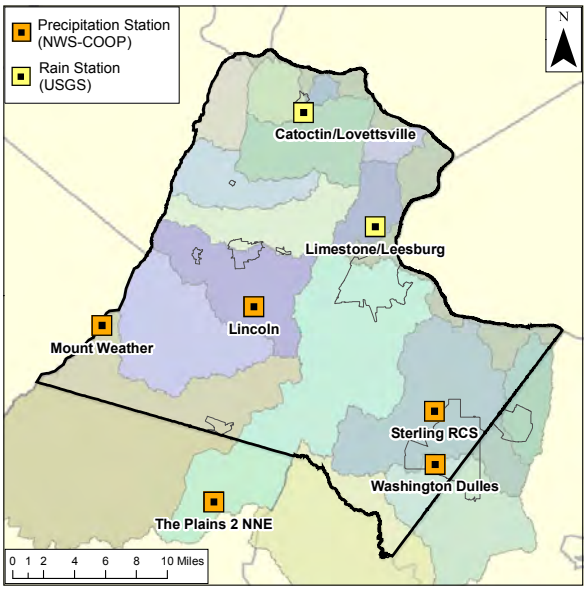


Figure 3. Precipitation monitoring sites.

Data from the long-term records indicate that annual precipitation has ranged from 20.4 inches (at the Lincoln station in 1930) to 67.7 inches (at the Sterling station in 2003). For the 30-year period 1978 through 2007, the normal (median) annual precipitation at the Dulles monitoring station was 40.0 inches. During 2008, precipitation recorded at the two stations with complete daily records was 44.0 and 45.4 inches (Table 1).

Table 1. Precipitation monitoring stations and data.

Precipitation Monitoring Station Name	Start of Record[1]	Station Operated by [2, 3]	Annual Statistics (Inches) for Period of Record[4]			2008 Total (Inches)	2008 Corrected[5] (inches)	Days missing in 2008
			Minimum	Median	Maximum			
Dulles	1964	NWS-COOP	27.0	38.9	65.7	44.0	44.0	0
Limestone Branch	2004	USGS	28.0	39.3	50.4	38.3	43.1	12
Lincoln	1930	NWS-COOP	20.4	41.3	63.5	42.4	48.8	24
Lovettsville	2005	USGS	30.3	40.4	45.4	35.2	36.4	8
Mt. Weather	1949	NWS-COOP	24.8	39.2	64.1	45.2	46.4	31
Sterling RCS	1978	NWS	30.2	40.5	67.7	46.8	46.8	1
The Plains	1955	NWS-COOP	27.7	41.4	63.1	45.4	45.4	0

[1] First full year that generally continuous data collection began.

[2] NWS-COOP = National Weather Service Cooperative weather station. USGS = U.S. Geological Survey.

[3] NWS-COOP stations record liquid and frozen precipitation; USGS stations record liquid precipitation only.

[4] Annual precipitation statistics based on site's period of available record through 2007 (see footnote 1).

[5] Missing daily data filled with the average of that day's data from the remaining active precipitation sites.

Figure 4 presents annual precipitation data from the Dulles station from 1978 through 2008. Figure 5 shows 2008 monthly precipitation at the Dulles station in relation to monthly data for the 30-year period from 1978 through 2007. In general, 2008 started out relatively dry, but a wet April, May, and September resulted in above normal precipitation for the year.

Loudoun County experienced several large precipitation events during 2008. In particular, storms on April 20 and 21, May 8 through 12, and September 5 and 6 produced a total of 16.35 inches of rainfall at the Dulles station with the storm event in May dropping 7.11 inches of rain over the 5-day period. A graph of daily precipitation is shown in Figure 6.

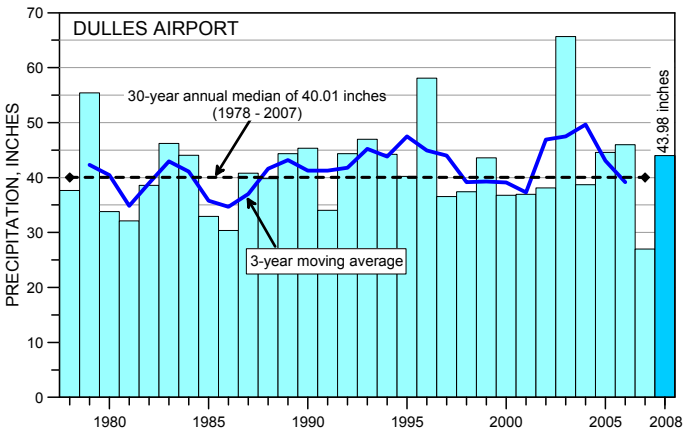


Figure 4. Annual precipitation at Dulles Airport from 1978 through 2008.

The 3-year moving average plot above is useful to smooth out yearly fluctuations and show somewhat longer trends of precipitation deficits and surpluses (compared to the median) which can indicate stresses on water supplies and the environment.

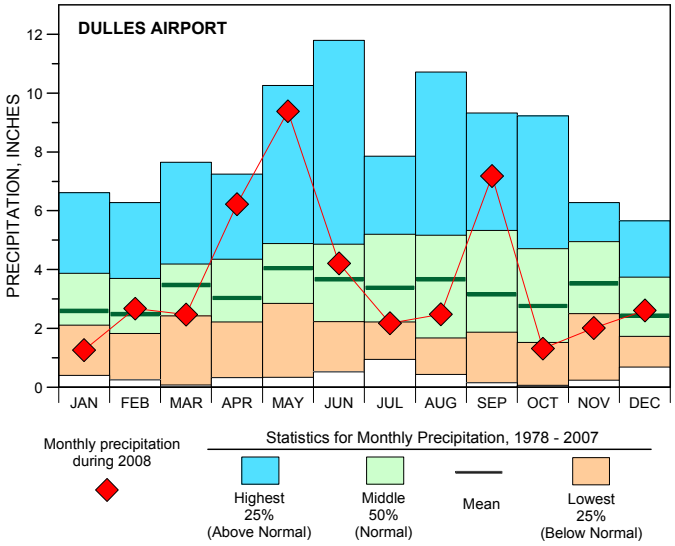


Figure 5. Monthly precipitation at Dulles Airport.

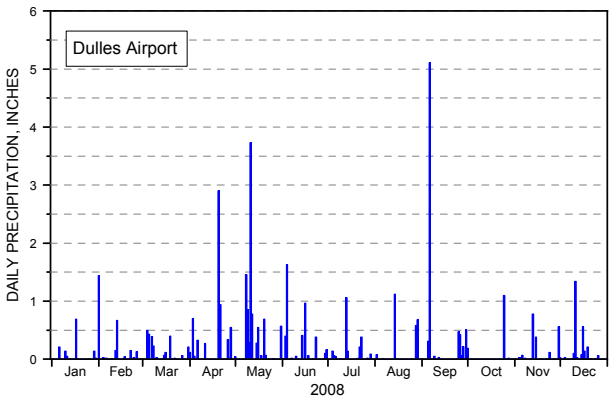


Figure 6. Daily precipitation at Dulles Airport during 2008.

Measurable precipitation was reported on 118 days during 2008 at the Dulles station. For those days with reported precipitation, the average accumulation was 0.37 inches and the median was 0.14 inches.

Streamflow

At the streamflow monitoring sites in Loudoun, average flow rates during 2008 were generally below normal, but minimum flows during 2008 were higher than the minimum flows recorded from 2002 through 2007.

Loudoun County has more than 1,000 miles of perennial stream channels (flow all year long) and an additional 800 miles of intermittent stream channels (flow primarily during wet periods). Knowing how much water flows in the larger perennial streams and how it varies over both short and long time periods is use-

ful in the assessment of flood control, stormwater structures, and environmental conditions. There are ten USGS stream gauges that measure and record water stage (level) in Loudoun County streams (Figure 7).

Measured water levels at each gauging station are reported via telemetry to the USGS, correlated to historical site-specific stream discharges (flows), and the data made available in near real-time with updates every 15 minutes on their web site (http://va.water.usgs.gov/Loudoun/data.htm).

The stream gauge stations are routinely checked and calibrated by the USGS to maintain accuracy but the data are considered provisional until passing the USGS's quality control process.

A review of the 2008 gauging data indicates that, while stream flows were within normal ranges throughout most of the year, flows during portions of the year were also below or above normal. Loudoun County experienced large storm events in April, May, September and December and the resulting stormwater runoff produced pronounced spikes in the flow hydrographs during these times. Figure 8 illustrates the flow of Goose Creek near Route 621 during 2008. Goose Creek, the County's largest stream, flows through the county from its headwaters in Fauquier County to the Potomac River. Hydrographs from Beaverdam Creek and Limestone Branch also showed pronounced low flow periods in January, August, and October. Table 2 lists the ten gauging stations in the county along with selected data statistics. All of the maximum flow rates for 2008 occurred on May 12 and the majority of low flows occurred near the end of August. Frequent very high and extended very low flows can be stressful on stream habitats and riparian communities.

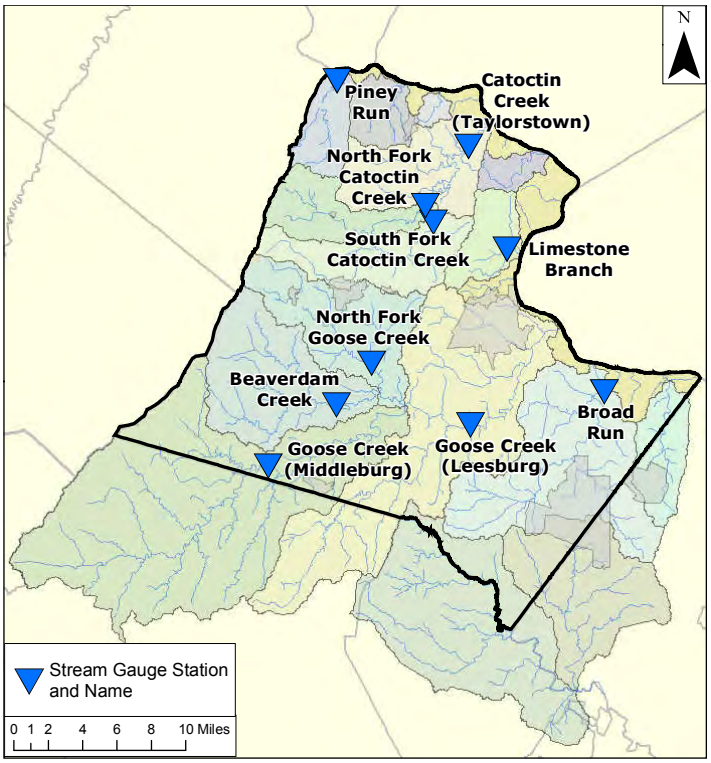


Figure 7. Locations of stream gauging stations.

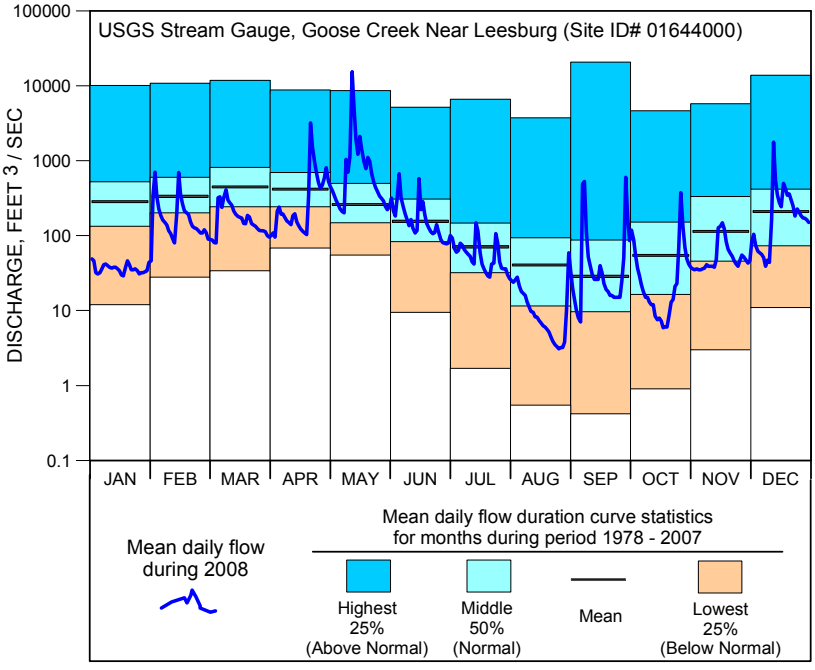


Figure 8. Stream discharge hydrograph for Goose Creek during 2008.

Table 2. Stream gauging stations and basic statistics.

Stream Gauge Site Name	Start of Record	Drainage Area[1] (sq. miles)	2008 Avg[2] (cfs)	'02-'07 Avg[3] (cfs)	2008 Min[4] (cfs)	'02-'07 Min[5] (cfs)	2008 Peak[6] (cfs)	'02-'07 Peak[7] (cfs)	2008 0 Flow[8] (days)	'02-'07 0 Flow[9] (days)
Beaverdam Creek	Jul 2001	47.2	34.7	56.3	0.0	0.0	2640	5000	26	118
Broad Run	Oct 2001	76.1	148.0	123.9	9.2	1.6	10300	5510	0	0
Catoctin Creek - Taylorstown	Oct 1970	89.5	90.8	107.2	2.8	0.1	6770	5400	0	22
Goose Creek - Leesburg	Jul 1909	332.0	237.6	396.6	3.4	1.2	15400	20800	0	0
Goose Creek - Middleburg	Oct 1965	122.0	92.0	143.9	1.0	0.0	4600	14000	0	55
Limestone Branch	Aug 2001	7.9	7.5	9.5	0.7	0.5	449	976	0	0
North Fork Catoctin Creek	Jul 2001	23.1	22.0	25.1	1.2	0.0	1190	1060	0	51
North Fork Goose Creek	Jul 2001	38.1	29.9	58.5	1.3	0.3	2040	3040	0	0
Piney Run	Oct 2001	13.5	12.3	14.9	1.3	0.0	488	436	0	17
South Fork Catoctin Creek	Jul 2001	31.6	31.7	37.5	1.5	0.0	1920	1840	0	33

[1] Drainage area above the stream gauge (square miles)

[2] Average daily flow rate during 2008 (ft^3/sec)

[3] Average daily flow rate for the period of 2002–2007 (ft^3/sec)

[4] The lowest 7-day average flow rate during 2008 (ft^3/sec)

[5] The lowest 7-day average flow rate for the period of 2002–2007 (ft^3/sec)

[6] Peak daily flow rate during 2008 (ft^3/sec)

[7] Peak daily flow rate for the period of 2002–2007 (ft^3/sec)

[8] Number of consecutive days with flow <0.2 cfs during 2008

[9] Number of consecutive days with flow < 0.2 cfs for the period 2002-2007

Groundwater Levels and Wells

Groundwater levels during 2008 were generally within the normal range of long-term recorded levels. There are approximately 14,000 active residential wells throughout Loudoun County and groundwater is the primary source of drinking water for the majority of residents in western Loudoun. In 2008, groundwater levels were recorded throughout the year in 11 dedicated monitoring wells at the sites shown in Figure 9. Eight of these wells were monitored by County staff from the Department of Building and Development and three were monitored by the USGS. Groundwater level data have been collected from the three USGS wells since the late 1960s or early 1970s. Table 3 shows well and groundwater level data from these monitoring wells.

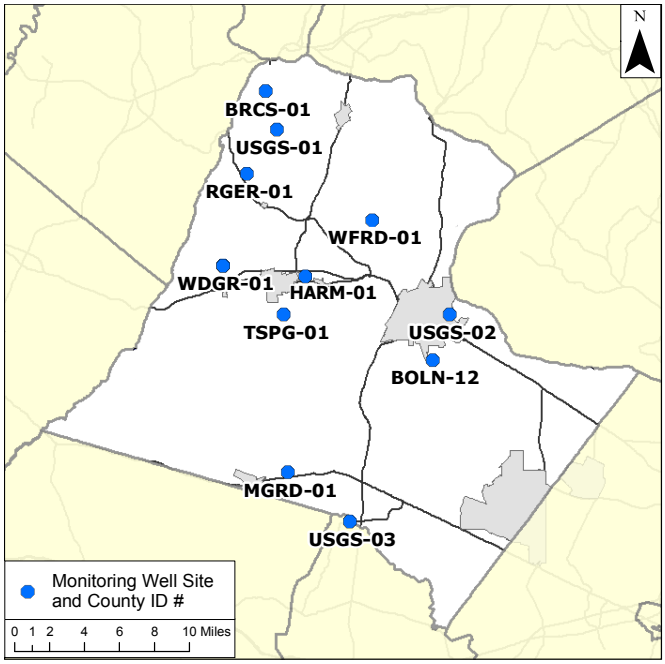


Figure 9. Locations of groundwater monitoring wells.

Figure 10 shows hydrographs for selected monitoring wells that are representative of groundwater levels for the years 2006 through 2008. Groundwater levels began 2008 at levels lower than normal because of low precipitation during the second half of 2007. However, with increased precipitation in April and May of 2008, groundwater levels recovered to more typical ranges.

Table 3. Monitoring well and groundwater level data.

Well Site ID (see map for location)	Monitoring Organization	Well Depth (feet)	Rock Type	Period of Record	Groundwater Level (feet)[1]			
					Historic High	2008 High	Historic Low	2008 Low
USGS-01	USGS	516	Meta-conglomerate/ metasiltstone	8/1969 - Present	51.67	50.34	61.5	61.97
USGS-02	USGS	535	Fluvial, deltaic sandstone	10/1977 - Present	25.93	19.73	41.52	30.56
USGS-03	USGS	165	Siltstone/sandstone	11/1968 - Present	6.73	6.59	13.09	11.54
BOLN-12	Loudoun	515	Fluvial, deltaic sandstone	12/2006 - Present	6.4	7.44	12.8	12.8
BRCS-01	Loudoun	320	Igneous intrusive	12/2007 - Present	21.43	21.43	30.66	30.66
HARM-01	Loudoun	945	Plutonic igneous intrusive	2/2005 - Present	35.14	36.87	54.99	49.67
MGRD-01	Loudoun	400	Plutonic igneous intrusive	12/2007 - Present	-2.67	-2.67	7.11	7.11
RGER-01	Loudoun	700	Igneous intrusive	2/2005 - Present	29.81	30.98	54.45	54.45
TSPG-01	Loudoun	360	Plutonic igneous intrusive	2/2005 - Present	65.93	69.92	82.1	80.98
WDGR-01	Loudoun	940	Mafic igneous intrusive	3/2005 - Present	8.96	9	22.4	21.63
WFRD-01	Loudoun	400	Plutonic igneous intrusive	11/2002 - Present	8.42	11.3	29.68	29.68

[1] Feet below ground surface. Negative number indicates feet above ground surface (flowing artesian condition).

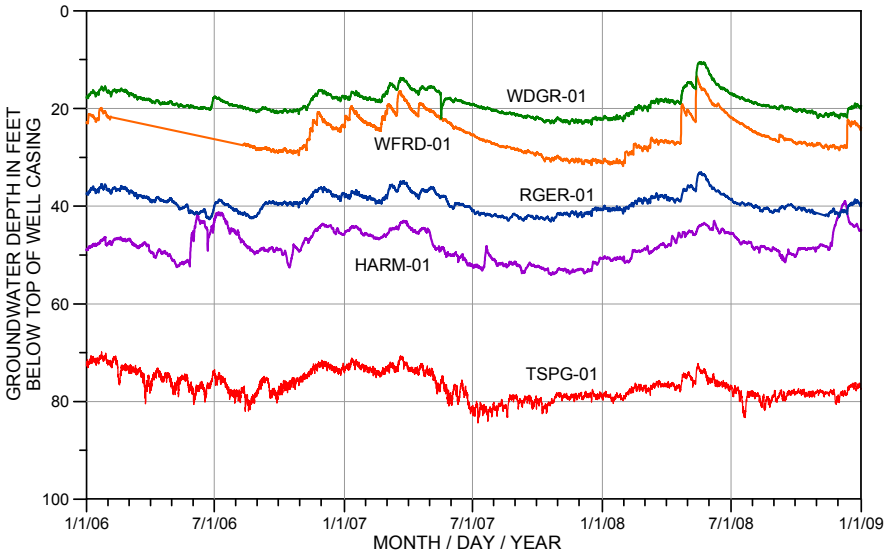


Figure 10. Groundwater levels from County WRMP monitoring wells with at least three years of monitoring data.

The depth from land surface to groundwater varies in different locations of the county primarily due to the local topography and geology. Throughout a normal year, groundwater levels generally rise in the winter and spring and drop in the summer and fall. This occurs because rainfall is distributed fairly evenly throughout the year, but evapotranspiration (evaporation of surface moisture and transpiration of water from plants) is high in the warm months and low during the cool months. With less water lost to evapotranspiration in the fall and winter, the groundwater system receives more recharge water and groundwater levels rise.

Short-term natural increases in groundwater levels occur because of recharge from precipitation. In the absence of additional recharge from precipitation and outside influences such as nearby pumping, groundwater levels typically exhibit a steady, slow decline over time after rain events. Figure 11 is a hydrograph from a monitoring well during 2008 with daily precipitation also plotted to show the effects of precipitation on groundwater levels.

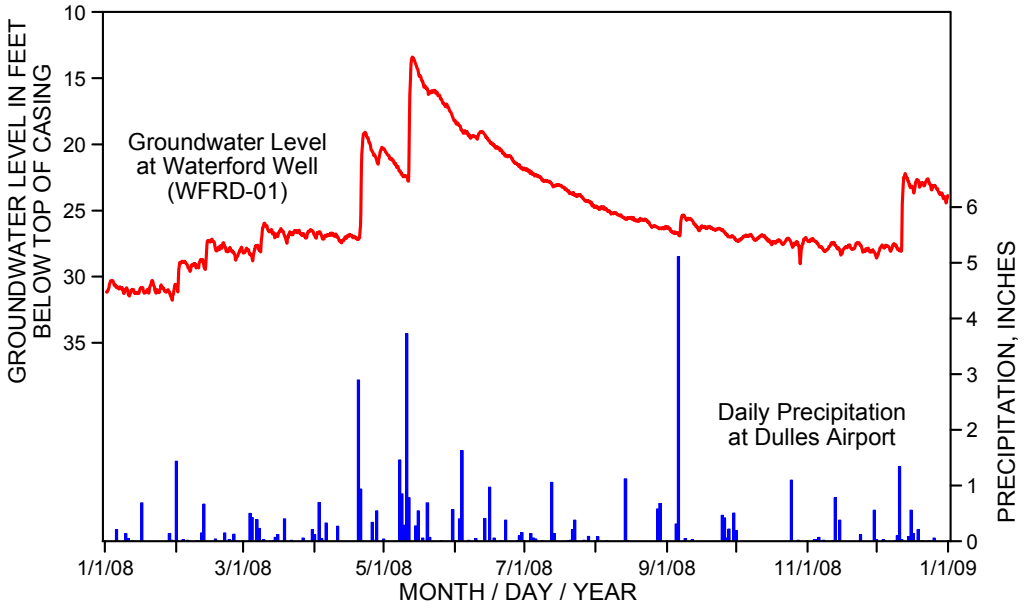


Figure 11. Daily precipitation and groundwater level changes during 2008.

During 2008, 179 new water wells were constructed. Figure 12 presents the number of wells drilled each year since 1978. The installation of new wells is primarily driven by the pace of residential construction and zoning changes affecting residential development potential. The median total depth of wells installed in 2008 was 420 feet and the median estimated yield (based on air-lift pumping) was 13 gallons per minute. The median total depth and median estimated yield of wells installed during the previous 10 years was 400 feet and 10 gallons per minute, respectively. These differences in depths and yields are not considered indicative of changes to groundwater availability.

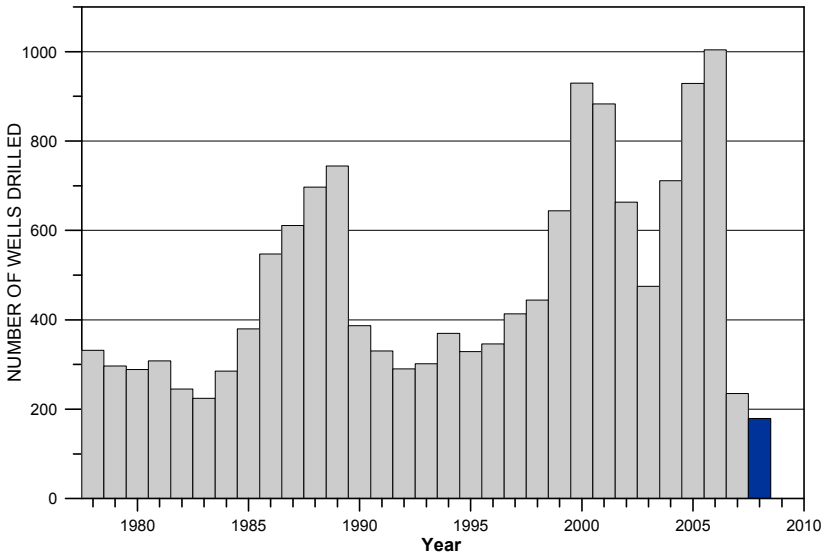


Figure 12. Number of wells constructed in Loudoun County between 1978 and 2008.

WATER QUALITY

The quality of surface water in Loudoun County was quantified in 2008 using several metrics including chemical, microbiological, and benthic macroinvertebrates. Groundwater quality was assessed through chemical and bacteria analyses conducted on well water samples. Monitoring results from each of these data types are discussed below.

Surface Water Chemistry

Chemical sampling and analysis of surface water in 2008 was primarily conducted by the Virginia Department of Environmental Quality (DEQ) as part of their state-wide surface water quality sampling program (see http://www.deq.state.va.us/watermonitoring/). In 2008, DEQ collected samples from approximately 26 sites in Loudoun County and all analytical results were within acceptable ranges.

Nutrients are of particular interest because of their detrimental effect at elevated concentrations on the Chesapeake Bay. Table 4 shows results of sampling by DEQ for nitrogen and phosphorus in surface waters in the county during 2008 and during the period 1999 through 2007.

Table 4. Nitrogen and phosphorus in surface waters.

Basic Statistic	Total Nitrogen		Total Phosphorus	
	1999-2007	2008	1999-2007	2008
# Samples	626	52	1136	46
Minimum	0.10	0.25	0.01	0.01
Maximum	4.09	2.84	3.6	0.15
Mean	1.26	1.20	0.06	0.04
Median	1.20	1.10	0.04	0.03

All concentrations in milligrams per liter

EPA guidance criteria for Virginia Region 9 is 0.69 mg/L for Total Nitrogen and 0.037 mg/L for Total Phosphorus.

Surface Water Microbiology

The primary microbiological area of concern for surface water relates to pathogens that may adversely affect human health. An accepted practice to test for pathogens from human and warm-blooded animal waste is to test water for ***Escherichia coli*** (E. coli) bacteria as an indicator of waste contamination. One of the criteria used by the U. S. Environmental Protection Agency (EPA) for E. coli is if the water is considered safe for humans after casual contact. This criterion is identified by EPA as "recreational use" and includes activities such as fishing and boating.

In 2008, DEQ collected and analyzed approximately 70 samples in Loudoun County and found that approximately 24 percent were above the recreational limit of 235 E. coli colonies per 100 milliliters. These sampling results were similar to those conducted in Loudoun County in previous years. Stream segments that are tested and exceed the recreational use criteria are identified as "impaired" by EPA. Several programs are in place to reduce bacterial contamination in the impaired surface waters of Loudoun County including initiatives to repair or upgrade on-site wastewater treatment systems (e.g., septic systems and drain fields), reduce pet waste, and fence livestock out of streams.

Stream water sampling in the Catoctin watershed by citizen volunteers (Loudoun Watershed Watch) has resulted in almost 1,000 bacteriological samples collected and analyzed over the past 4 years, of which almost 40 percent were above the recreational use limit for E. coli. These data indicate that microbiological contamination is highly variable, but generally increases with stormwater runoff.

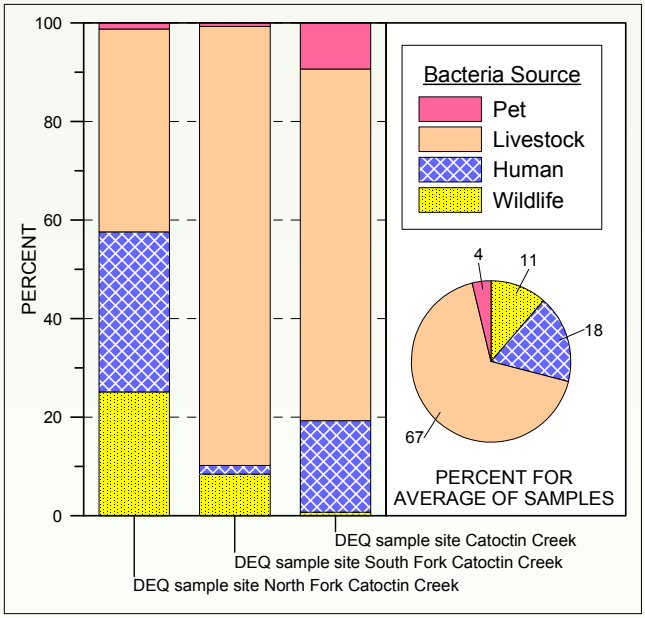


Figure 13. Bacteria sources in stream water samples.

DEQ conducted a year-long study in the Catoctin watershed during 2008 to determine the source of waste responsible for the bacteria contamination. They sampled three stream segments, one each in the North Fork, South Fork, and lower Catoctin creeks. Specialized laboratory analyses were used to determine what kind of warm-blooded animals produced the waste responsible for the E. coli found in the samples. Figure 13 illustrates that waste sources are distributed between pet, livestock, wildlife, and human. Although the proportions are variable, livestock is generally the largest contributor with human sources generally second.

Benthic Macroinvertebrates

Benthic macroinvertebrates are stream bottom-dwelling invertebrate organisms (mostly insect larvae) that can be seen without magnification. Their tolerance of poor water quality varies depending on the species and, as a result, these organisms are used as indicators of water quality.

Sampling a stream for benthic macroinvertebrates usually involves collecting all the organisms within a small area of the stream bottom, identifying the types of organisms collected to the order or family taxa level, and counting the number of each type. These results are then converted to a "macroinvertebrate score" which is used to qualitatively grade the water quality at one of several levels ranging from excellent to poor. In 2008, two techniques were used to evaluate the benthic macroinvertebrate populations: the Virginia Stream Condition Index (VA SCI) used by DEQ and the Virginia Save Our Streams (VA SOS) index used by several citizen volunteer organizations in and adjacent to the county. In 2008, DEQ sampled 11 locations in Loudoun and calculated VA SCI scores which ranged from severely stressed to excellent. Figure 14 illustrates the average stream conditions from 45 samples obtained at 18 locations by DEQ during 2007 and 2008.

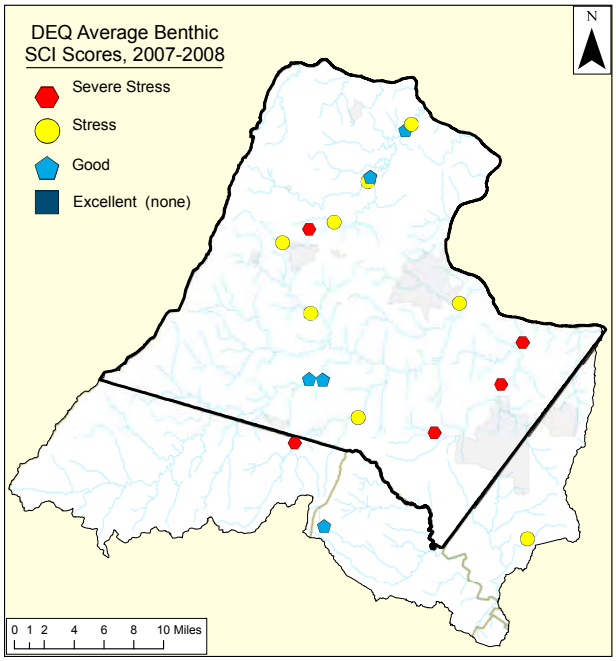


Figure 14. Benthic monitoring results by DEQ in 2007 and 2008

Several volunteer organizations work within the watersheds of the county to collected benthic macroinvertebrate data. In 2008, the volunteer organizations Loudoun Wildlife Conservancy, Goose Creek Association and other groups collected samples from approximately 44 locations using the VA SOS methodology. Results ranged from acceptable to unacceptable. Figure 15 illustrates the average VA SOS scores from 2007 and 2008.

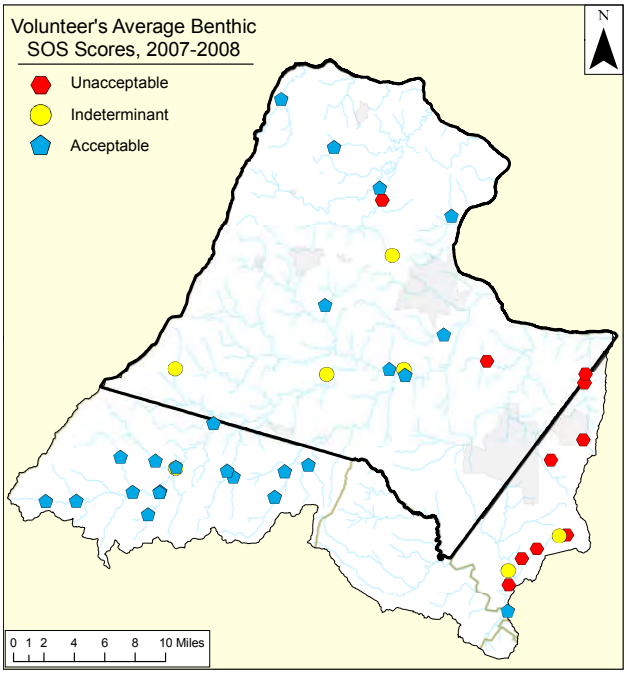


Figure 15. Benthic monitoring results by volunteers in 2007 and 2008

Stream Impairments

Each year, DEQ tests a statistically significant fraction of Virginia's rivers, lakes, and tidal waters as part of their water quality assessment. Over 130 different pollutants are monitored to determine whether the waters can be safely used for swimming, fishing and drinking. Waters that do not meet standards are reported to EPA in the Clean Water Act 303(d) Impaired Waters Report. DEQ has developed lists of impaired waters every even calendar year since 1992. In Loudoun County, DEQ water quality impairments have included:

- recreational/swimming (bacteria)
- aquatic life (benthic macroinvertebrates)
- fishing/consumption (tissue analysis)

In the report released in 2008, there were 13 new impaired stream segments in Loudoun County totaling 43 stream miles. This increased the existing 158 miles of impaired streams by 27 percent. Figure 16 and Figure 17 illustrate the impairments for recreational/swimming and aquatic life uses, respectively. New impairments for aquatic life use slightly exceeded those for recreational/swimming use. Based on past testing results, it is likely that testing in stream segments that were not previously sampled will lead to new impairments listed in 2010.

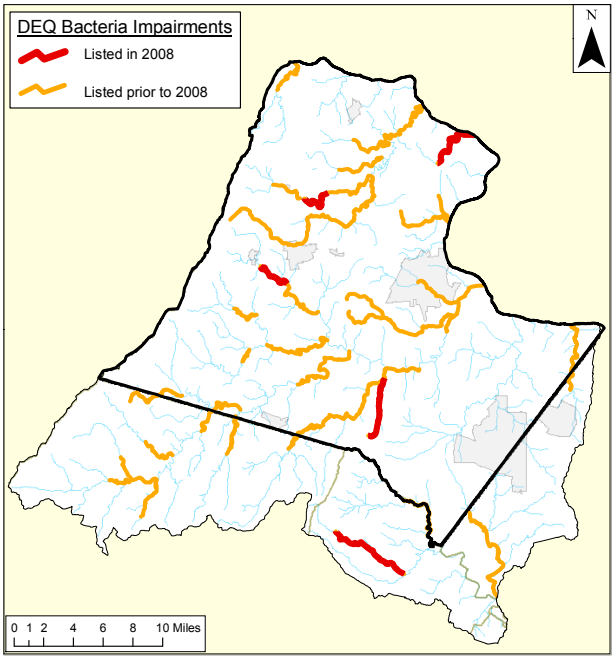


Figure 16. Recreational/swimming use (bacteria) impaired stream segments added in 2008

Groundwater Quality

Groundwater is the source of drinking water for most of Loudoun County outside of Loudoun Water's central service area and the Town of Leesburg. Information on groundwater quality is obtained from several sources. Before new potable water wells can be used, they must be tested and pass drinking water quality standards for a wide range of chemical parameters listed by the County Health Department. In 2008, groundwater samples collected and analyzed from new wells were generally consistent with historical data (Table 5). There are some areas of the county that have elevated levels of iron and manganese which are aesthetic contaminants and do not adversely affect human health at the concentrations found in the county. In general, the county has excellent groundwater quality.

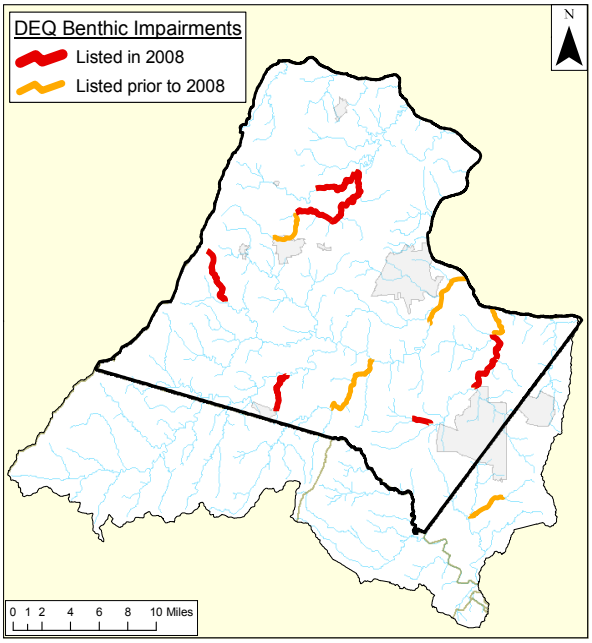


Figure 17. Aquatic life use (benthic macroinvertebrates) impaired stream segments added in 2008.

Table 5. Statistics for selected groundwater chemistry parameters.

Analyte	MCL(mg/L)	Samples		# above MCL	% above MCL
pH	<6.5 or >8.5*	*All*	2690	301	11.2
		2008	69	11	15.9
Nitrate	10	*All*	2765	15	0.5
		2008	145	0	0
Sulfate	250	*All*	2765	7	0.2
		2008	145	0	0
Lead	0.015	*All*	2766	27	0.9
		2008	145	0	0
Fluoride	4	*All*	2765	4	0.1
		2008	148	0	0
Benzene	0.005	*All*	2765	0	0
		2008	146	0	0
Toluene	1	*All*	2766	1	0.03
		2008	146	0	0
Ethylbenzene	0.7	*All*	2765	0	0
		2008	145	0	0
Xylene	10	*All*	2766	0	0
		2008	146	0	0
Arsenic	0.01	*All*	2770	14	0.5
		2008	145	0	0
Manganese	0.05**	*All*	2765	1795	64.8
		2008	145	62	45.7
Iron	0.3**	*All*	2765	1960	70.9
		2008	145	66	45.5
TDS	500**	*All*	2765	12	0.4
		2008	146	2	1.4

* Standard pH units.
** Secondary Maximum Contaminant Level for taste, color, and odor.

As part of the WRMP, nine monitoring wells were sampled for a variety of chemical parameters. A list of the analytes which were detected is shown in Table 6. The results were consistent with historic findings with two samples exceeding the secondary maximum contaminant limit (SMCL) for iron (0.3 mg/L) and six samples exceeding the SMCL for manganese (0.05 mg/L).

There are a few isolated spots in the county where serious groundwater contamination is known to exist, the most notable being Hidden Lane Landfill in northeast Loudoun, which was placed on EPA's National Priorities List (i.e., superfund site) in 2008. (For additional information on the Hidden Lane Landfill, see www.loudoun.gov/tce.) The most prevalent sources of potential groundwater pollution are the on-site wastewater treatment systems (OWTS) serving homes and small businesses in the rural areas of the county. There are approximately 14,500 active OWTSs in the county and during 2008, about 200 new OWTSs were in-

stalled. An OWTS that is properly installed and regularly serviced should not pose a threat to groundwater quality. However, improper OTWS installation or maintenance can cause wastewater to be untreated or undertreated and lead to groundwater or surface water contamination. Because OWTS are typically used in areas with private water wells, it is important to properly maintain the OWTS and regularly have the well water sampled and tested to assure that it is safe to drink.

Table 6. Groundwater sampling data from WRMP monitoring wells.

Well ID	Temperature (ºC)	pH (std units)	Specific Conductance (uS/cm)	Iron (mg/L)	Manganese (mg/L)	Alkalinity (mg/L)	Chloride (mg/L)	Hardness (mg/L)	TDS (mg/L)	Sulfate (mg/L)
RGER-01	14.3	8.15	383	ND	0.095	88	48	140	180	14
WDGR-01	14.6	8.17	233	0.08	0.065	100	7	92	120	10
HARM-01	14.6	7.24	175	0.4	0.078	80	7	64	96	10
TSPG-01	13.9	7.76	260	ND	0.061	98	15	110	140	16
WFRD-01	14.6	7.1	246	0.26	0.089	70	17	91	110	15
BRCS-01	16.1	8.38	194	0.1	0.023	80	ND	55	84	6
MGRD-01	16.9	8.08	300	0.8	0.061	140	ND	140	140	ND

ND = below detection limit uS/cm = microSiemens per centimeter TDS = Total Dissolved Solids

OUTLOOK FOR 2009

In 2009, Loudoun County Department of Building & Development will be completing several major tasks as part of the final year of an EPA grant that has helped establish the WRMP. These tasks include:

County-wide Stream Assessment

An assessment of streams will be conducted at numerous locations across the county based on three fundamental types of stream data:

- benthic macroinvertebrates,
- stream habitat conditions, and
- the boundary between perennial and intermittent streams.

Groundwater Sampling

The county has extensive groundwater chemical data collected as part of the permitting process of new wells, however, there are almost no chemical data collected on wells after they pass the Health Department permit requirements and water quality in older wells is poorly known. In 2009, County staff will start to fill in that gap by requesting permission to sample existing residential wells based on a targeted and probabilistic selection methodology. In addition, sampling will be conducted at several of the county's dedicated groundwater monitoring wells as part of the continuing WRMP work.

Additional Groundwater Monitoring Wells

Continued expansion of the groundwater monitoring well network is planned with additional wells acquired through the well use donation process and by drilling wells at specific locations. Water level data recorders will be placed in the new monitoring wells to record groundwater levels over time.

Additional information on water resources in Loudoun County may be found on the County's web site at: ***www.loudoun.gov/bd***