# Task B.3.3 Stream Discharge

### B.3.3 Stream discharge (using data set 2.1)

USGS Streamflow

Annual Statistics

Mean Annual Discharge by Year

Median August Flow Rate and Rate per Sq Mile

Streamflow Duration (Plots and tabular distribution by percentile)

Relating USGS Streamflow (memo)

Real-Time (15-minute) Streamflow Snapshots (Dec 2006-August 2007)

Stream Gage Drainage Areas

Groundwater Recharge from Streamflow (memo)

Using RORA for Recharge Calculations (memo)

Baseflow Summary (Historic and Current Calculations)

Recharge Summary (Published and Current Calculations)

Streamflow Drainage Area

Low Flow and Base Flow Statistics (memo)

Base Flow using DFLOW

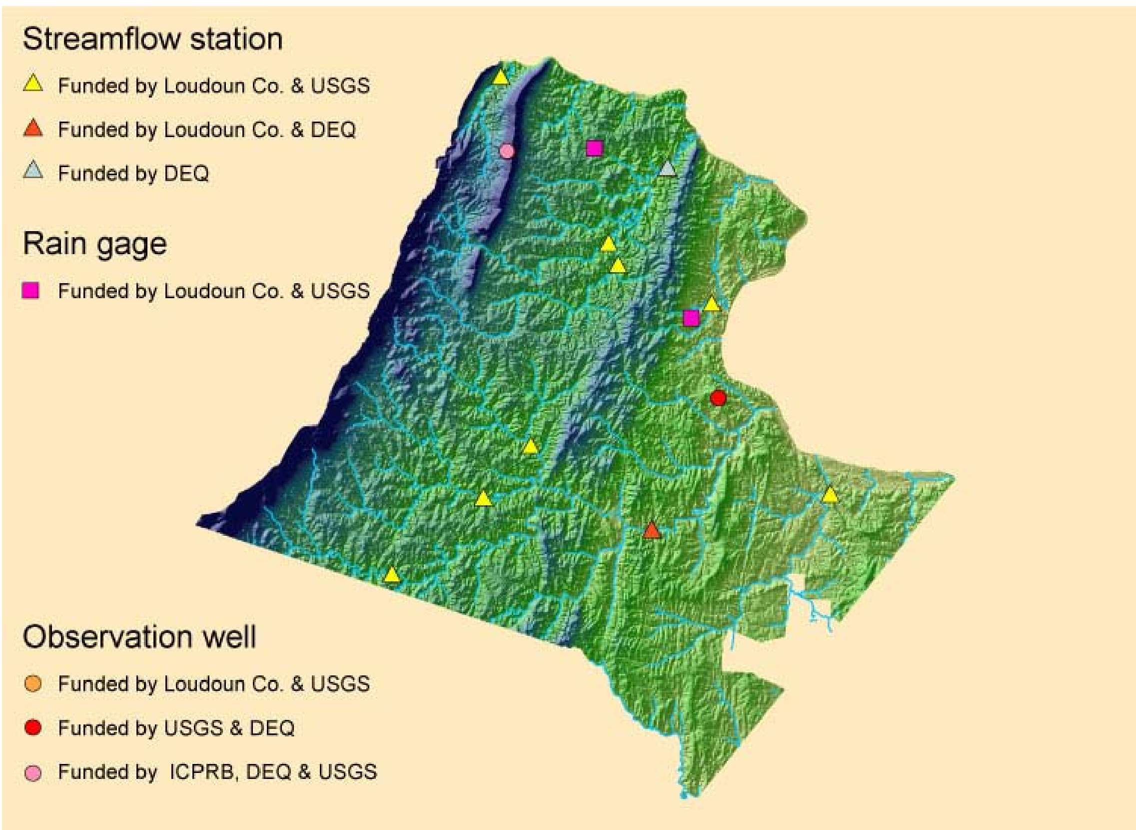
Automated Base Flow Separation and Recession using SWAT (memo)

Base Flow Calculations Summary using DFLOW

**Data Set 2.1**

Stream Stage & Discharge – USGS (and DEQ)

Ten stream gaging sites in Loudoun County (see map for locations) established by USGS and currently operated by USGS (8 sites) and DEQ (2 sites). Data include daily stage (ft) and discharge (cfs). Site locations and POR are: Broad Run at Rt. 7 (10/01-present), Limestone Branch at Rt 15 (9/01-present), Goose Creek nr. Rt 621 (1/30-present), Catoctin Creek at Taylorstown (11/70-present), S.F. Catoctin Creek at Rt 698 (7/01-present), N.F. Catoctin Creek at Rt 681 (8/01-present), N.F. Goose Creek at Rt 734/Lincoln (8/01-present), Beaverdam Creek at Rt 734/Mountvail (8/01-present), Goose Creek nr Middleburg (10/65-12/96 | 6/01-present), Piney Run at Rt 671 (10/01-present). POR data and some statistics for these sites available on USGS web page. Since December 2006, the 15-minute "real-time" data available for only last 30 days have been snap-shotted each month, providing stage/discharge of provisional values for more detailed hydrographs.




Locations of stream gages, wells, and rainfall monitoring sites managed by, or in cooperation with, USGS.

## USGS Streamflow Web Download

This spreadsheet contains hyperlink to execute web queries from USGS NWIS web sites for the stream gages in Loudoun.  The process includes a complete download of all **daily** data, approved and provisional.

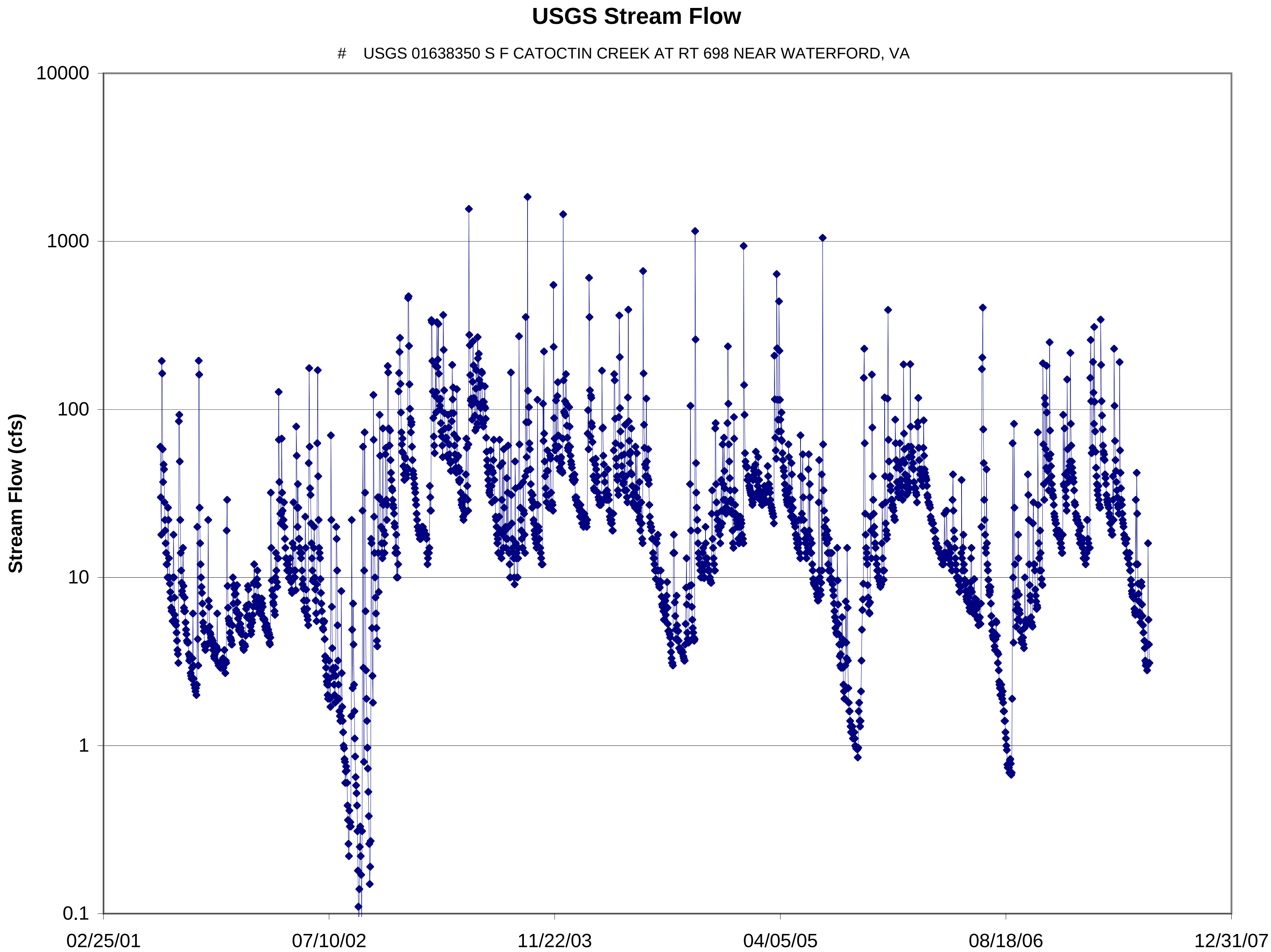
The spreadsheet offers the option to uses data "as is" from last update or update all stations.  The update process will takes several minutes to process.

To ensure that data is updated correctly, 10 charts are linked to the data downloads.

URL's for the recent 30 day, **15-minute** data are included in "Sites" tab, but are not part of the routine web query.

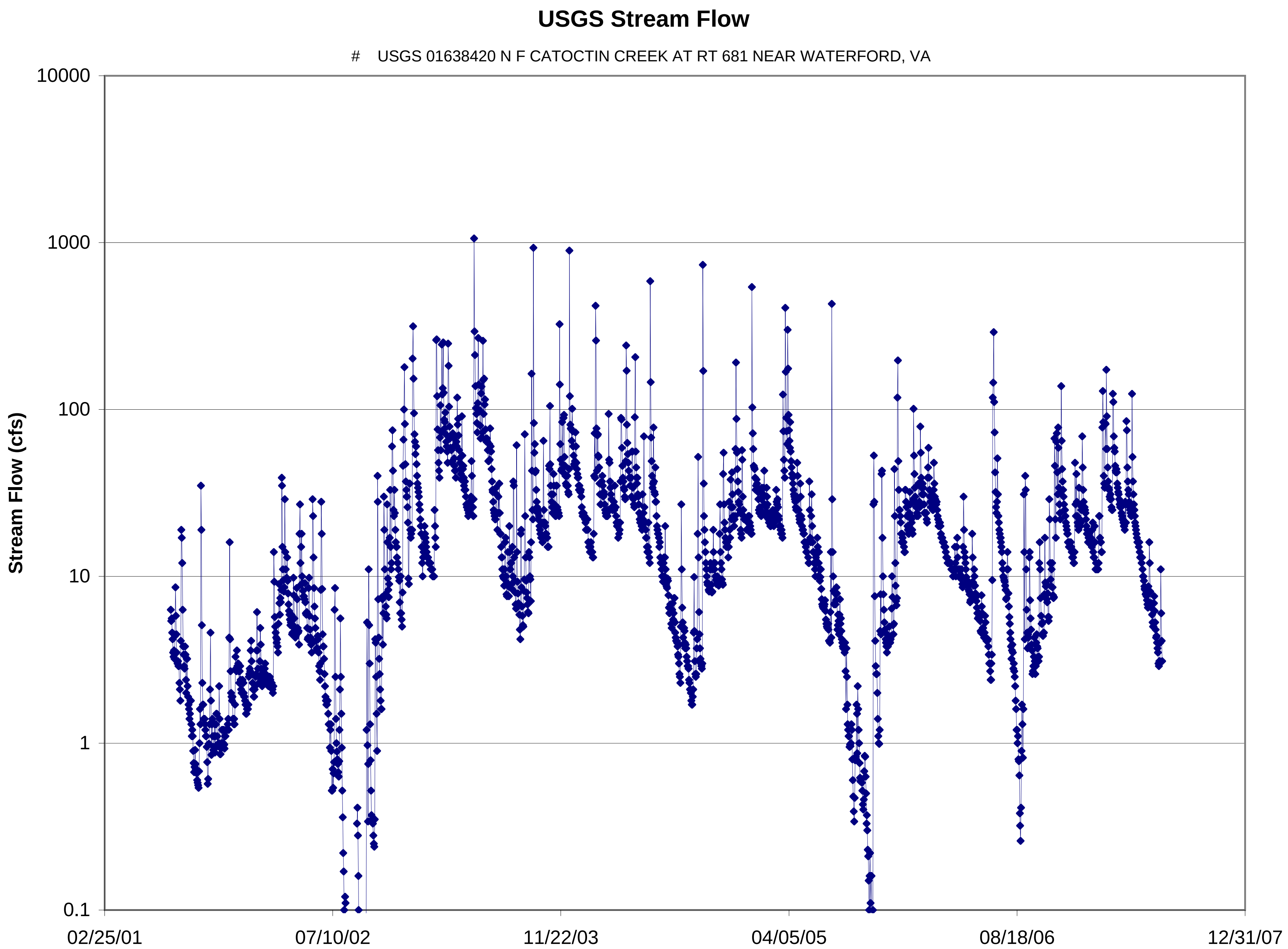
D Ward  12/20/2006

31-Aug-07



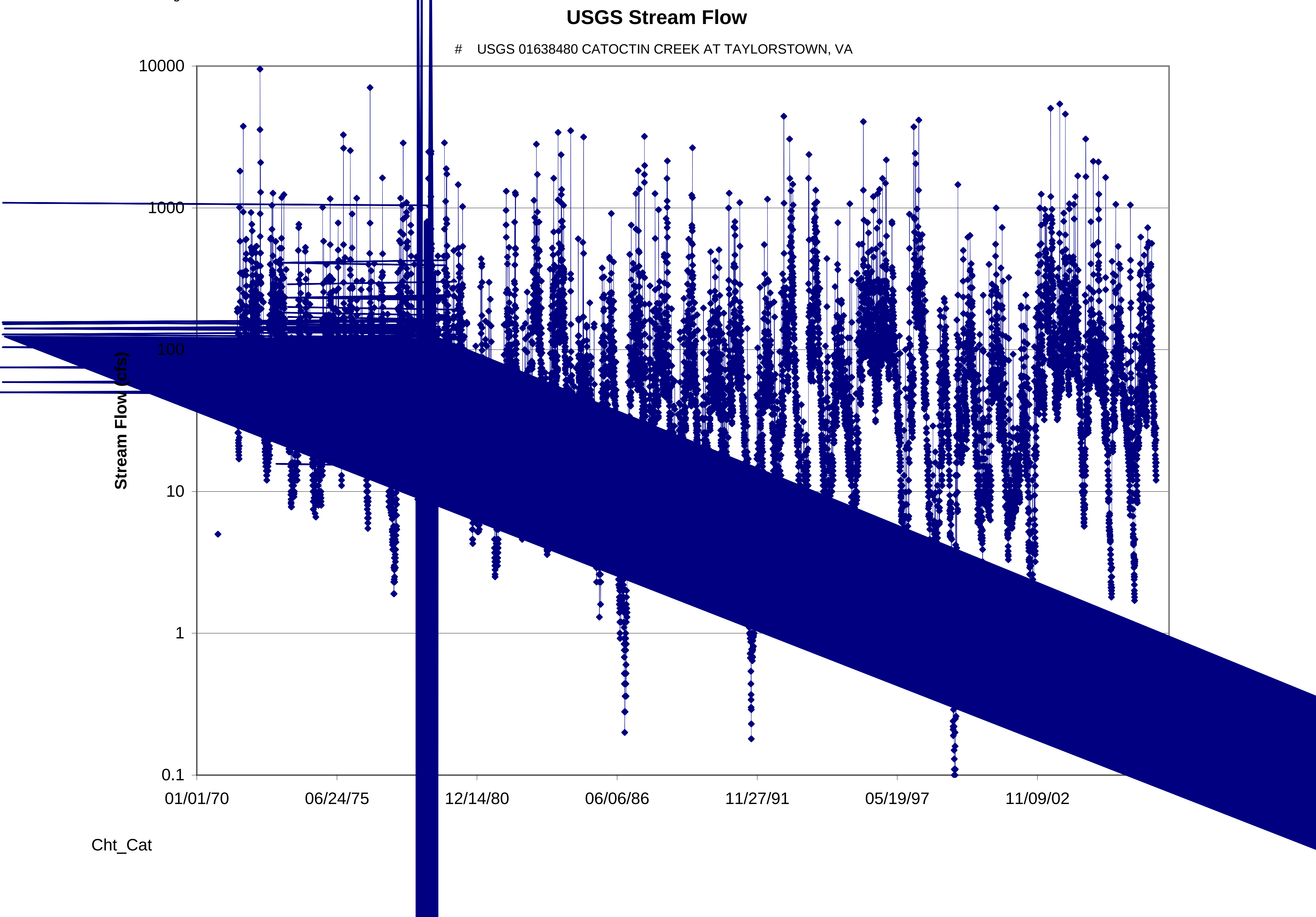

Cht_SF_Cat

31-Aug-07



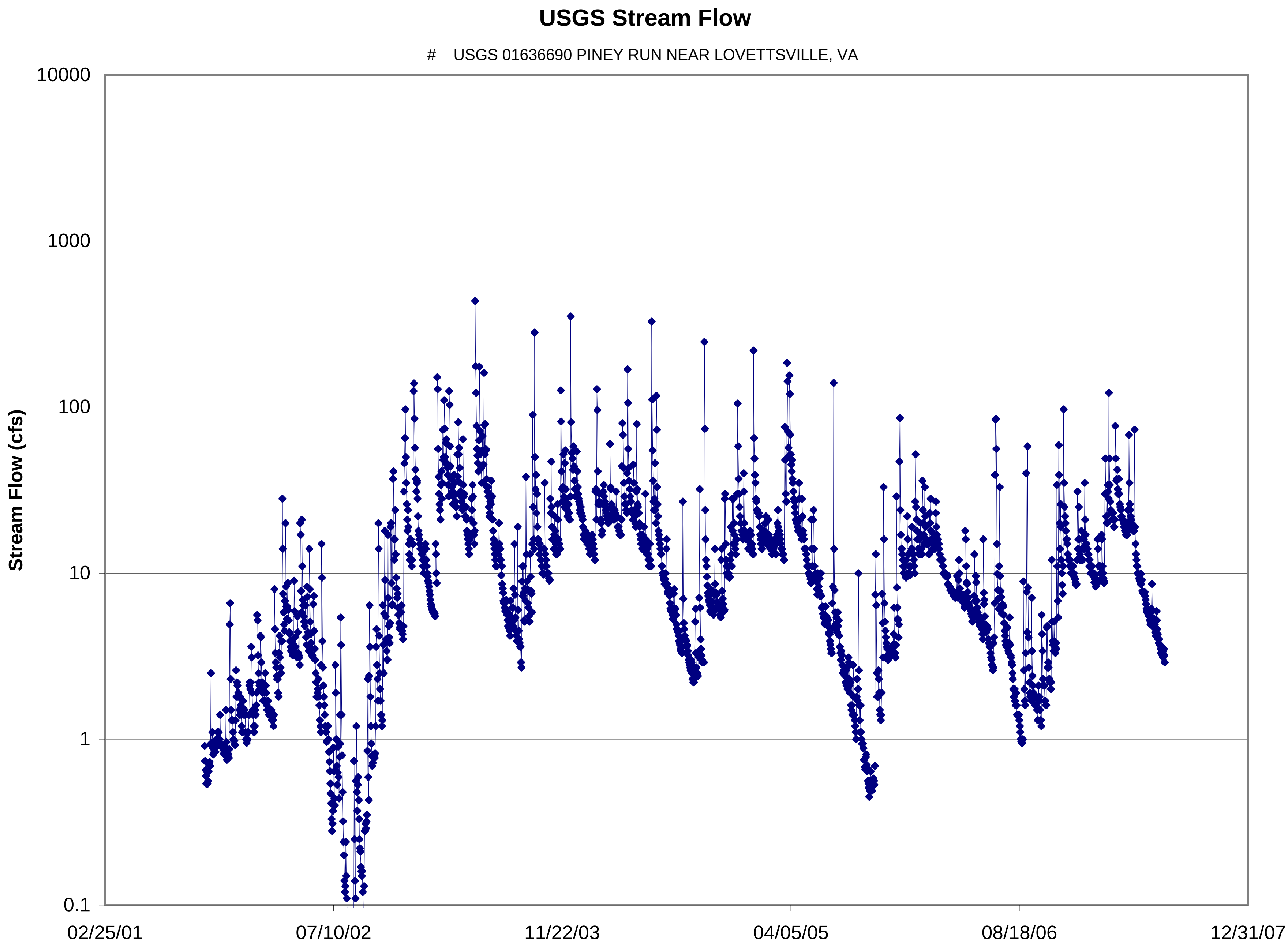

Cht_NF_Cat

31-Aug-07



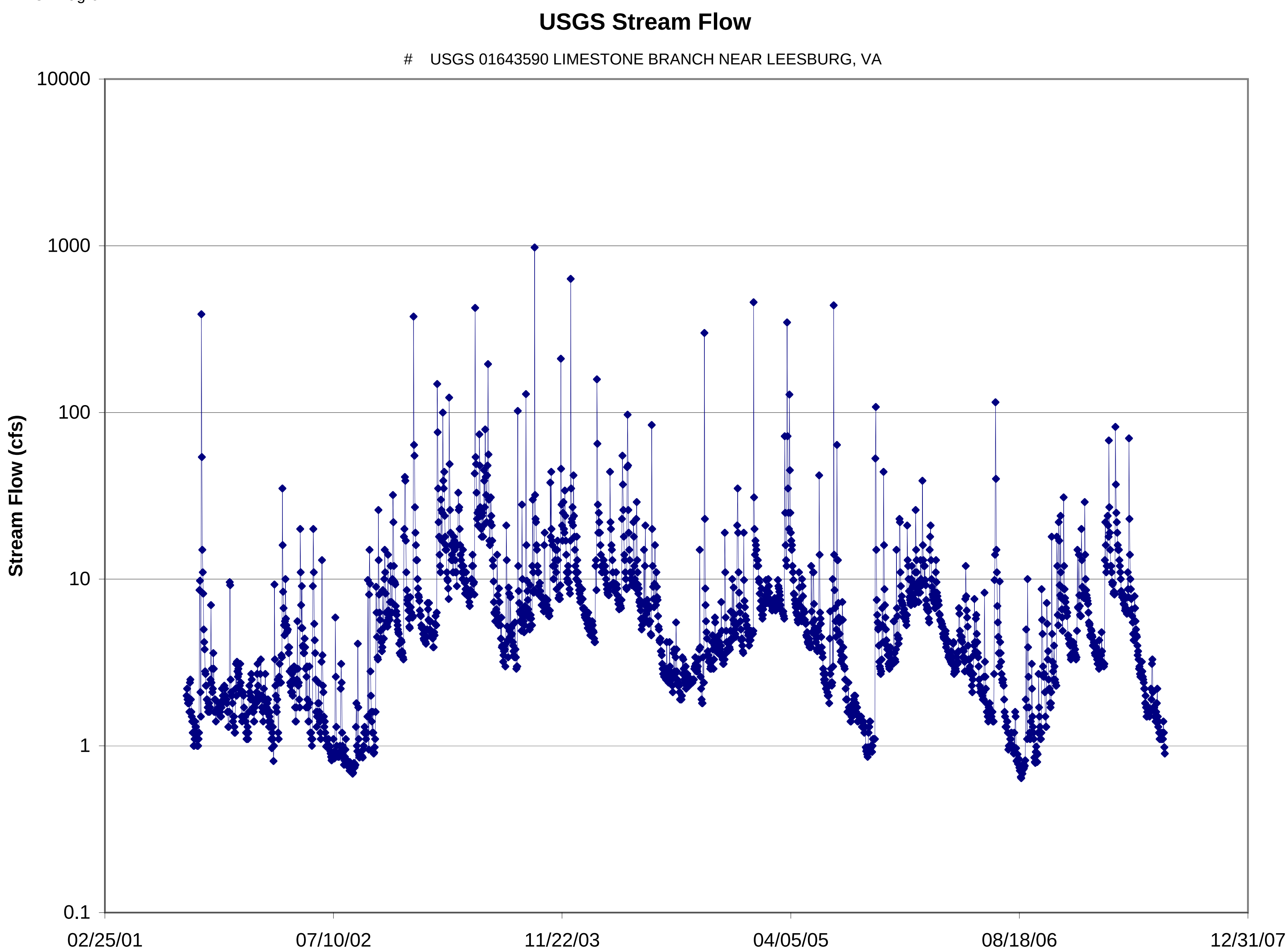

Cht_Cat

31-Aug-07



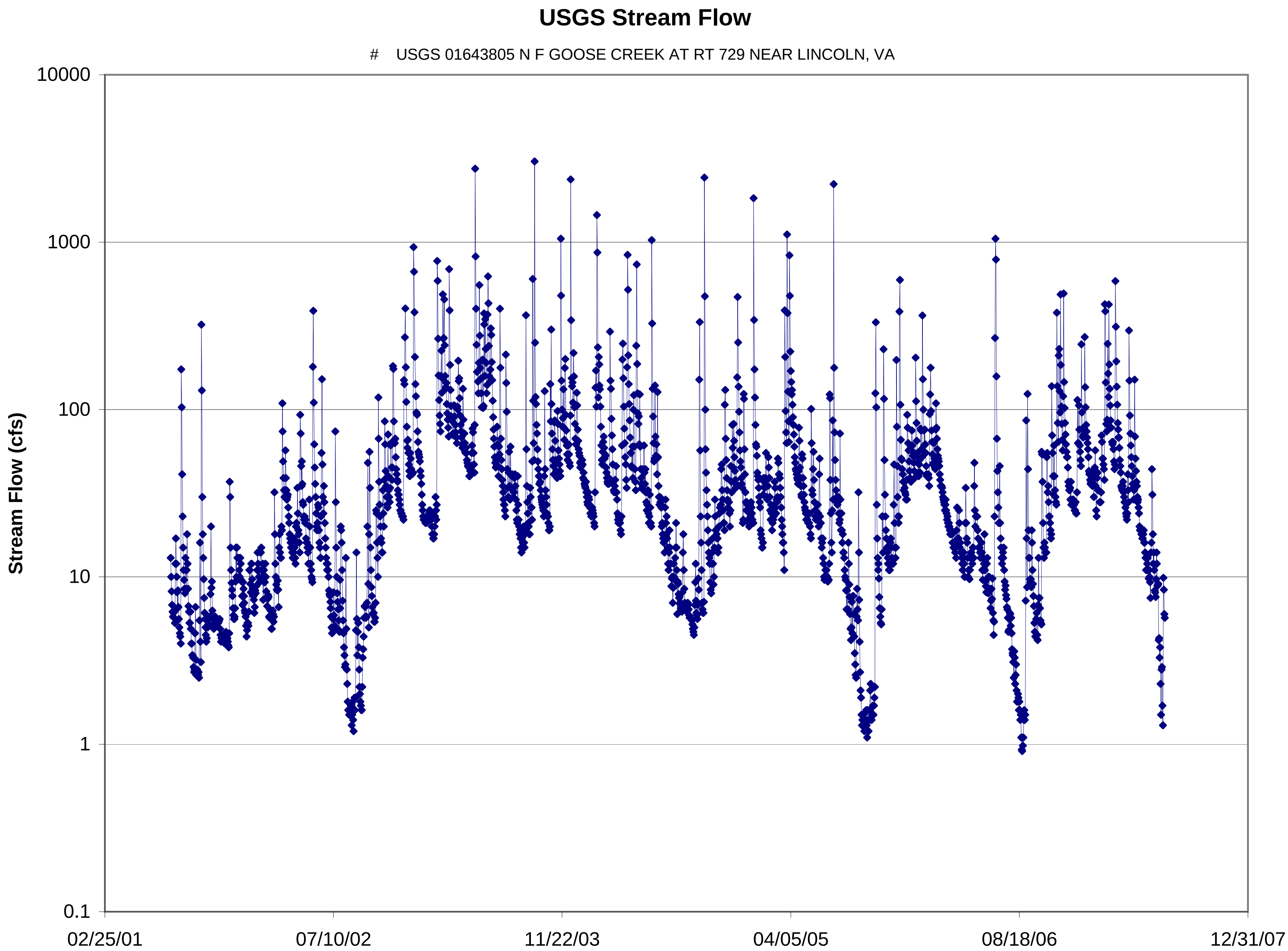

Cht_Piney

31-Aug-07



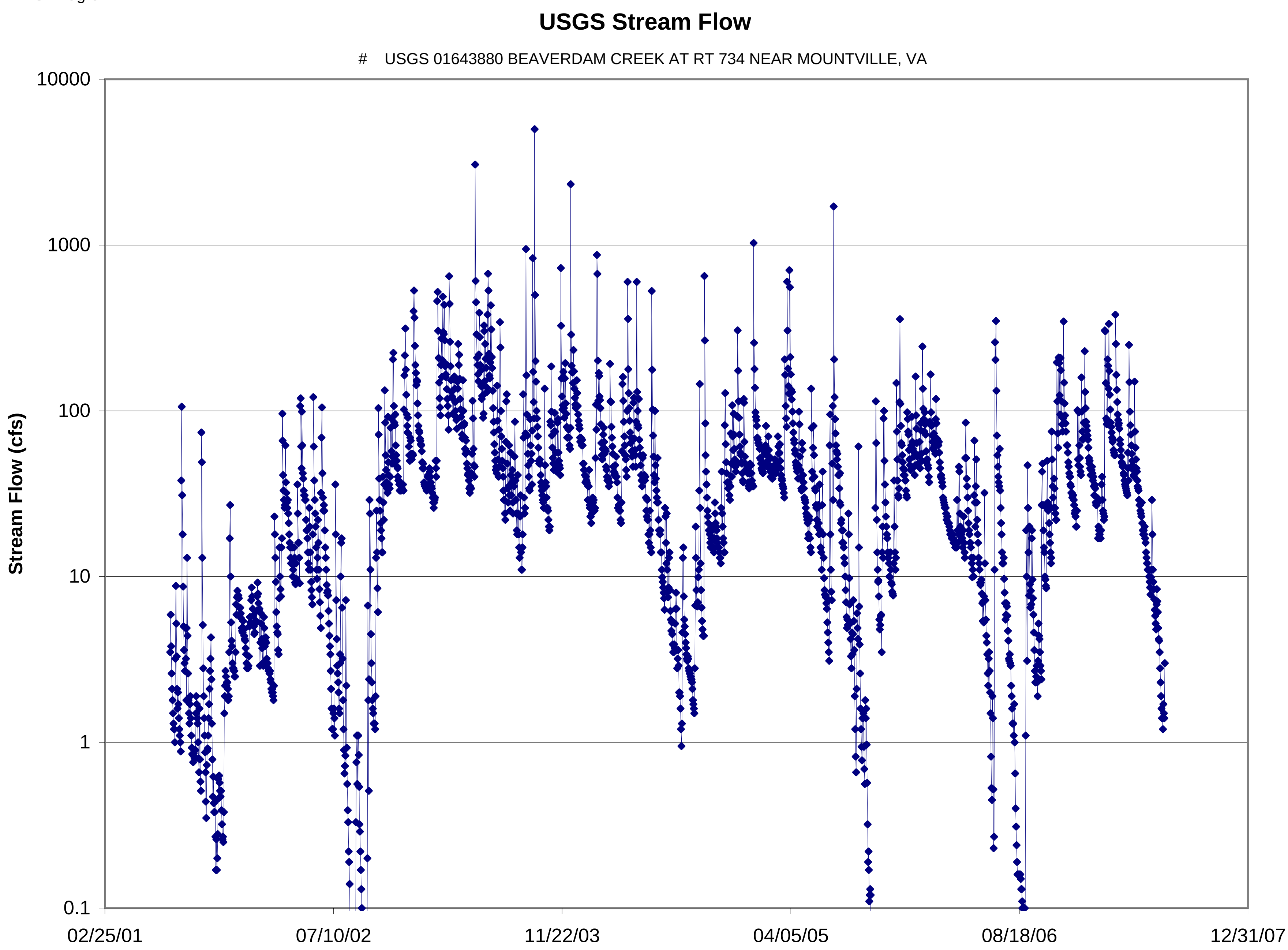

Cht_Lime

31-Aug-07



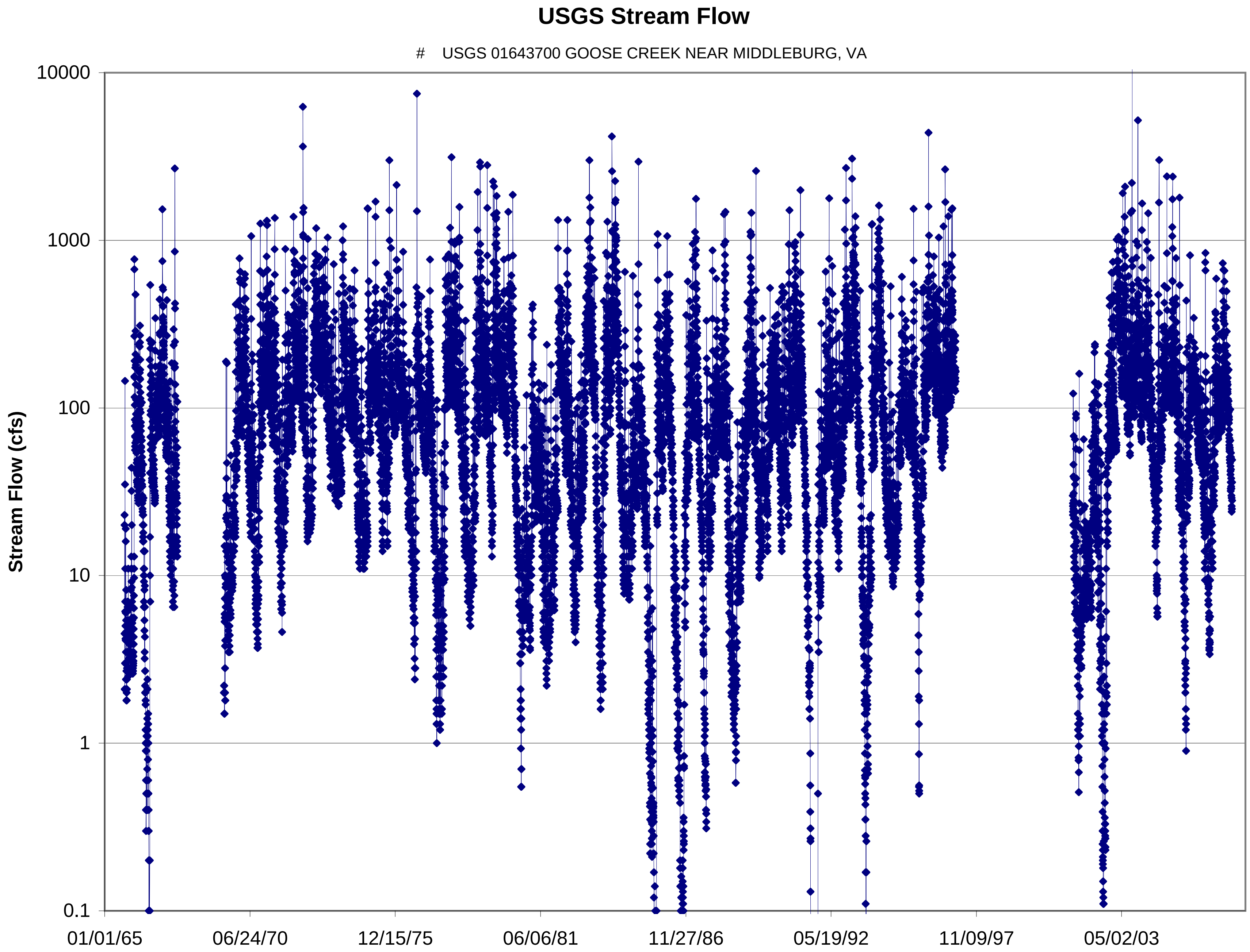

Cht_NF_GC

31-Aug-07



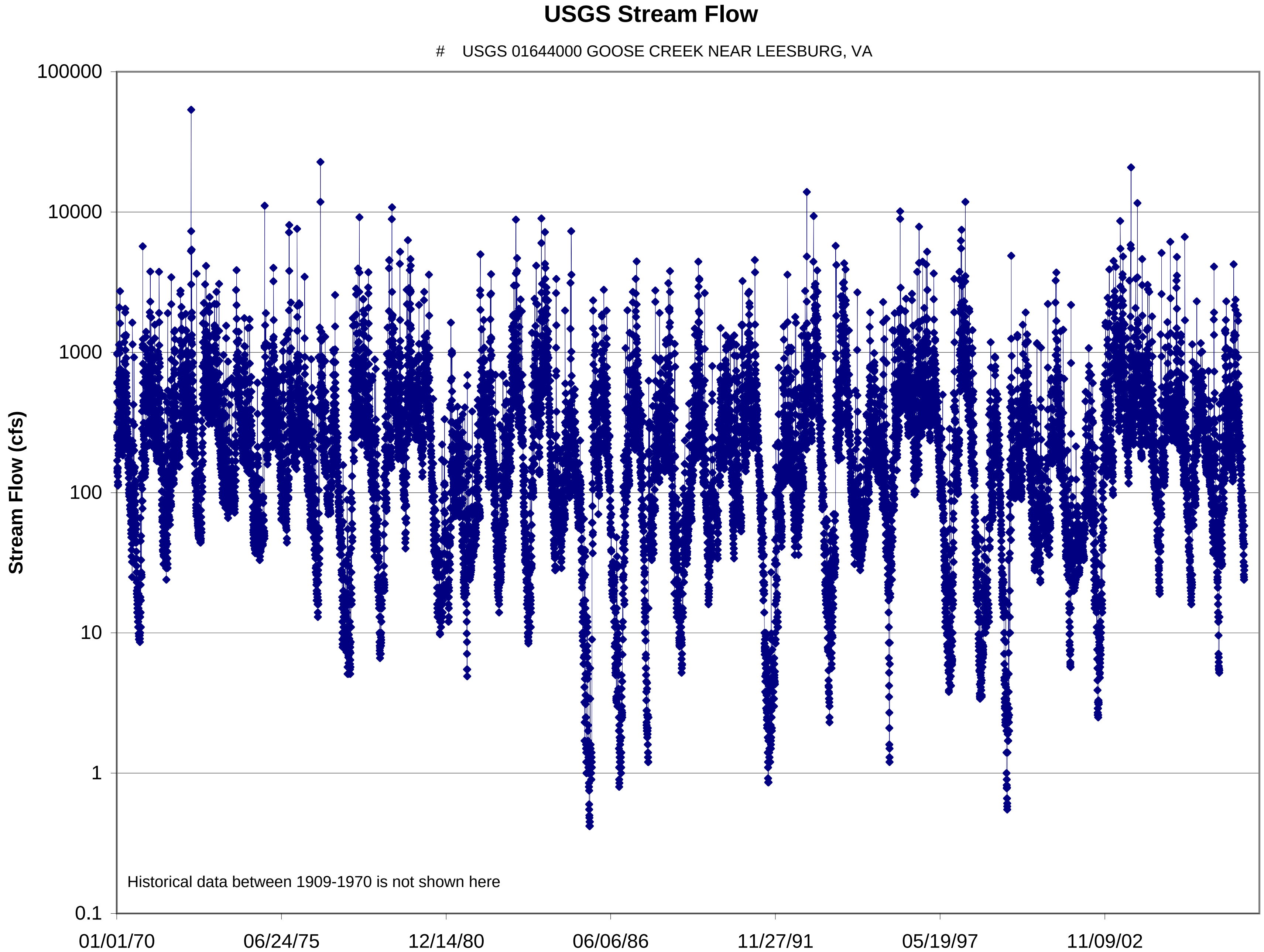

Cht_Beaver

31-Aug-07



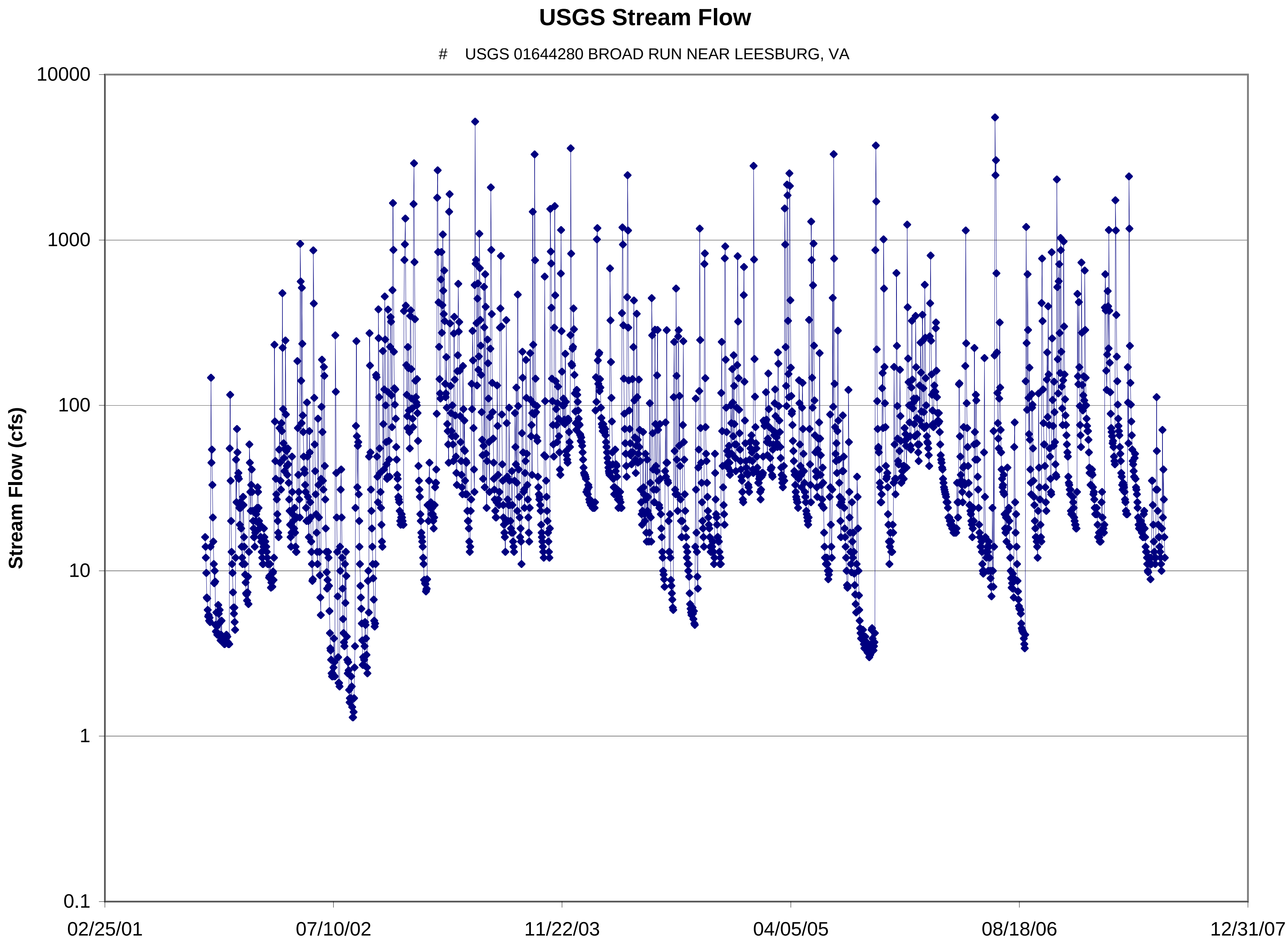

Cht_GC_Middle

31-Aug-07




Cht_GC_Lee

31-Aug-07




Cht_BR

Water Resources National Water Information System: Web Interface

Data Category: Surface Water
Geographic Area: Virginia
GO

# USGS Surface-Water Annual Statistics for Virginia

**The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications. The user is responsible for assessment and use of statistics from this site. For more details on why the statistics may not match, click here.**

## USGS 01636690 PINEY RUN NEAR LOVETTSVILLE, VA

| | Output formats |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 39°18'39.0", Longitude 77°43'06.6" NAD83<br>Drainage area 13.5 square miles<br>Gage datum 396.78 feet above sea level NAVD88 | HTML table of all data<br>Tab-separated data<br>Reselect output format |

| Water Year | 00060, Discharge, cubic feet per second (Calculation Period: 2002-10-01 -> 2006-09-30) Calculation period restricted by USGS staff due to special conditions at/near site |
|---|---|
| 2002 | 2.42 |
| 2003 | 25.6 |
| 2004 | 23.8 |
| 2005 | 15.8 |
| 2006 | 9.36 |
| ** No Incomplete Data is used for Statistical Calculation | |

## USGS 01638350 S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA

| | |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 39°11'28.0", Longitude 77°36'55.6" NAD83<br>Drainage area 31.6 square miles<br>Gage datum 335.84 feet above sea level NAVD88 | **Output formats**<br>HTML table of all data<br>Tab-separated data<br>Reselect output format |

| Water Year | 00060, Discharge, cubic feet per second (Calculation Period: 2002-10-01 -> 2006-09-30) Calculation period restricted by USGS staff due to special conditions at/near site |
|---|---|
| 2002 | 10.4 |
| 2003 | 72.9 |
| 2004 | 52.6 |
| 2005 | 35.3 |
| 2006 | 25.8 |
| ** No Incomplete Data is used for Statistical Calculation | |

## USGS 01638420 N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA

| | |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 39°12'18.0", Longitude 77°37'26.0" NAD83<br>Drainage area 23.1 square miles<br>Gage datum 325.21 feet above sea level NAVD88 | **Output formats**<br>HTML table of all data<br>Tab-separated data<br>Reselect output format |

| Water Year | 00060, Discharge, cubic feet per second (Calculation Period: 2002-10-01 -> 2006-09-30) Calculation period restricted by USGS staff due to special conditions at/near site |
|---|---|
| 2002 | 3.69 |
| 2003 | 47.5 |

| | |
|---|---|
| 2004 | 38.1 |
| 2005 | 24.9 |
| 2006 | 17.0 |
| ** No Incomplete Data is used for Statistical Calculation | |

## USGS 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA

| | Output formats |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 39°15'16", Longitude 77°34'36" NAD27<br>Drainage area 89.5 square miles<br>Gage datum 247.37 feet above sea level NGVD29 | HTML table of all data<br>Tab-separated data<br>Reselect output format |

| Water Year | 00060, Discharge, cubic feet per second<br>(Calculation Period: 1972-10-01 -> 2006-09-30)<br><br>Calculation period restricted by USGS staff due to special conditions at/near site |
|---|---|
| 1972 | 196.2 |
| 1973 | 133.3 |
| 1974 | 63.8 |
| 1975 | 109.8 |
| 1976 | 84.0 |
| 1977 | 87.3 |
| 1978 | 126.9 |
| 1979 | 132.3 |
| 1980 | 119.2 |
| 1981 | 34.6 |
| 1982 | 77.2 |
| 1983 | 116.2 |

| | |
|---|---|
| 1984 | 167.7 |
| 1985 | 51.5 |
| 1986 | 56.9 |
| 1987 | 118.9 |
| 1988 | 101.9 |
| 1989 | 84.5 |
| 1990 | 58.8 |
| 1991 | 78.4 |
| 1992 | 48.7 |
| 1993 | 143.9 |
| 1994 | 125.8 |
| 1995 | 53.7 |
| 1996 | 166.8 |
| 1997 | 111.3 |
| 1998 | 162.6 |
| 1999 | 30.9 |
| 2000 | 66.6 |
| 2001 | 59.7 |
| 2002 | 20.9 |
| 2003 | 206.8 |
| 2004 | 164.6 |
| 2005 | 104.5 |
| 2006 | 68.5 |

** No Incomplete Data is used for Statistical Calculation

## USGS 01643590 LIMESTONE BRANCH NEAR LEESBURG, VA

| | |
|---|---|
| Loudoun County, Virginia | **Output formats** |

| | |
|---|---|
| Hydrologic Unit Code 02070008<br>Latitude 39°10'03.4", Longitude 77°32'09.3" NAD83<br>Drainage area 7.88 square miles<br>Gage datum 219.97 feet above sea level NAVD88 | HTML table of all data<br>Tab-separated data<br>Reselect output format |

| Water Year | 00060, Discharge, cubic feet per second (Calculation Period: 2002-10-01 -> 2006-09-30) Calculation period restricted by USGS staff due to special conditions at/near site |
|---|---|
| 2002 | 2.48 |
| 2003 | 19.2 |
| 2004 | 13.7 |
| 2005 | 10.4 |
| 2006 | 5.87 |
| ** No Incomplete Data is used for Statistical Calculation | |

## USGS 01643700 GOOSE CREEK NEAR MIDDLEBURG, VA

| | Output formats |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 38°59'11", Longitude 77°47'49" NAD27<br>Drainage area 122 square miles<br>Gage datum 329.80 feet above sea level NGVD29 | HTML table of all data<br>Tab-separated data<br>Reselect output format |

| Water Year | 00060, Discharge, cubic feet per second (Calculation Period: 1966-10-01 -> 2006-09-30) Calculation period restricted by USGS staff due to special conditions at/near site |
|---|---|
| 1966 | 42.8 |
| 1967 | 109.9 |
| 1970 | 103.9 |

| | |
|---|---|
| 1971 | 150.1 |
| 1972 | 208.4 |
| 1973 | 193.7 |
| 1974 | 126.7 |
| 1975 | 153.5 |
| 1976 | 118.3 |
| 1977 | 110.7 |
| 1978 | 183.7 |
| 1979 | 201.1 |
| 1980 | 190.7 |
| 1981 | 36.5 |
| 1982 | 107.6 |
| 1983 | 155.7 |
| 1984 | 227.7 |
| 1985 | 49.8 |
| 1986 | 92.1 |
| 1987 | 107.0 |
| 1988 | 101.7 |
| 1989 | 99.7 |
| 1990 | 96.6 |
| 1991 | 133.6 |
| 1992 | 75.9 |
| 1993 | 215.4 |
| 1994 | 150.0 |
| 1995 | 83.8 |
| 1996 | 219.4 |
| 2002 | 20.8 |
| 2003 | 301.4 |

| | |
|---|---|
| 2004 | 197.4 |
| 2005 | 155.1 |
| 2006 | 80.5 |
| ** No Incomplete Data is used for Statistical Calculation | |

## USGS 01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA

| | |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 39°04'20.3", Longitude 77°41'02.2" NAD83<br>Drainage area 38.1 square miles<br>Gage datum 300 feet above sea level NGVD29 | **Output formats**<br>HTML table of all data<br>Tab-separated data<br>Reselect output format |

| **Water Year** | **00060, Discharge, cubic feet per second (Calculation Period: 2002-10-01 -> 2006-09-30)**<br><br>**Calculation period restricted by USGS staff due to special conditions at/near site** |
|---|---|
| 2002 | 15.1 |
| 2003 | 110.8 |
| 2004 | 85.6 |
| 2005 | 55.1 |
| 2006 | 38.2 |
| ** No Incomplete Data is used for Statistical Calculation | |

## USGS 01643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA

| | |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 39°02'15.8", Longitude 77°43'20.1" NAD83<br>Drainage area 47.2 square miles<br>Gage datum 307.03 feet above sea level NAVD88 | **Output formats**<br>HTML table of all data<br>Tab-separated data |

Reselect output format

| Water Year | **00060, Discharge, cubic feet per second (Calculation Period: 2002-10-01 -> 2006-09-30)** **Calculation period restricted by USGS staff due to special conditions at/near site** |
|---|---|
| 2002 | 10.2 |
| 2003 | 129.3 |
| 2004 | 70.8 |
| 2005 | 54.8 |
| 2006 | 32.5 |
| ** No Incomplete Data is used for Statistical Calculation | |

## USGS 01644000 GOOSE CREEK NEAR LEESBURG, VA

| | |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 39°01'10", Longitude 77°34'40" NAD27<br>Drainage area 332 square miles<br>Gage datum 248.93 feet above sea level NGVD29 | **Output formats**<br>HTML table of all data<br>Tab-separated data<br>Reselect output format |

| Water Year | **00060, Discharge, cubic feet per second (Calculation Period: 1910-10-01 -> 2006-09-30)** **Calculation period restricted by USGS staff due to special conditions at/near site** |
|---|---|
| 1910 | 229.1 |
| 1912 | 530.3 |
| 1931 | 55.2 |
| 1932 | 205.7 |
| 1933 | 513.0 |

| | |
|---|---|
| 1934 | 179.4 |
| 1935 | 349.6 |
| 1936 | 357.2 |
| 1937 | 468.7 |
| 1938 | 308.4 |
| 1939 | 265.2 |
| 1940 | 247.3 |
| 1941 | 223.8 |
| 1942 | 180.5 |
| 1943 | 501.0 |
| 1944 | 161.9 |
| 1945 | 347.5 |
| 1946 | 364.4 |
| 1947 | 174.6 |
| 1948 | 282.6 |
| 1949 | 460.6 |
| 1950 | 268.6 |
| 1951 | 463.7 |
| 1952 | 394.0 |
| 1953 | 407.6 |
| 1954 | 119.0 |
| 1955 | 263.9 |
| 1956 | 308.5 |
| 1957 | 260.4 |
| 1958 | 412.8 |
| 1959 | 129.9 |
| 1960 | 285.0 |
| 1961 | 331.6 |

| | |
|---|---|
| 1962 | 184.6 |
| 1963 | 188.7 |
| 1964 | 307.4 |
| 1965 | 271.0 |
| 1966 | 125.4 |
| 1967 | 283.7 |
| 1968 | 296.4 |
| 1969 | 148.9 |
| 1970 | 258.1 |
| 1971 | 386.5 |
| 1972 | 663.7 |
| 1973 | 511.0 |
| 1974 | 311.9 |
| 1975 | 430.9 |
| 1976 | 318.9 |
| 1977 | 305.3 |
| 1978 | 466.3 |
| 1979 | 516.5 |
| 1980 | 452.7 |
| 1981 | 109.6 |
| 1982 | 289.6 |
| 1983 | 419.9 |
| 1984 | 623.1 |
| 1985 | 162.8 |
| 1986 | 256.9 |
| 1987 | 286.0 |
| 1988 | 297.2 |
| 1989 | 268.3 |

| | |
|---|---|
| 1990 | 254.1 |
| 1991 | 333.6 |
| 1992 | 191.4 |
| 1993 | 579.4 |
| 1994 | 439.9 |
| 1995 | 207.8 |
| 1996 | 617.5 |
| 1997 | 417.7 |
| 1998 | 567.3 |
| 1999 | 121.5 |
| 2000 | 247.4 |
| 2001 | 231.4 |
| 2002 | 80.0 |
| 2003 | 811.5 |
| 2004 | 526.5 |
| 2005 | 404.2 |
| 2006 | 248.0 |
| ** No Incomplete Data is used for Statistical Calculation | |

## USGS 01644280 BROAD RUN NEAR LEESBURG, VA

| | Output formats |
|---|---|
| Loudoun County, Virginia<br>Hydrologic Unit Code 02070008<br>Latitude 39°02'47.1", Longitude 77°25'56.6" NAD83<br>Drainage area 76.1 square miles<br>Gage datum 193.65 feet above sea level NAVD88 | HTML table of all data<br>Tab-separated data<br>Reselect output format |

| Water Year | 00060, Discharge, cubic feet per second<br>(Calculation Period: 2002-10-01 -> 2006-09-30) |
|---|---|

| | **Calculation period restricted by USGS staff due to special conditions at/near site** |
|---|---|
| 2002 | 37.9 |
| 2003 | 203.9 |
| 2004 | 131.4 |
| 2005 | 121.6 |
| 2006 | 129.1 |
| ** No Incomplete Data is used for Statistical Calculation | |

**USGS 01636690 PINEY RUN NEAR LOVETTSVILLE, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 2002 | 2.42 |
| 2003 | 25.6 |
| 2004 | 23.8 |
| 2005 | 15.8 |
| 2006 | 9.36 |

**USGS 01638350 S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 2002 | 10.4 |
| 2003 | 72.9 |
| 2004 | 52.6 |
| 2005 | 35.3 |
| 2006 | 25.8 |

**USGS 01638420 N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 2002 | 3.69 |
| 2003 | 47.5 |
| 2004 | 38.1 |
| 2005 | 24.9 |
| 2006 | 17 |

**USGS 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 1972 | 196.2 |
| 1973 | 133.3 |
| 1974 | 63.8 |
| 1975 | 109.8 |
| 1976 | 84 |
| 1977 | 87.3 |
| 1978 | 126.9 |
| 1979 | 132.3 |
| 1980 | 119.2 |
| 1981 | 34.6 |
| 1982 | 77.2 |
| 1983 | 116.2 |
| 1984 | 167.7 |
| 1985 | 51.5 |
| 1986 | 56.9 |
| 1987 | 118.9 |
| 1988 | 101.9 |
| 1989 | 84.5 |
| 1990 | 58.8 |

| | |
|---|---|
| 1991 | 78.4 |
| 1992 | 48.7 |
| 1993 | 143.9 |
| 1994 | 125.8 |
| 1995 | 53.7 |
| 1996 | 166.8 |
| 1997 | 111.3 |
| 1998 | 162.6 |
| 1999 | 30.9 |
| 2000 | 66.6 |
| 2001 | 59.7 |
| 2002 | 20.9 |
| 2003 | 206.8 |
| 2004 | 164.6 |
| 2005 | 104.5 |
| 2006 | 68.5 |

**USGS 01643590 LIMESTONE BRANCH NEAR LEESBURG, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 2002 | 2.48 |
| 2003 | 19.2 |
| 2004 | 13.7 |
| 2005 | 10.4 |
| 2006 | 5.87 |

**USGS 01643700 GOOSE CREEK NEAR MIDDLEBURG, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 1966 | 42.8 |
| 1967 | 109.9 |
| 1970 | 103.9 |
| 1971 | 150.1 |
| 1972 | 208.4 |
| 1973 | 193.7 |
| 1974 | 126.7 |
| 1975 | 153.5 |
| 1976 | 118.3 |
| 1977 | 110.7 |
| 1978 | 183.7 |
| 1979 | 201.1 |
| 1980 | 190.7 |
| 1981 | 36.5 |
| 1982 | 107.6 |
| 1983 | 155.7 |
| 1984 | 227.7 |
| 1985 | 49.8 |
| 1986 | 92.1 |
| 1987 | 107 |
| 1988 | 101.7 |

| | |
|---|---|
| 1989 | 99.7 |
| 1990 | 96.6 |
| 1991 | 133.6 |
| 1992 | 75.9 |
| 1993 | 215.4 |
| 1994 | 150 |
| 1995 | 83.8 |
| 1996 | 219.4 |
| 2002 | 20.8 |
| 2003 | 301.4 |
| 2004 | 197.4 |
| 2005 | 155.1 |
| 2006 | 80.5 |

**USGS 01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 2002 | 15.1 |
| 2003 | 110.8 |
| 2004 | 85.6 |
| 2005 | 55.1 |
| 2006 | 38.2 |

**USGS 01643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 2002 | 10.2 |
| 2003 | 129.3 |
| 2004 | 70.8 |
| 2005 | 54.8 |
| 2006 | 32.5 |

**USGS 01644000 GOOSE CREEK NEAR LEESBURG, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 1910 | 229.1 |
| 1912 | 530.3 |
| 1931 | 55.2 |
| 1932 | 205.7 |
| 1933 | 513 |
| 1934 | 179.4 |
| 1935 | 349.6 |
| 1936 | 357.2 |
| 1937 | 468.7 |
| 1938 | 308.4 |
| 1939 | 265.2 |
| 1940 | 247.3 |
| 1941 | 223.8 |
| 1942 | 180.5 |

## *Mean Annual*

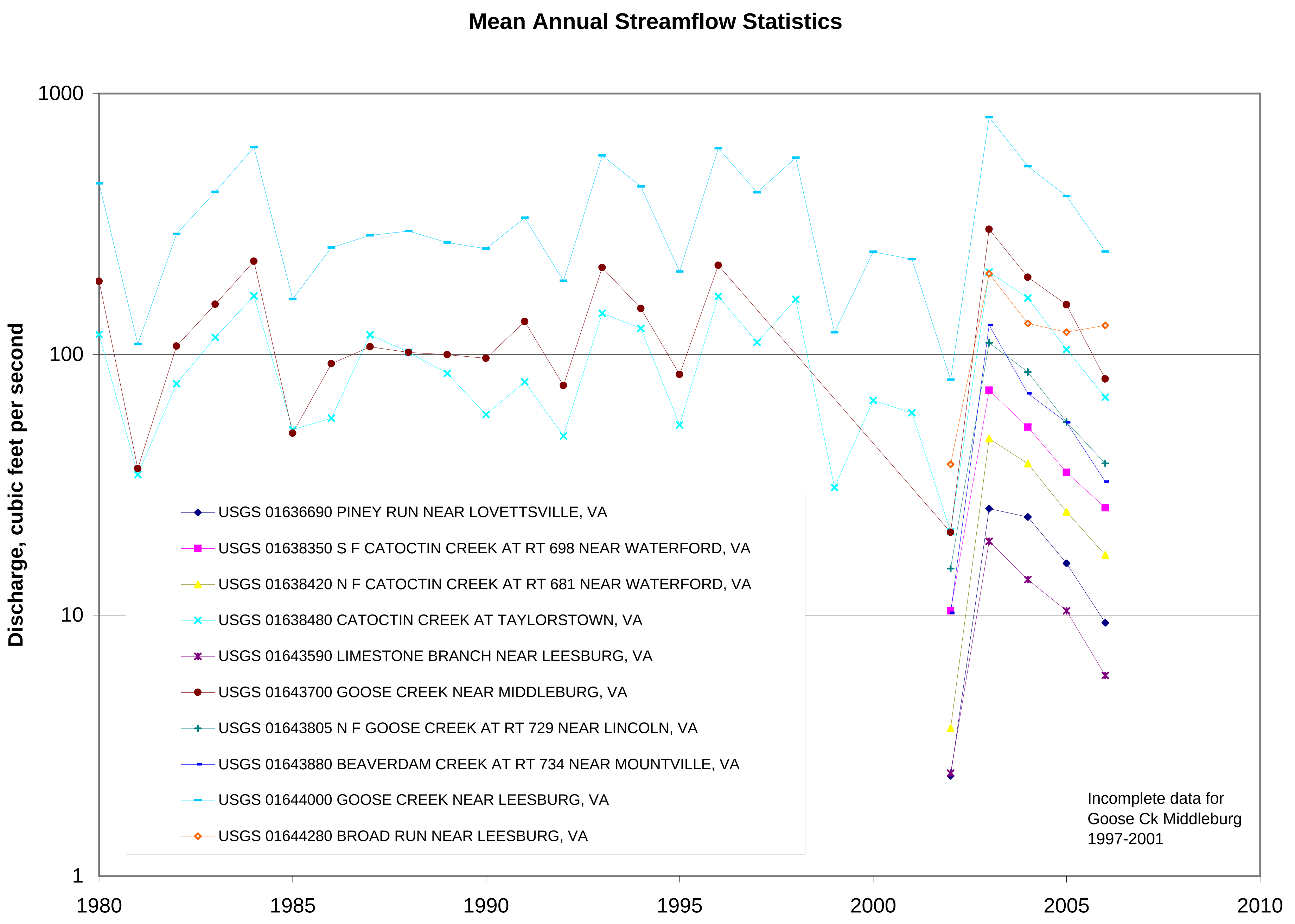
| | |
|---|---|
| 1943 | 501 |
| 1944 | 161.9 |
| 1945 | 347.5 |
| 1946 | 364.4 |
| 1947 | 174.6 |
| 1948 | 282.6 |
| 1949 | 460.6 |
| 1950 | 268.6 |
| 1951 | 463.7 |
| 1952 | 394 |
| 1953 | 407.6 |
| 1954 | 119 |
| 1955 | 263.9 |
| 1956 | 308.5 |
| 1957 | 260.4 |
| 1958 | 412.8 |
| 1959 | 129.9 |
| 1960 | 285 |
| 1961 | 331.6 |
| 1962 | 184.6 |
| 1963 | 188.7 |
| 1964 | 307.4 |
| 1965 | 271 |
| 1966 | 125.4 |
| 1967 | 283.7 |
| 1968 | 296.4 |
| 1969 | 148.9 |
| 1970 | 258.1 |
| 1971 | 386.5 |
| 1972 | 663.7 |
| 1973 | 511 |
| 1974 | 311.9 |
| 1975 | 430.9 |
| 1976 | 318.9 |
| 1977 | 305.3 |
| 1978 | 466.3 |
| 1979 | 516.5 |
| 1980 | 452.7 |
| 1981 | 109.6 |
| 1982 | 289.6 |
| 1983 | 419.9 |
| 1984 | 623.1 |
| 1985 | 162.8 |
| 1986 | 256.9 |
| 1987 | 286 |
| 1988 | 297.2 |
| 1989 | 268.3 |
| 1990 | 254.1 |
| 1991 | 333.6 |
| 1992 | 191.4 |
| 1993 | 579.4 |
| 1994 | 439.9 |

| | |
|---|---|
| 1995 | 207.8 |
| 1996 | 617.5 |
| 1997 | 417.7 |
| 1998 | 567.3 |
| 1999 | 121.5 |
| 2000 | 247.4 |
| 2001 | 231.4 |
| 2002 | 80 |
| 2003 | 811.5 |
| 2004 | 526.5 |
| 2005 | 404.2 |
| 2006 | 248 |

**USGS 01644280 BROAD RUN NEAR LEESBURG, VA**

| Water Year | Discharge, cubic feet per second |
|---|---|
| 2002 | 37.9 |
| 2003 | 203.9 |
| 2004 | 131.4 |
| 2005 | 121.6 |
| 2006 | 129.1 |

The above data maybe refreshed using
http://nwis.waterdata.usgs.gov/va/nwis/annual/?referred_module=sw&site_no=01636690&por_01636690_2=188986,00060,2,2002,2006&site_no=01638350&por_01638350_2=1955020,00060,2,2002,2006&site_no=01638420&por_01638420_2=1955021,00060,2,2002,2006&site_no=01638480&por_01638480_1=188988,00060,1,1971,2006&site_no=01643590&por_01643590_2=188990,00060,2,2002,2006&site_no=01643700&por_01643700_1=188994,00060,1,1966,2006&site_no=01643805&por_01643805_2=1955022,00060,2,2002,2006&site_no=01643880&por_01643880_2=1955023,00060,2,2002,2006&site_no=01644000&por_01644000_2=189001,00060,2,1910,2006&site_no=01644280&por_01644280_2=189017,00060,2,2002,2006&year_type=W&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list



Mean Annual Streamflow Statistics
Discharge, cubic feet per second
1000
100
10
1
1980
1985
1990
1995
2000
2005
2010
USGS 01636690 PINEY RUN NEAR LOVETTSVILLE, VA
USGS 01638350 S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA
USGS 01638420 N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA
USGS 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA
USGS 01643590 LIMESTONE BRANCH NEAR LEESBURG, VA
USGS 01643700 GOOSE CREEK NEAR MIDDLEBURG, VA
USGS 01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA
USGS 01643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA
USGS 01644000 GOOSE CREEK NEAR LEESBURG, VA
USGS 01644280 BROAD RUN NEAR LEESBURG, VA
Incomplete data for
Goose Ck Middleburg
1997-2001

# Streamflow Duration Plots

Streamflow-duration plots, which depict the flow-duration curves of daily-streamflow data grouped by months, are posted by the US Geological Survey for all streamflow gages in Virginia. Flow-duration plots are used to place current streamflow conditions in context of historic flow-conditions. Combined with other information such as ground-water levels, precipitation, and soil moisture, flow-duration plots can help local government agencies and water-resource managers assess regional drought conditions.

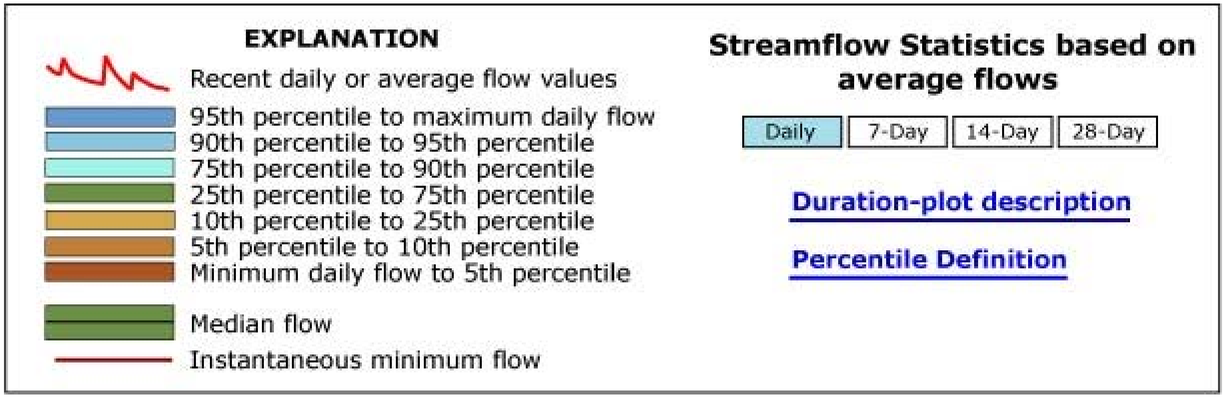
Currently available plots include statistics of daily streamflow data and the current daily streamflow data. Additional plots based on 7-day, 14-day, and 28-day running averages of the streamflow data are planned.

The following table are the ten stations in Loudoun County.

| Station | Location |
|---|---|
| 1636690 | PINEY RUN NEAR LOVETTSVILLE, VA |
| 1638350 | S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA |
| 1638420 | N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA |
| 1638480 | CATOCTIN CREEK AT TAYLORSTOWN, VA |
| 1643590 | LIMESTONE BRANCH NEAR LEESBURG, VA |
| 1643700 | GOOSE CREEK NEAR MIDDLEBURG, VA |
| 1643805 | N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA |
| 1643880 | BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA |
| 1644000 | GOOSE CREEK NEAR LEESBURG, VA |
| 1644280 | BROAD RUN NEAR LEESBURG, VA |

Tin review of the statictics, most of the stations only have a few years of data, therefore only the ‘daily” statictics are presented here.  For complete data, the reader is referred to http://va.water.usgs.gov/duration_plots/dp_map_potomac.htm

For each of the ten stations, the following key applies for each chart:


EXPLANATION
Recent daily or average flow values
95th percentile to maximum daily flow
90th percentile to 95th percentile
75th percentile to 90th percentile
25th percentile to 75th percentile
10th percentile to 25th percentile
5th percentile to 10th percentile
Minimum daily flow to 5th percentile
Median flow
Instantaneous minimum flow
Streamflow Statistics based on average flows
Daily
7-Day
14-Day
28-Day
Duration-plot description
Percentile Definition

# Duration Plot and Table of Daily Streamflow

## 01636690 PINEY RUN NEAR LOVETTSVILLE, VA

**LOCATION**.--Latitude 39°18'39.0", Longitude 77°43'06.6", North American Datum of 1983, Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--13.5 square miles.

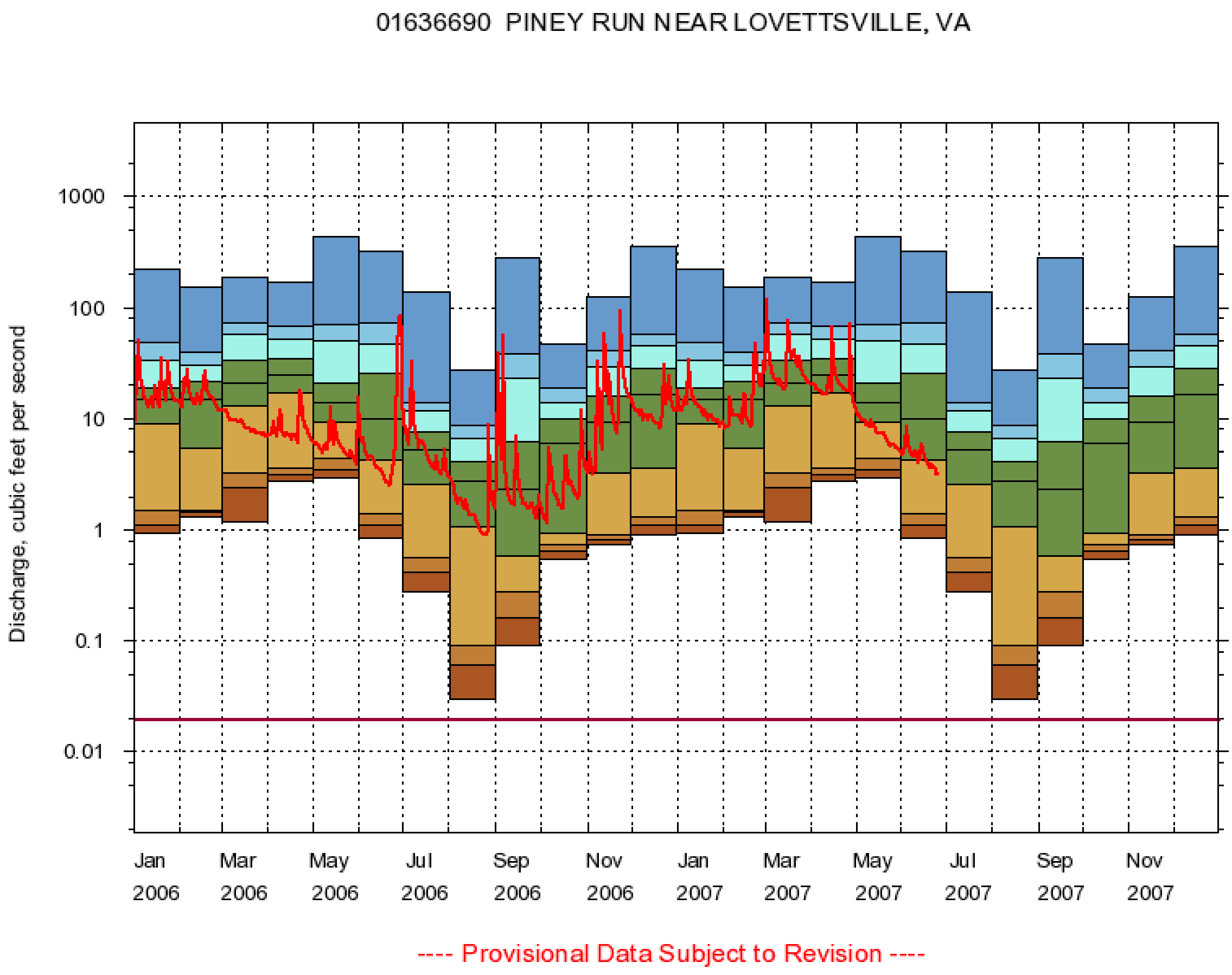
**PERIOD OF RECORD**.--October 2001 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--U.S. Geological Survey, Virginia Water Science Center.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01636690 PINEY RUN NEAR LOVETTSVILLE, VA

| Month | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.95 | 1.12 | 1.50 | 8.90 | 15.0 | 19.0 | 33.8 | 48.0 | 219 | | 4 |
| February | 1.30 | 1.46 | 1.52 | 5.50 | 15.0 | 22.0 | 30.0 | 39.2 | 151 | | 3 |
| March | 1.20 | 2.42 | 3.30 | 13.0 | 21.0 | 33.0 | 57.7 | 73.8 | 185 | | 4 |
| April | 2.80 | 3.20 | 3.60 | 16.8 | 24.5 | 35.0 | 52.0 | 68.6 | 169 | | 4 |
| May | 3.00 | 3.52 | 4.43 | 9.42 | 14.0 | 21.0 | 49.5 | 70.6 | 436 | | 4 |
| June | 0.84 | 1.10 | 1.39 | 4.30 | 10.0 | 25.2 | 46.6 | 73.2 | 327 | | 4 |
| July | 0.28 | 0.41 | 0.56 | 2.58 | 5.30 | 7.72 | 11.7 | 14.0 | 140 | | 4 |
| August | 0.03 | 0.06 | 0.09 | 1.08 | 2.80 | 4.20 | 6.62 | 8.78 | 27.0 | | 4 |
| September | 0.09 | 0.16 | 0.28 | 0.58 | 2.30 | 6.25 | 23.1 | 38.0 | 281 | | 4 |
| October | 0.54 | 0.64 | 0.73 | 0.95 | 6.00 | 10.0 | 14.0 | 18.8 | 47.0 | | 4 |
| November | 0.75 | 0.82 | 0.90 | 3.30 | 9.45 | 16.0 | 29.1 | 41.0 | 126 | | 4 |
| December | 0.92 | 1.10 | 1.33 | 3.65 | 16.5 | 28.2 | 45.4 | 57.4 | 352 | | 4 |

Instantaneous minimum flow for period of record = 0.02 cubic feet per second

# Duration Plot and Table of Daily Streamflow

## 01638350 SOUTH FORK CATOCTIN CREEK AT ROUTE 698 NEAR WATERFORD, VA

**LOCATION**.--Latitude 39°11'28.0", Longitude 77°36'55.6", North American Datum of 1983,
Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--31.6 square miles.

**PERIOD OF RECORD**.--July 2001 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--U.S. Geological Survey, Virginia Water Science Center.

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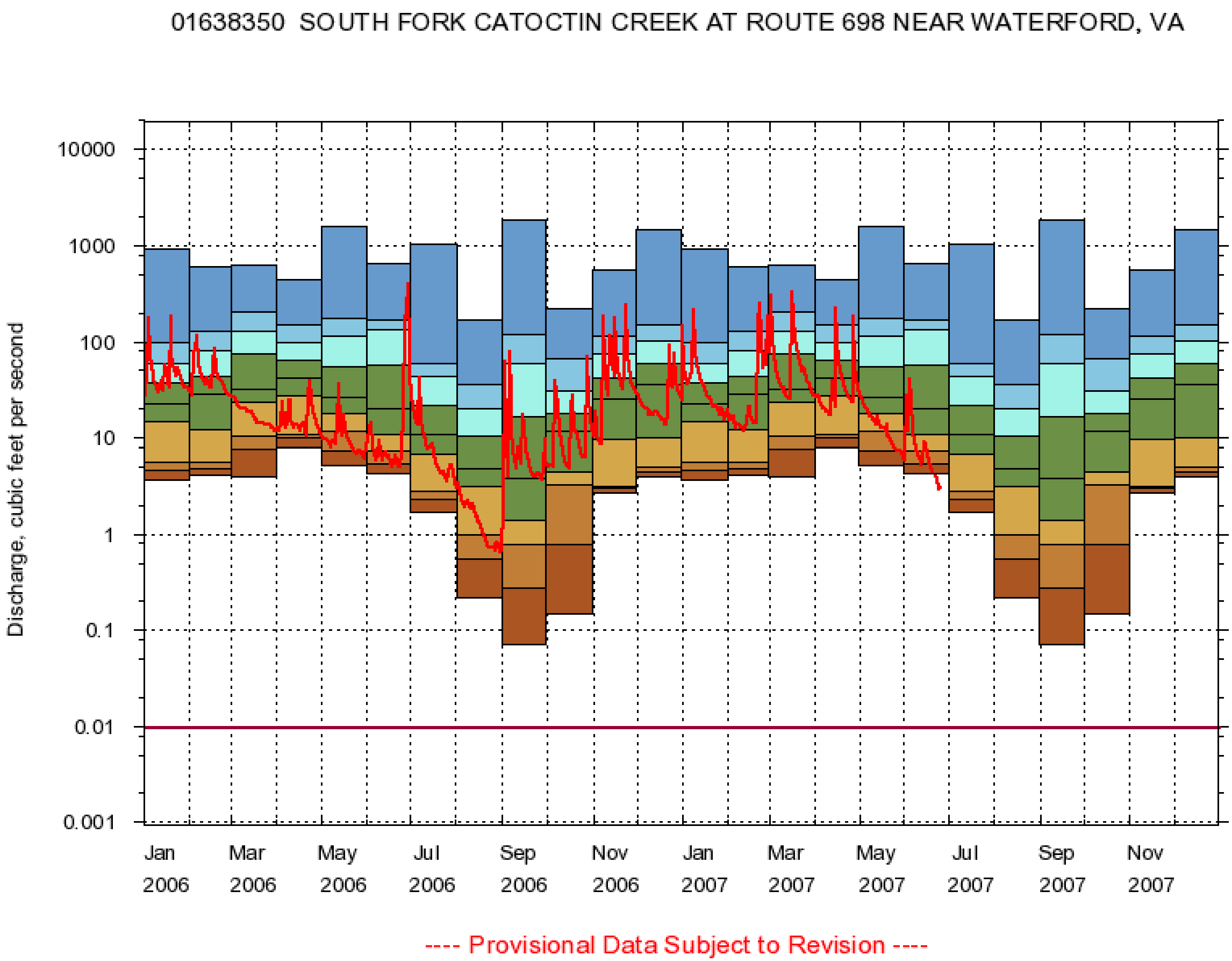
## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01638350 SOUTH FORK CATOCTIN CREEK AT ROUTE 698 NEAR WATERFORD, VA

| | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 3.70 | 4.63 | 5.66 | 15.0 | 22.5 | 37.2 | 58.5 | 99.8 | 939 | | 4 |
| February | 4.10 | 4.90 | 5.60 | 12.0 | 29.0 | 43.0 | 82.2 | 129 | 607 | | 3 |
| March | 4.00 | 7.72 | 10.3 | 23.8 | 32.5 | 74.8 | 129 | 207 | 638 | | 4 |
| April | 8.10 | 10.0 | 11.0 | 27.0 | 41.5 | 63.5 | 96.6 | 150 | 440 | | 4 |
| May | 5.20 | 7.30 | 11.6 | 17.8 | 26.5 | 54.0 | 115 | 174 | 1,560 | | 4 |
| June | 4.30 | 5.50 | 7.30 | 10.8 | 20.0 | 58.2 | 136 | 168 | 665 | | 4 |
| July | 1.70 | 2.30 | 2.84 | 6.80 | 11.0 | 22.0 | 43.6 | 58.6 | 1,050 | | 5 |
| August | 0.22 | 0.55 | 0.98 | 3.10 | 4.80 | 10.5 | 20.0 | 35.5 | 166 | | 5 |
| September | 0.07 | 0.28 | 0.78 | 1.40 | 3.80 | 16.8 | 60.2 | 118 | 1,840 | | 5 |
| October | 0.15 | 0.77 | 3.33 | 4.38 | 11.5 | 18.2 | 30.7 | 65.8 | 221 | | 4 |
| November | 2.70 | 3.00 | 3.10 | 9.52 | 25.5 | 42.2 | 75.2 | 113 | 550 | | 4 |
| December | 4.00 | 4.43 | 4.93 | 10.0 | 36.0 | 60.0 | 101 | 148 | 1,450 | | 4 |

Instantaneous minimum flow for period of record = 0.01 cubic feet per second

# Duration Plot and Table of Daily Streamflow

## 01638420 NORTH FORK CATOCTIN CREEK AT ROUTE 681 NEAR WATERFORD, VA

**LOCATION**.--Latitude 39°12'18.0", Longitude 77°37'26.0", North American Datum of 1983,
Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--23.1 square miles.

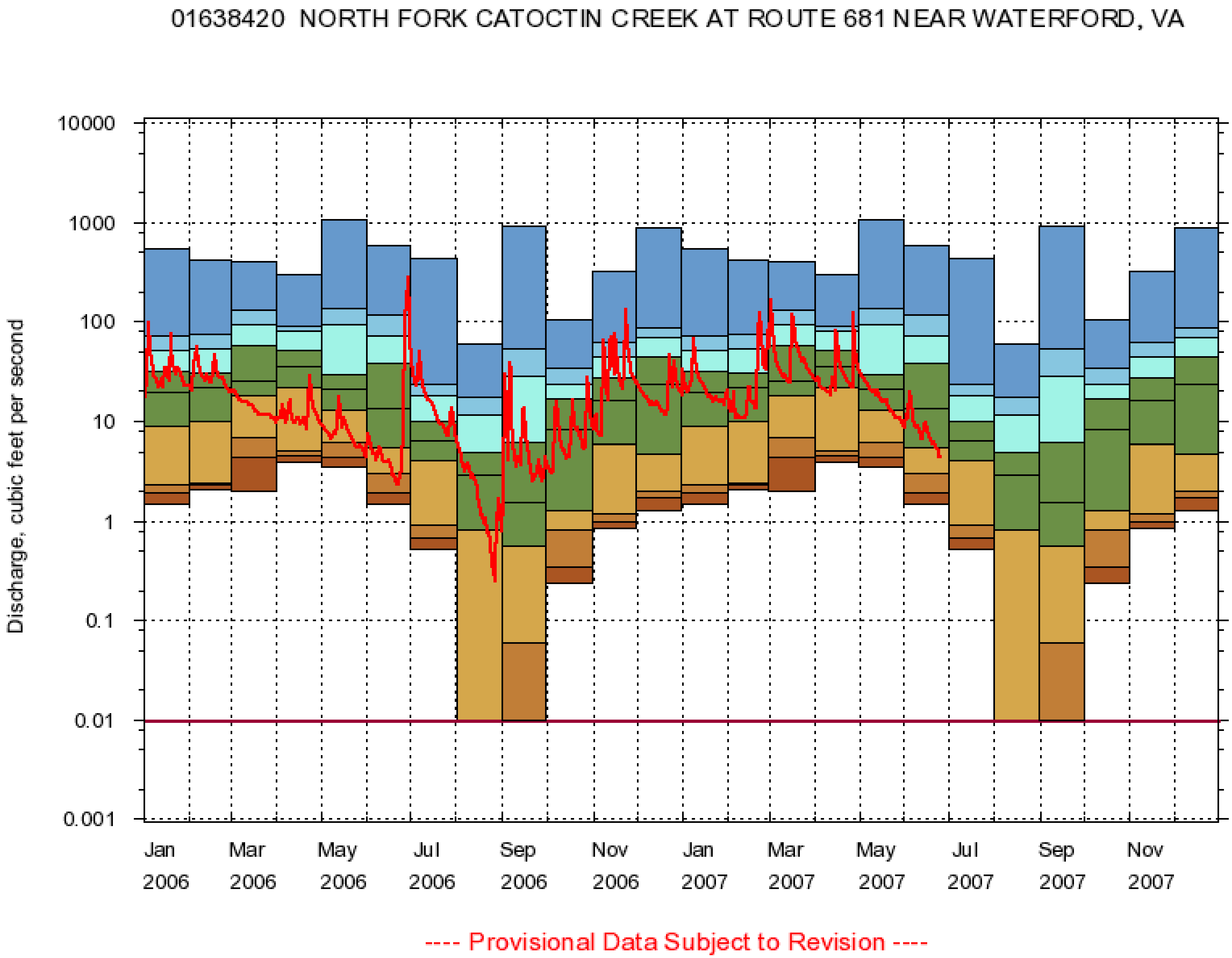
**PERIOD OF RECORD**.--July 2001 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--U.S. Geological Survey, Virginia Water Science Center.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01638420 NORTH FORK CATOCTIN CREEK AT ROUTE 681 NEAR WATERFORD, VA

| | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|
| January | 1.50 | 1.90 | 2.30 | 9.02 | 19.5 | 32.0 | 51.9 | 71.8 | 542 | 4 |
| February | 2.10 | 2.30 | 2.40 | 10.0 | 22.0 | 31.0 | 52.8 | 76.4 | 418 | 3 |
| March | 2.00 | 4.34 | 6.93 | 18.0 | 25.0 | 57.2 | 95.4 | 133 | 407 | 4 |
| April | 3.90 | 4.60 | 5.10 | 21.8 | 36.0 | 51.0 | 81.0 | 91.1 | 300 | 4 |
| May | 3.50 | 4.38 | 6.25 | 13.0 | 21.0 | 30.0 | 92.8 | 136 | 1,060 | 4 |
| June | 1.50 | 1.90 | 2.99 | 5.42 | 13.5 | 37.8 | 73.3 | 116 | 587 | 4 |
| July | 0.52 | 0.69 | 0.92 | 4.08 | 6.35 | 10.0 | 18.5 | 24.0 | 429 | 4 |
| August | 0.00 | 0.00 | 0.00 | 0.82 | 2.90 | 4.85 | 11.6 | 17.3 | 61.0 | 5 |
| September | 0.00 | 0.00 | 0.06 | 0.56 | 1.55 | 6.10 | 28.5 | 53.6 | 933 | 5 |
| October | 0.24 | 0.35 | 0.81 | 1.30 | 8.25 | 17.0 | 23.7 | 34.2 | 105 | 4 |
| November | 0.86 | 0.99 | 1.19 | 5.82 | 16.0 | 27.0 | 44.3 | 62.6 | 325 | 4 |
| December | 1.30 | 1.72 | 2.00 | 4.65 | 23.5 | 44.0 | 70.9 | 87.1 | 897 | 4 |

**Instantaneous minimum flow for period of record = 0.00 cubic feet per second**
**Flow values of 0.00 are plotted as 0.01**

# Duration Plot and Table of Daily Streamflow

## 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA

**LOCATION**.--Latitude 39°15'16", Longitude 77°34'36", North American Datum of 1927, Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--89.5 mi2.

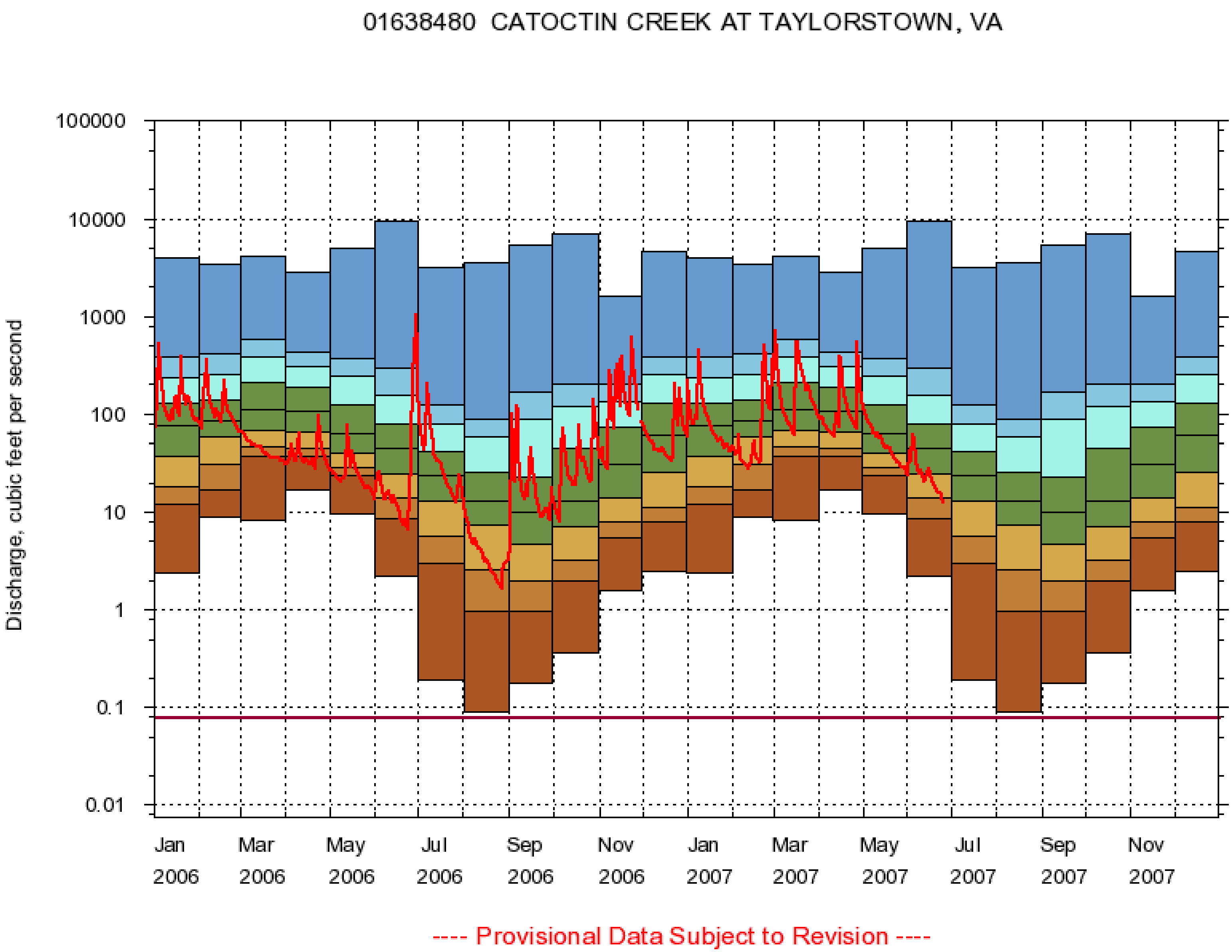
**PERIOD OF RECORD**.--August 1971 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--Virginia Department of Environmental Quality - Water Division.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA

| | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|
| January | 2.40 | 12.0 | 18.0 | 38.0 | 77.0 | 127 | 239 | 384 | 4,050 | 35 |
| February | 8.90 | 17.0 | 31.0 | 58.0 | 85.0 | 140 | 256 | 417 | 3,400 | 32 |
| March | 8.40 | 38.0 | 46.3 | 68.0 | 113 | 209 | 379 | 574 | 4,160 | 35 |
| April | 17.0 | 37.0 | 45.9 | 65.8 | 108 | 185 | 311 | 428 | 2,810 | 34 |
| May | 9.50 | 23.6 | 28.3 | 40.0 | 64.0 | 124 | 244 | 375 | 5,030 | 35 |
| June | 2.20 | 8.70 | 14.0 | 25.0 | 45.0 | 78.0 | 158 | 292 | 9,530 | 34 |
| July | 0.19 | 2.96 | 5.73 | 13.0 | 24.0 | 42.0 | 79.7 | 126 | 3,190 | 35 |
| August | 0.09 | 0.98 | 2.54 | 7.40 | 13.0 | 26.0 | 59.0 | 90.0 | 3,500 | 36 |
| September | 0.18 | 0.96 | 2.00 | 4.70 | 9.90 | 23.0 | 89.0 | 169 | 5,400 | 35 |
| October | 0.36 | 1.97 | 3.24 | 7.10 | 13.0 | 45.0 | 121 | 205 | 7,040 | 35 |
| November | 1.60 | 5.50 | 8.10 | 14.0 | 30.5 | 74.2 | 135 | 200 | 1,620 | 34 |
| December | 2.50 | 7.90 | 11.0 | 25.2 | 61.0 | 127 | 255 | 384 | 4,580 | 35 |

**Instantaneous minimum flow for period of record = 0.08 cubic feet per second**

# Duration Plot and Table of Daily Streamflow

## 01643590 LIMESTONE BRANCH NEAR LEESBURG, VA

**LOCATION**.--Latitude 39°10'03.4", Longitude 77°32'09.3", North American Datum of 1983, Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--7.88 square miles.

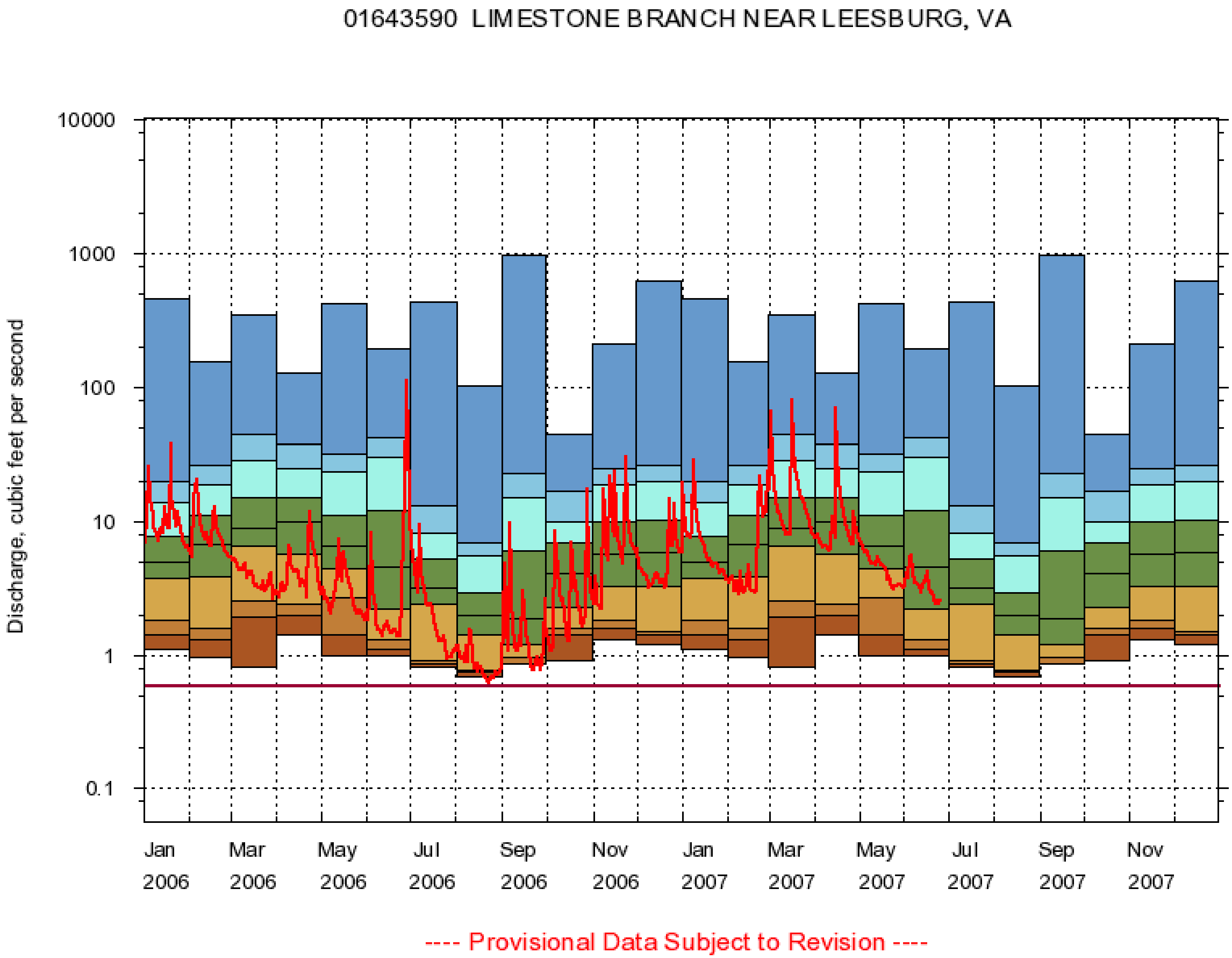
**PERIOD OF RECORD**.--August 2001 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--U.S. Geological Survey, Virginia Water Science Center.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01643590 LIMESTONE BRANCH NEAR LEESBURG, VA

| | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 1.10 | 1.43 | 1.80 | 3.78 | 5.00 | 7.70 | 13.7 | 19.8 | 459 | | 4 |
| February | 0.97 | 1.30 | 1.60 | 3.90 | 6.70 | 11.0 | 18.8 | 26.2 | 158 | | 3 |
| March | 0.81 | 1.92 | 2.53 | 6.50 | 8.80 | 15.2 | 28.8 | 44.0 | 347 | | 4 |
| April | 1.40 | 2.00 | 2.40 | 5.70 | 10.0 | 15.0 | 25.1 | 37.4 | 128 | | 4 |
| May | 1.00 | 1.40 | 2.69 | 4.38 | 6.50 | 11.0 | 23.7 | 32.4 | 424 | | 4 |
| June | 0.98 | 1.10 | 1.30 | 2.20 | 4.55 | 12.0 | 30.1 | 42.2 | 195 | | 4 |
| July | 0.82 | 0.86 | 0.91 | 2.40 | 3.15 | 5.22 | 8.14 | 13.0 | 440 | | 4 |
| August | 0.68 | 0.75 | 0.77 | 1.40 | 2.00 | 2.90 | 5.50 | 6.90 | 102 | | 4 |
| September | 0.85 | 0.87 | 0.96 | 1.20 | 1.90 | 6.05 | 15.0 | 23.0 | 976 | | 5 |
| October | 0.90 | 1.40 | 1.60 | 2.30 | 4.10 | 7.00 | 9.85 | 16.8 | 44.0 | | 4 |
| November | 1.30 | 1.60 | 1.80 | 3.25 | 5.70 | 10.0 | 19.0 | 25.2 | 210 | | 4 |
| December | 1.20 | 1.42 | 1.50 | 3.28 | 5.90 | 10.2 | 19.7 | 26.6 | 633 | | 4 |

**Instantaneous minimum flow for period of record = 0.60 cubic feet per second**

# Duration Plot and Table of Daily Streamflow

## 01643700 GOOSE CREEK NEAR MIDDLEBURG, VA

**LOCATION**.--Latitude 38°59'11", Longitude 77°47'49", North American Datum of 1927,
Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--122 square miles.

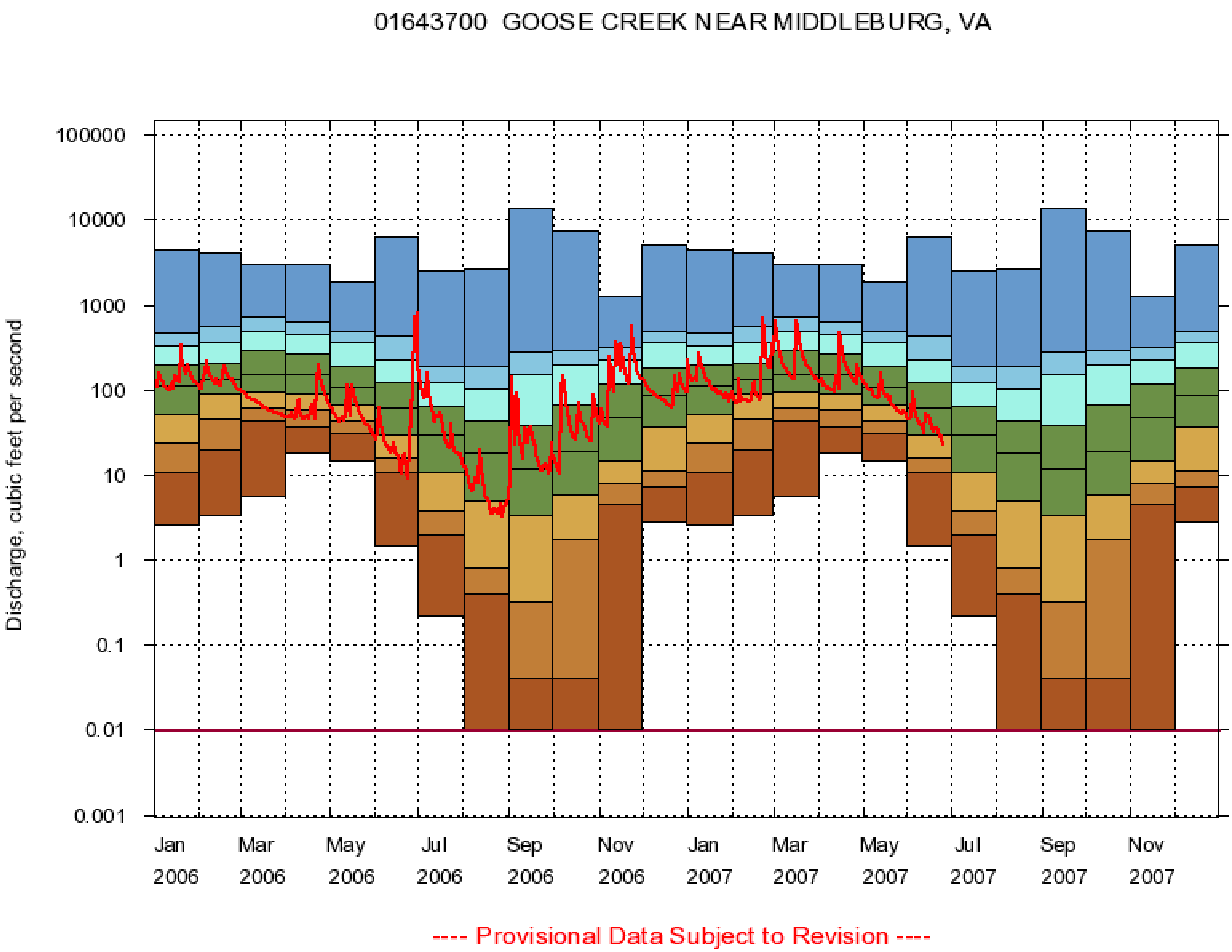
**PERIOD OF RECORD**.--October 1965 to September 1967, July 1969 to September 1996, June 2001 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--U.S. Geological Survey, Virginia Water Science Center.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01643700 GOOSE CREEK NEAR MIDDLEBURG, VA

| Month | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|
| January | 2.60 | 11.0 | 24.0 | 51.0 | 112 | 200 | 338 | 466 | 4,380 | 35 |
| February | 3.30 | 20.0 | 45.1 | 90.0 | 133 | 202 | 360 | 570 | 4,160 | 31 |
| March | 5.60 | 43.0 | 61.0 | 95.0 | 155 | 288 | 491 | 732 | 3,070 | 34 |
| April | 18.0 | 36.0 | 57.8 | 90.0 | 154 | 270 | 452 | 640 | 3,000 | 33 |
| May | 15.0 | 31.0 | 43.2 | 66.0 | 109 | 189 | 356 | 490 | 1,910 | 34 |
| June | 1.50 | 11.0 | 16.0 | 29.0 | 62.0 | 122 | 221 | 434 | 6,270 | 33 |
| July | 0.22 | 2.00 | 3.80 | 11.0 | 29.0 | 64.0 | 123 | 190 | 2,590 | 36 |
| August | 0.01 | 0.40 | 0.80 | 4.90 | 18.0 | 43.0 | 103 | 187 | 2,680 | 36 |
| September | 0.00 | 0.04 | 0.33 | 3.40 | 12.0 | 38.0 | 154 | 282 | 14,000 | 35 |
| October | 0.00 | 0.04 | 1.73 | 6.00 | 19.0 | 67.8 | 201 | 292 | 7,500 | 35 |
| November | 0.00 | 4.57 | 7.99 | 15.0 | 46.5 | 119 | 223 | 322 | 1,260 | 34 |
| December | 2.80 | 7.50 | 11.3 | 36.0 | 87.0 | 180 | 358 | 495 | 5,190 | 35 |

**Instantaneous minimum flow for period of record = 0.00 cubic feet per second**
**Flow values of 0.00 are plotted as 0.01**

# Duration Plot and Table of Daily Streamflow

## 01643805 NORTH FORK GOOSE CREEK AT ROUTE 729 NEAR LINCOLN, VA

**LOCATION**.--Latitude 39°04'20.3", Longitude 77°41'02.2", North American Datum of 1983, Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--38.1 square miles.

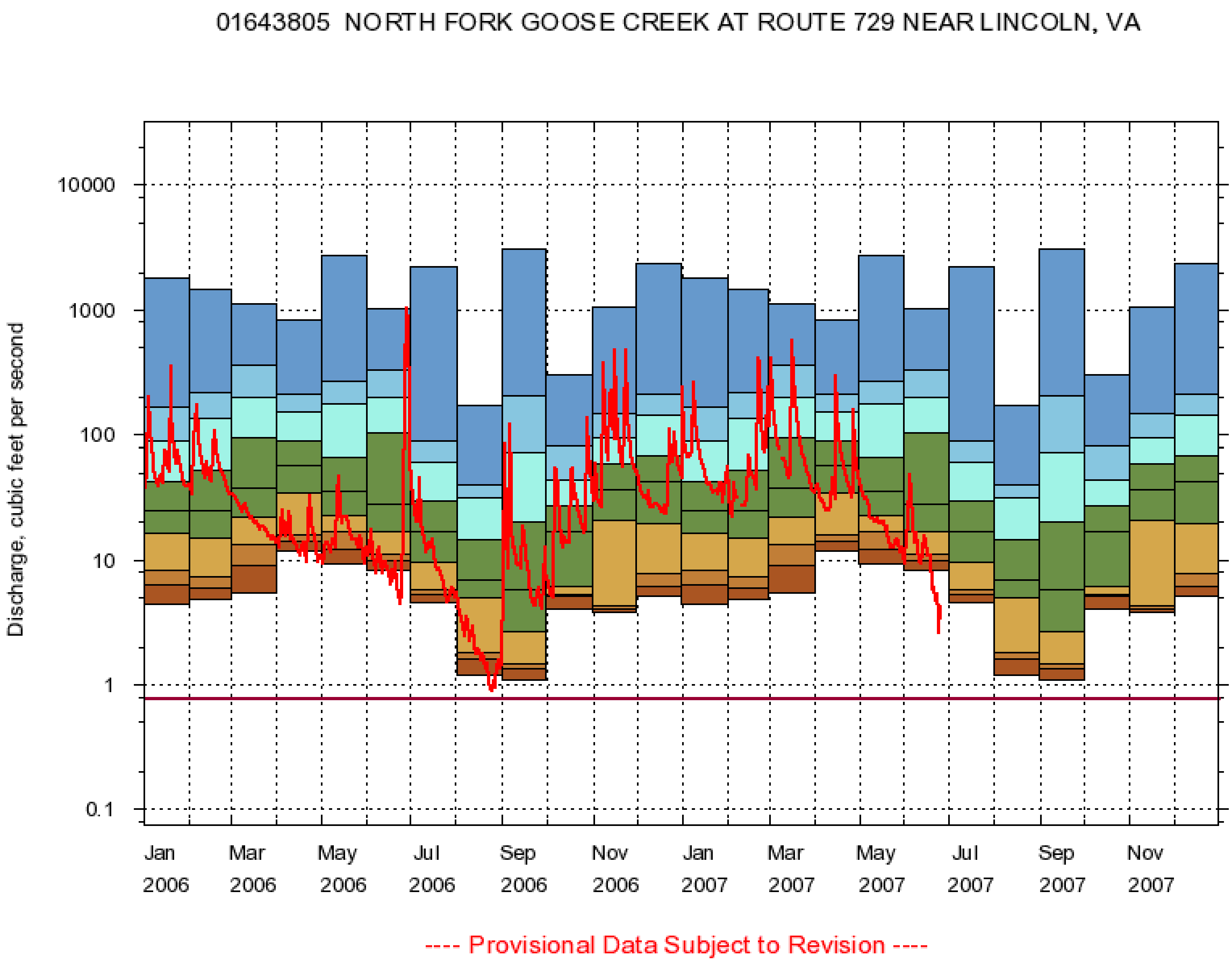
**PERIOD OF RECORD**.--July 2001 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--U.S. Geological Survey, Virginia Water Science Center.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01643805 NORTH FORK GOOSE CREEK AT ROUTE 729 NEAR LINCOLN, VA

| Month | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|
| January | 4.40 | 6.26 | 8.16 | 16.2 | 25.0 | 42.0 | 89.4 | 169 | 1,830 | 4 |
| February | 4.90 | 5.92 | 7.32 | 15.0 | 25.0 | 52.0 | 134 | 218 | 1,450 | 3 |
| March | 5.40 | 9.08 | 13.3 | 22.0 | 38.0 | 95.8 | 200 | 363 | 1,110 | 4 |
| April | 12.0 | 14.0 | 16.0 | 34.8 | 57.5 | 90.2 | 154 | 212 | 839 | 4 |
| May | 9.30 | 12.3 | 17.0 | 23.0 | 36.0 | 65.5 | 175 | 271 | 2,750 | 4 |
| June | 8.30 | 10.0 | 11.0 | 17.0 | 28.0 | 103 | 202 | 328 | 1,030 | 4 |
| July | 4.60 | 5.26 | 5.86 | 9.60 | 17.0 | 30.0 | 60.8 | 88.2 | 2,220 | 4 |
| August | 1.20 | 1.60 | 1.84 | 4.95 | 7.00 | 14.5 | 31.2 | 40.0 | 174 | 5 |
| September | 1.10 | 1.34 | 1.49 | 2.70 | 5.85 | 20.0 | 72.9 | 206 | 3,040 | 5 |
| October | 4.10 | 5.10 | 5.23 | 6.10 | 17.0 | 27.0 | 43.4 | 83.0 | 301 | 4 |
| November | 3.80 | 4.10 | 4.30 | 20.8 | 37.0 | 59.5 | 93.5 | 150 | 1,050 | 4 |
| December | 5.10 | 6.13 | 7.70 | 19.5 | 43.0 | 68.5 | 144 | 212 | 2,370 | 4 |

**Instantaneous minimum flow for period of record = 0.80 cubic feet per second**

# Duration Plot and Table of Daily Streamflow

## 01643880 BEAVERDAM CREEK AT ROUTE 734 NEAR MOUNTVILLE, VA

**LOCATION**.--Latitude 39°02'15.8", Longitude 77°43'20.1", North American Datum of 1983,
Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--47.2 square miles.

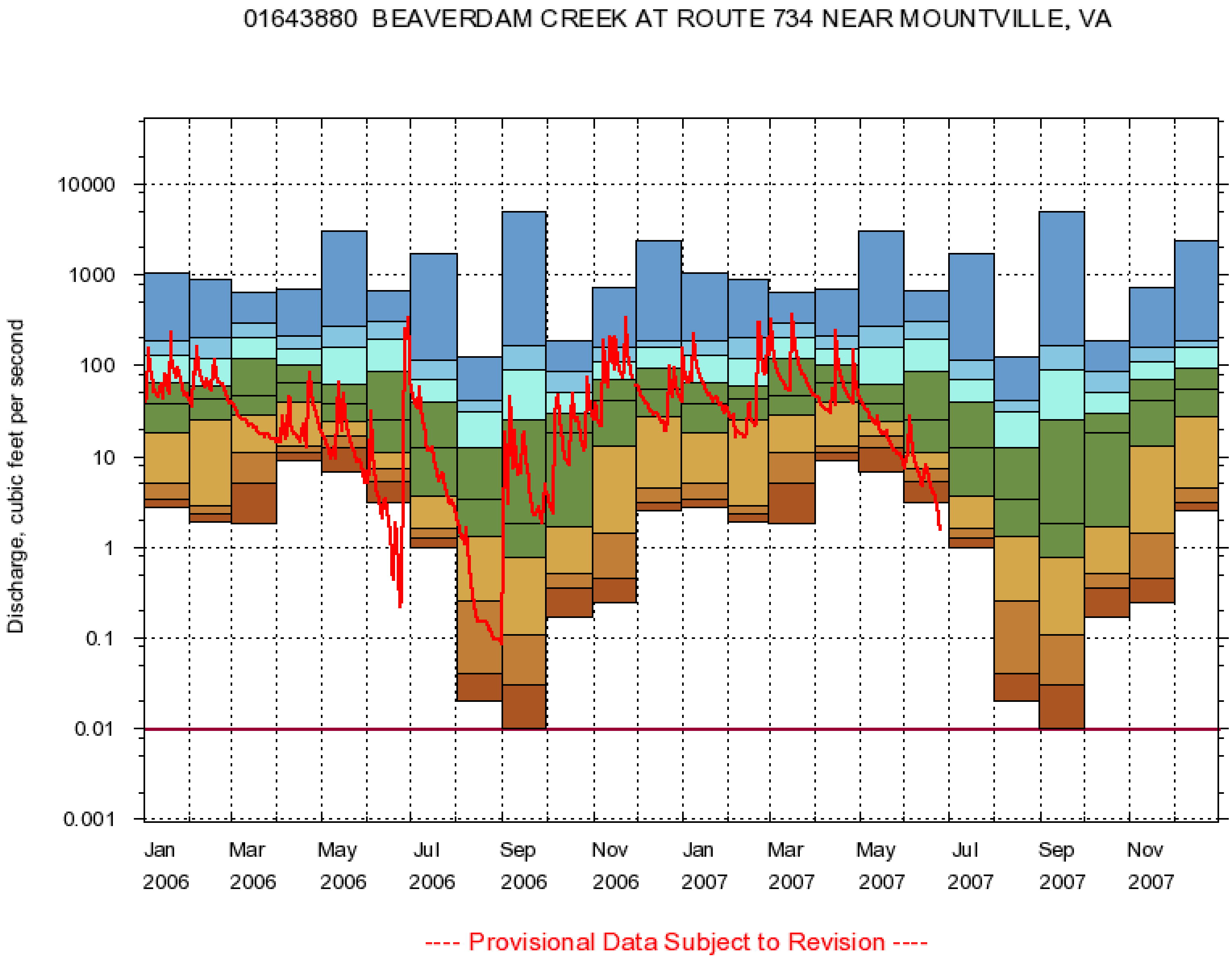
**PERIOD OF RECORD**.--July 2001 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--U.S. Geological Survey, Virginia Water Science Center.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01643880 BEAVERDAM CREEK AT ROUTE 734 NEAR MOUNTVILLE, VA

| | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 2.80 | 3.40 | 5.13 | 18.0 | 37.5 | 64.0 | 130 | 188 | 1,030 | | 4 |
| February | 1.90 | 2.36 | 2.82 | 25.0 | 43.0 | 59.0 | 118 | 204 | 873 | | 3 |
| March | 1.80 | 5.16 | 10.9 | 28.0 | 46.0 | 118 | 199 | 298 | 649 | | 4 |
| April | 9.00 | 11.0 | 12.9 | 39.0 | 64.0 | 102 | 153 | 211 | 705 | | 4 |
| May | 6.80 | 12.3 | 17.0 | 23.8 | 38.5 | 63.2 | 162 | 269 | 3,060 | | 4 |
| June | 3.10 | 5.30 | 7.45 | 11.0 | 25.0 | 87.2 | 197 | 311 | 672 | | 4 |
| July | 1.00 | 1.28 | 1.60 | 3.62 | 12.5 | 40.0 | 70.9 | 115 | 1,710 | | 4 |
| August | 0.02 | 0.04 | 0.26 | 1.30 | 3.40 | 12.5 | 31.0 | 41.9 | 126 | | 5 |
| September | 0.00 | 0.03 | 0.11 | 0.76 | 1.80 | 25.5 | 90.0 | 168 | 5,000 | | 5 |
| October | 0.17 | 0.35 | 0.51 | 1.68 | 18.5 | 30.0 | 50.7 | 84.6 | 185 | | 4 |
| November | 0.25 | 0.46 | 1.41 | 13.0 | 41.5 | 70.8 | 108 | 158 | 726 | | 4 |
| December | 2.50 | 3.06 | 4.46 | 26.8 | 54.0 | 93.5 | 161 | 186 | 2,330 | | 4 |

**Instantaneous minimum flow for period of record = 0.00 cubic feet per second**
**Flow values of 0.00 are plotted as 0.01**

# Duration Plot and Table of Daily Streamflow

## 01644000 GOOSE CREEK NEAR LEESBURG, VA

**LOCATION**.--Latitude 39°01'10", Longitude 77°34'40", North American Datum of 1927, Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--332 square miles.

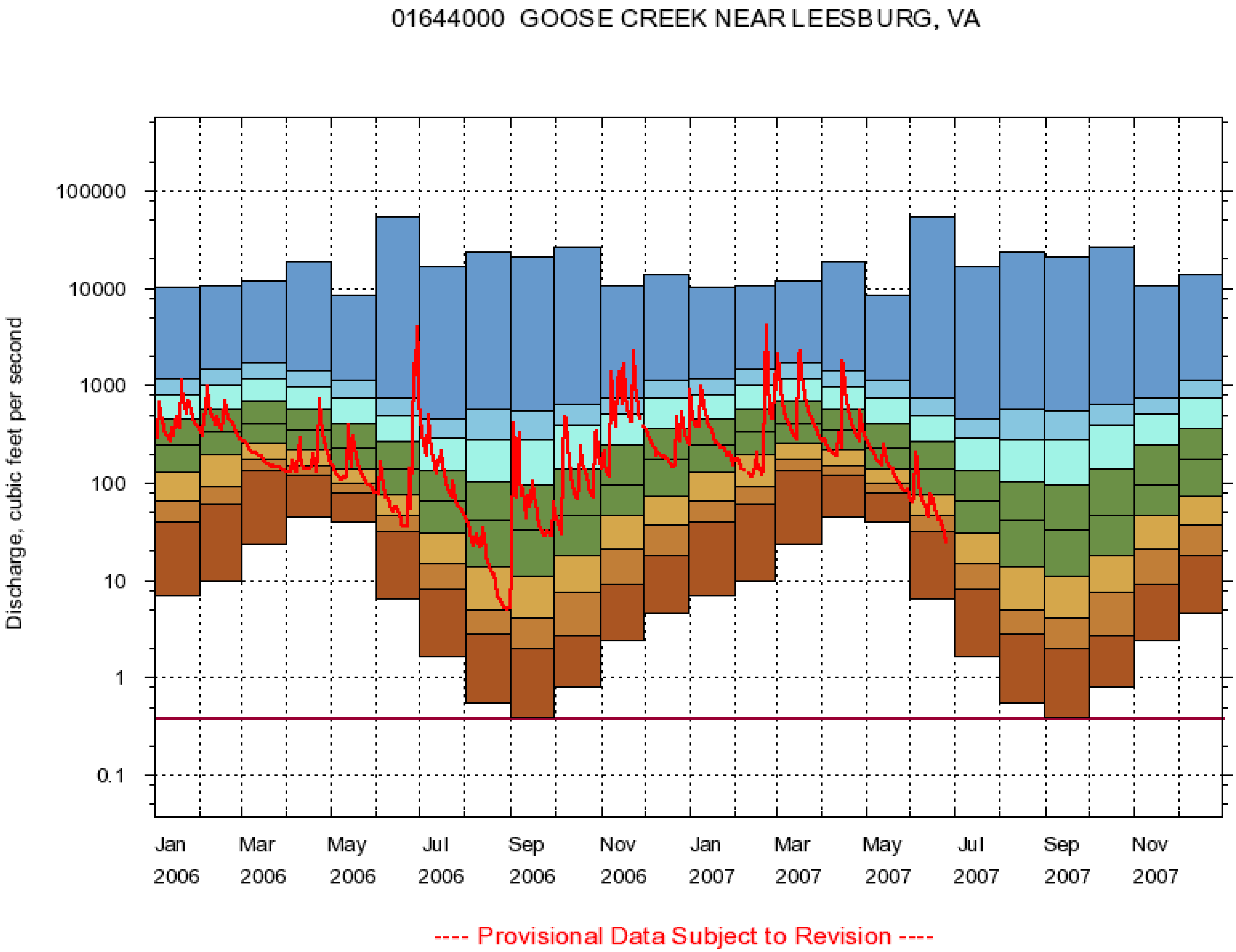
**PERIOD OF RECORD**.--July 1909 to April 1911, September 1911 to December 1912, January 1930 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--Virginia Department of Environmental Quality - Water Division.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01644000 GOOSE CREEK NEAR LEESBURG, VA

| | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 7.00 | 40.0 | 65.0 | 130 | 250 | 460 | 822 | 1,200 | 10,100 | | 81 |
| February | 10.0 | 60.6 | 93.1 | 200 | 333 | 576 | 1,020 | 1,490 | 10,800 | | 74 |
| March | 24.0 | 135 | 178 | 259 | 415 | 700 | 1,160 | 1,700 | 11,800 | | 81 |
| April | 46.0 | 120 | 150 | 221 | 355 | 580 | 979 | 1,420 | 19,000 | | 79 |
| May | 40.0 | 80.0 | 101 | 143 | 234 | 410 | 744 | 1,150 | 8,610 | | 80 |
| June | 6.60 | 32.0 | 46.9 | 77.0 | 141 | 266 | 496 | 754 | 53,600 | | 78 |
| July | 1.70 | 8.28 | 15.0 | 31.0 | 67.0 | 136 | 291 | 454 | 17,000 | | 81 |
| August | 0.55 | 2.80 | 5.10 | 14.0 | 42.0 | 103 | 279 | 571 | 24,000 | | 81 |
| September | 0.40 | 2.00 | 4.20 | 11.0 | 33.0 | 95.0 | 284 | 558 | 20,800 | | 80 |
| October | 0.80 | 2.70 | 7.58 | 18.0 | 47.0 | 139 | 388 | 653 | 26,100 | | 81 |
| November | 2.40 | 9.32 | 21.0 | 47.2 | 95.0 | 247 | 513 | 751 | 10,700 | | 79 |
| December | 4.60 | 18.0 | 37.8 | 73.0 | 177 | 370 | 749 | 1,150 | 13,900 | | 81 |

**Instantaneous minimum flow for period of record = 0.40 cubic feet per second**

# Duration Plot and Table of Daily Streamflow

## 01644280 BROAD RUN NEAR LEESBURG, VA

**LOCATION**.--Latitude 39°02'47.1", Longitude 77°25'56.6", North American Datum of 1983, Loudoun County, VA, Hydrologic Unit 02070008.

**DRAINAGE AREA**.--76.1 square miles.

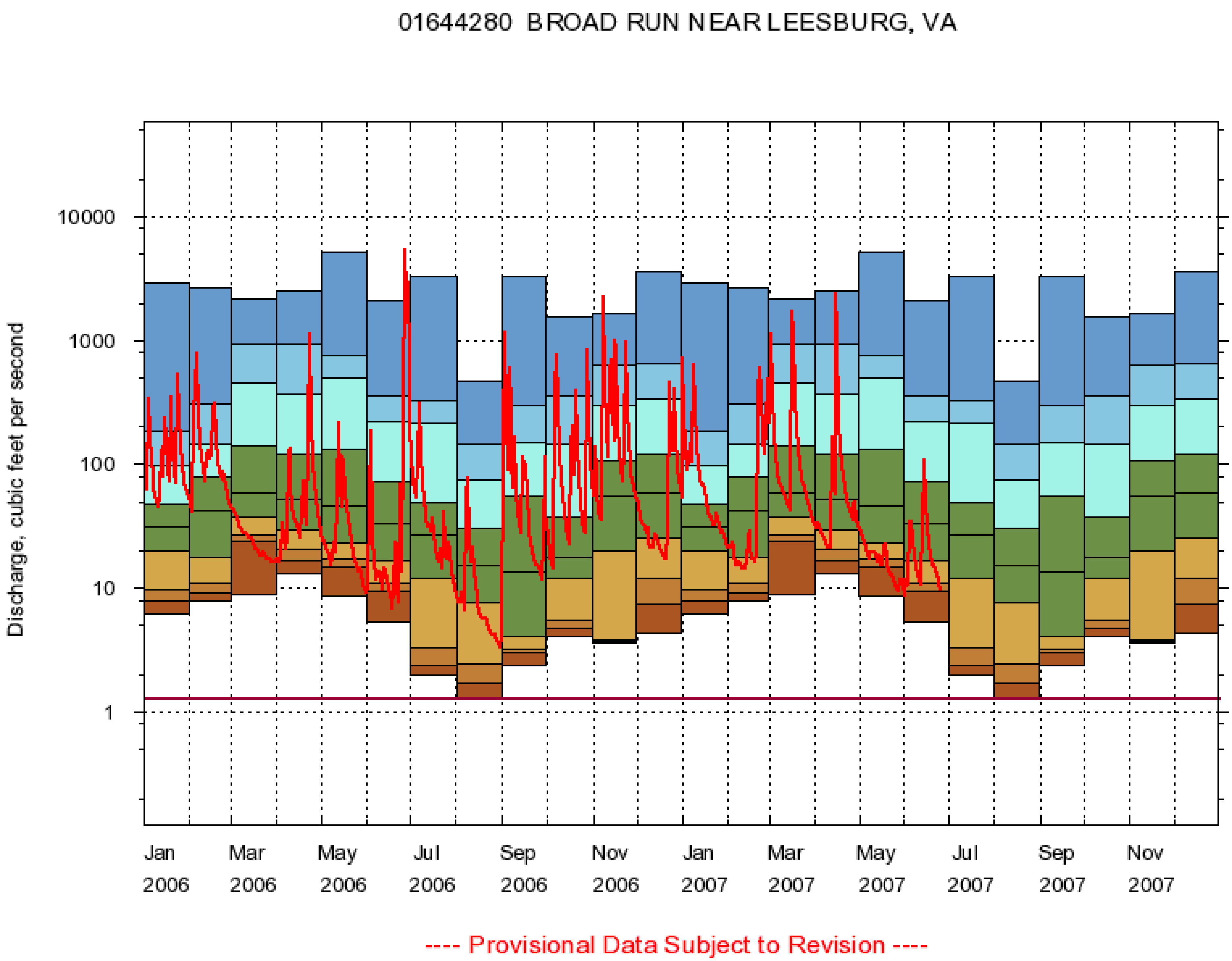
**PERIOD OF RECORD**.--October 2001 to current year.

**DURATION STATISTIC COMPUTATION PERIOD**.--All data through September 2005.

**REGULATION**.--No known regulation.

**GAGE OPERATION**.--U.S. Geological Survey, Virginia Water Science Center.

## Duration Plot with Daily Streamflow Conditions



## Duration Table of Daily Streamflow

Flow values in cubic feet per second

01644280 BROAD RUN NEAR LEESBURG, VA

| Month | Minimum daily flow | 5th percentile | 10th percentile | 25th percentile | Median | 75th percentile | 90th percentile | 95th percentile | Maximum daily flow | | Years of record |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 6.30 | 7.88 | 9.74 | 20.0 | 31.0 | 47.5 | 97.0 | 184 | 2,910 | | 4 |
| February | 7.90 | 9.22 | 11.0 | 18.0 | 42.0 | 80.0 | 147 | 304 | 2,640 | | 3 |
| March | 8.80 | 24.0 | 27.0 | 37.8 | 59.0 | 140 | 455 | 924 | 2,160 | | 4 |
| April | 13.0 | 17.0 | 20.9 | 30.0 | 52.0 | 121 | 368 | 938 | 2,530 | | 4 |
| May | 8.70 | 15.0 | 17.3 | 23.0 | 46.5 | 133 | 492 | 750 | 5,200 | | 4 |
| June | 5.40 | 9.38 | 10.9 | 17.0 | 33.0 | 72.5 | 223 | 359 | 2,080 | | 4 |
| July | 2.00 | 2.40 | 3.33 | 12.0 | 27.0 | 49.5 | 215 | 324 | 3,300 | | 4 |
| August | 1.30 | 1.70 | 2.43 | 7.75 | 15.5 | 30.2 | 75.7 | 144 | 467 | | 4 |
| September | 2.40 | 3.00 | 3.20 | 4.08 | 13.5 | 54.8 | 149 | 295 | 3,290 | | 4 |
| October | 4.10 | 4.82 | 5.46 | 12.0 | 18.0 | 37.5 | 146 | 362 | 1,540 | | 4 |
| November | 3.60 | 3.70 | 3.90 | 19.8 | 55.5 | 107 | 298 | 633 | 1,670 | | 4 |
| December | 4.40 | 7.56 | 12.0 | 25.8 | 58.5 | 120 | 339 | 653 | 3,580 | | 4 |

**Instantaneous minimum flow for period of record = 1.30 cubic feet per second**

# Relating USGS Streamflow Data

David Ward
December 21, 2006

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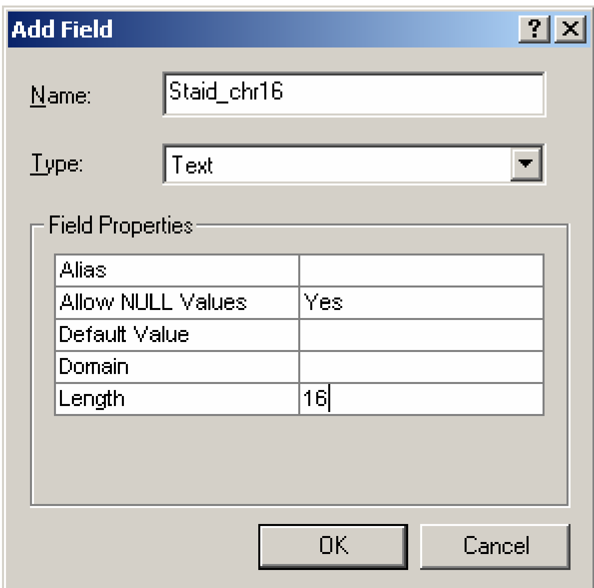
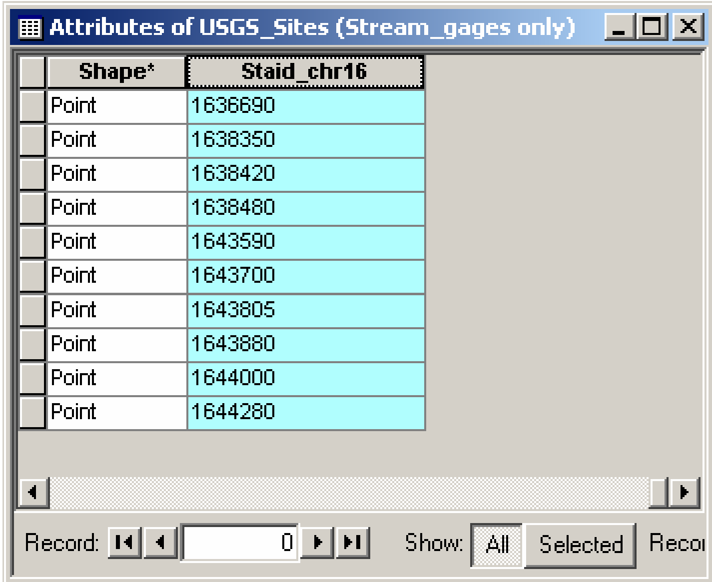
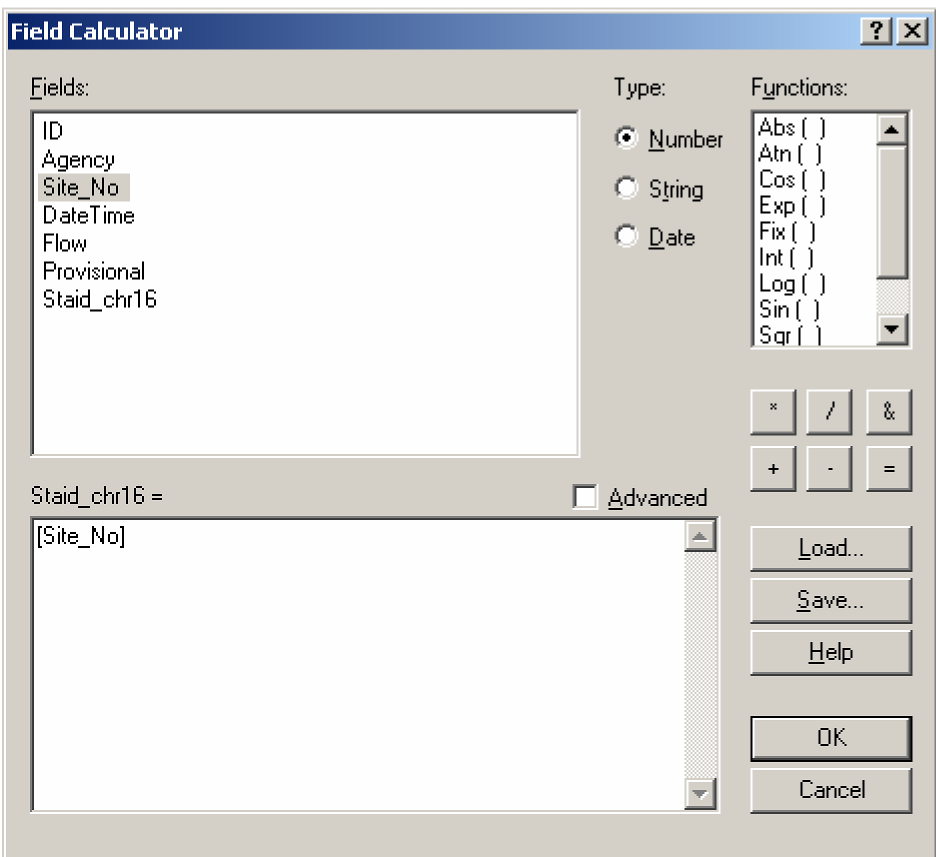
Stream flow is monitored at ten USGS stream gaging stations.  These locations are stored separately from the actual streamflow data.  The streamflow data is obtained via a web query which downloads all historical and also recent provisional data in one Excel file.  The gagaing stations are part of the USGS site inventory station location file.  The two tables are related through the identification number.  Here we are storing the station as a "Double" for consistency with the groundwater data which actually uses all 15 digits.  Because of problem with the "relate" crashing ArcGIS, we need to create character string of length 16 in the point feature class and the relate table.



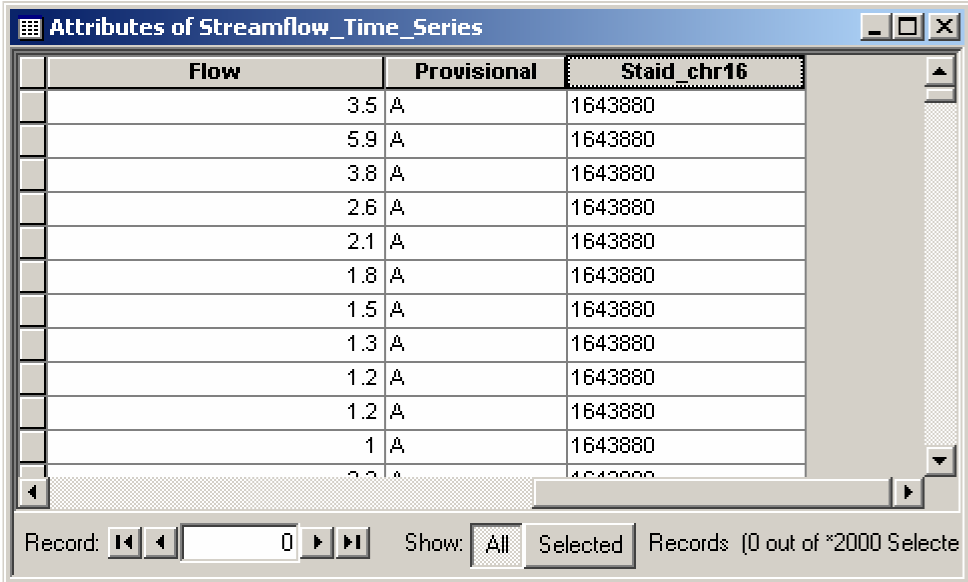

So now the stations have this additional field.




For the Time Series table, Add field
Use field calculator




to yield:




| Flow | Provisional | Staid_chr16 |
|---|---|---|
| 3.5 | A | 1643880 |
| 5.9 | A | 1643880 |
| 3.8 | A | 1643880 |
| 2.6 | A | 1643880 |
| 2.1 | A | 1643880 |
| 1.8 | A | 1643880 |
| 1.5 | A | 1643880 |
| 1.3 | A | 1643880 |
| 1.2 | A | 1643880 |
| 1.2 | A | 1643880 |
| 1 | A | 1643880 |

Presently the conversion from excel to Access is performed manually. There are ten named ranges in the Excel file and each is separately imported using “Get External Data”. The separate tables are then copy and paste appended into one table which exceeds 75,000 records (more than one Excel worksheet can handle.

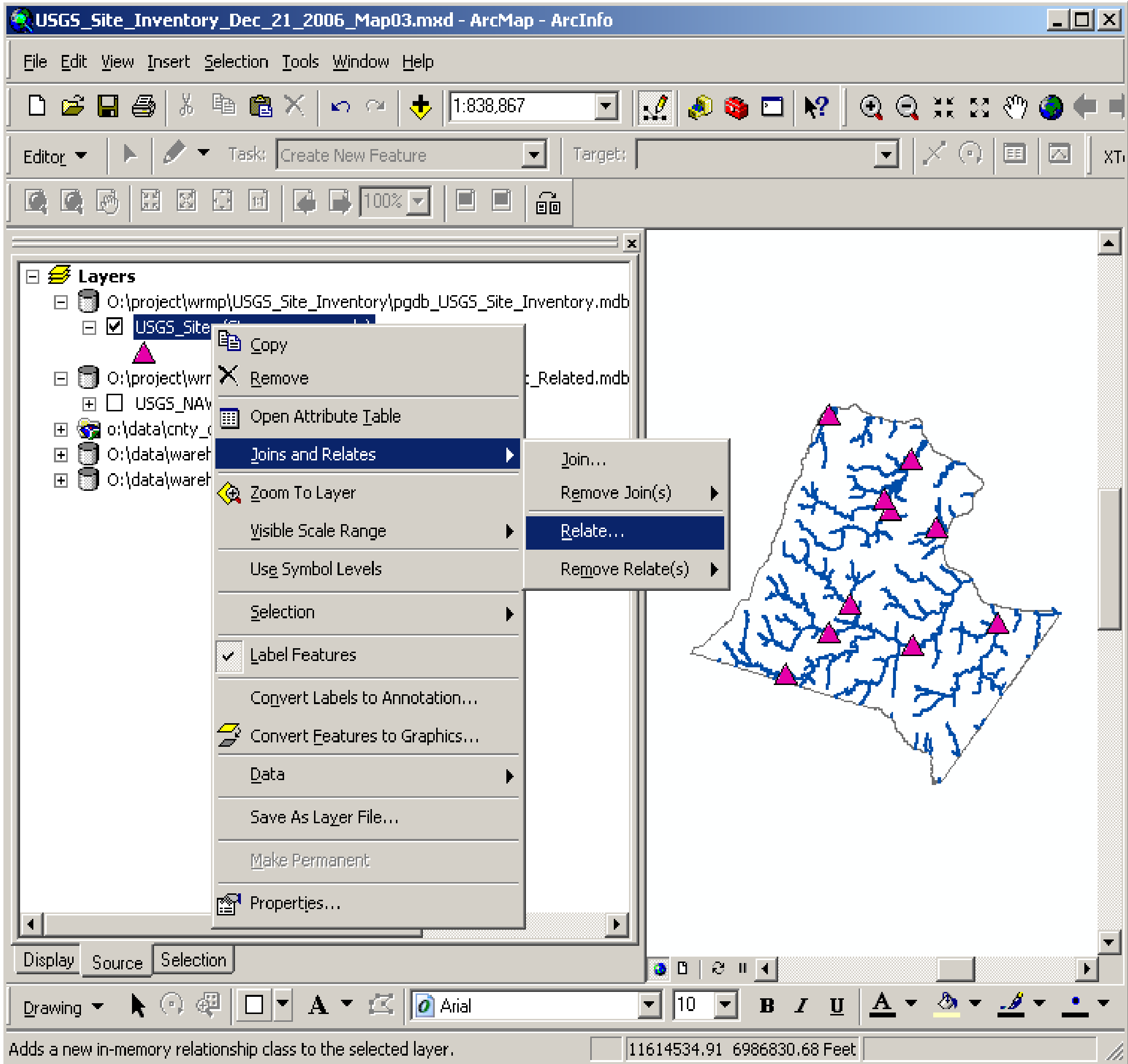
These Access tables are then copied to O:\project\wrmp\USGS_Streamflow and related to the site points in O:\project\wrmp\USGS_Site_Inventory.

Now these can be related in a one-to-many relationship. For each station there are numerous streamflow measurements.

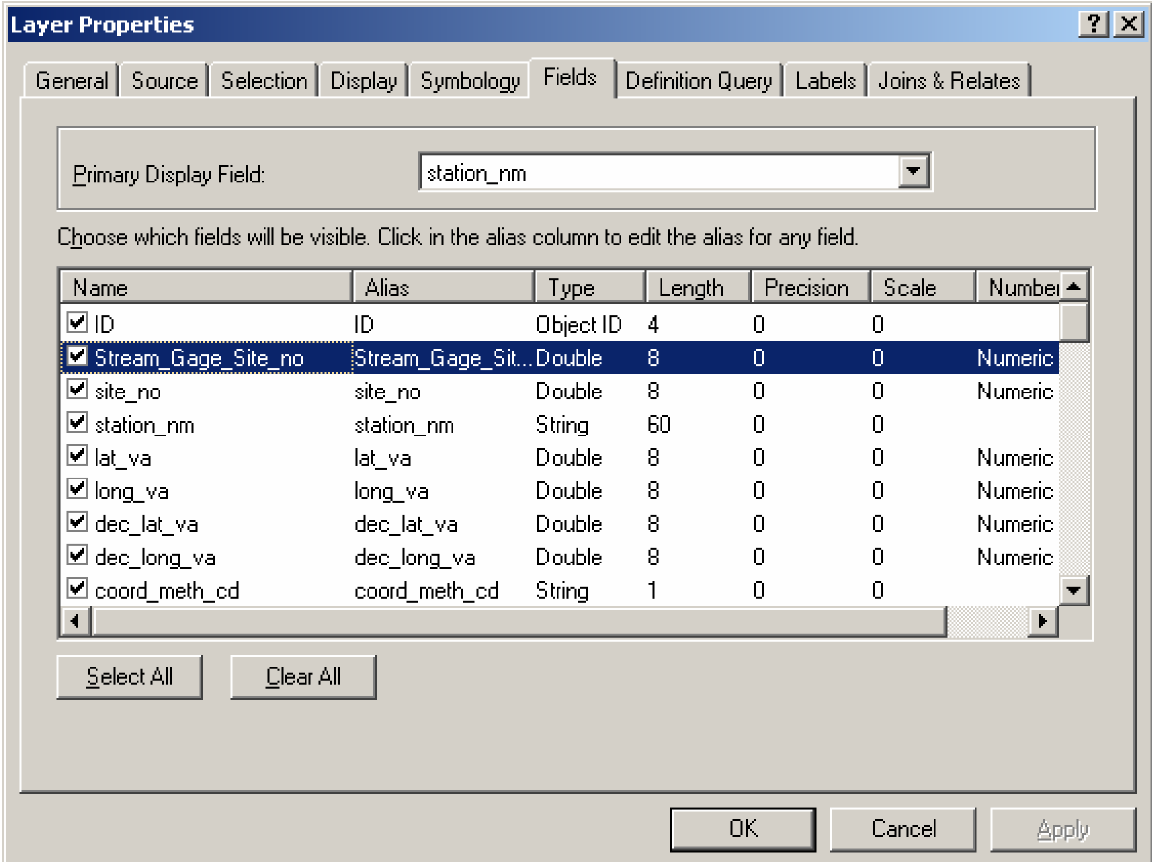
One can manually create the relate and store in the .mxd file, or one can use ArcToolBox to create a relationship class. If you create the relate in the .mxd, one needs to save as layer file such that others may use the data in the same way. Preferably the relate is stored as a relationship class in pgdb. Thus far experience in working with NAWQA data is that pgdb relationship classes crash ArcMap. Therefore, with streamfloe, we will only create the relate manually and store this in the .mxd and .lyr file.

**Step 1: Relate directly within ArcMap.**

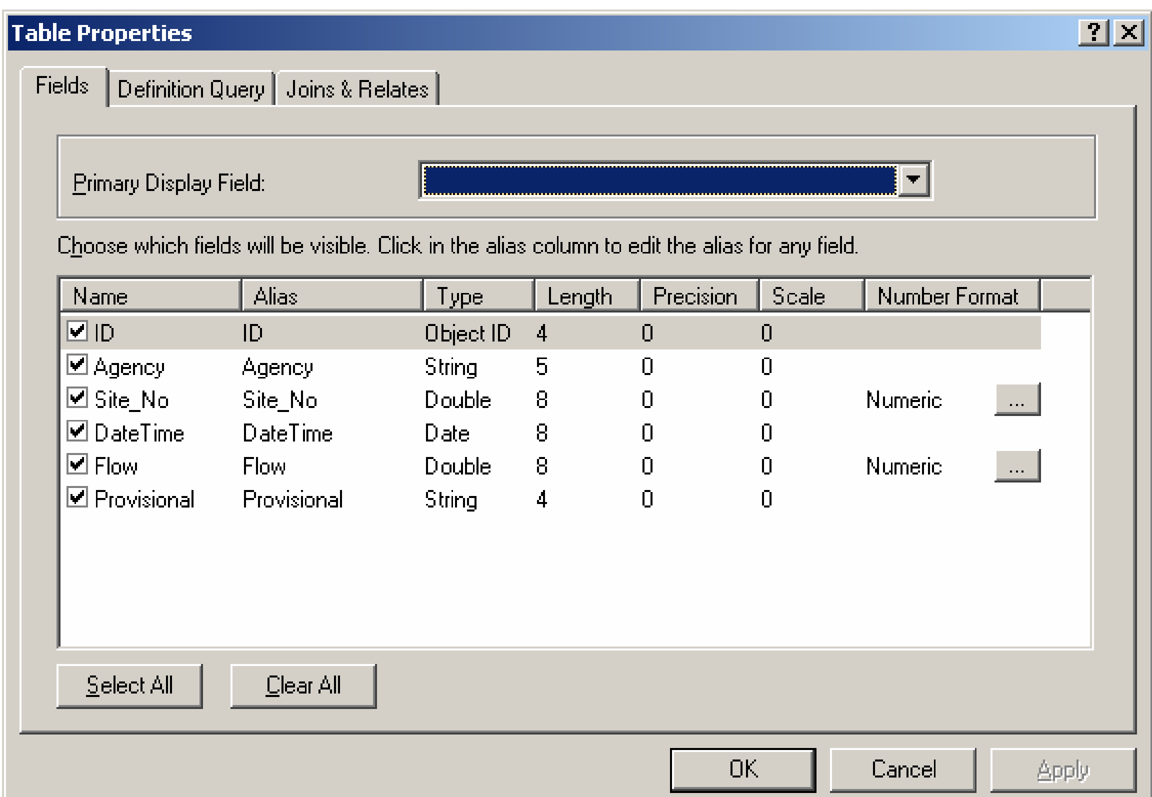
Select the “Site” layer and create the Relate.



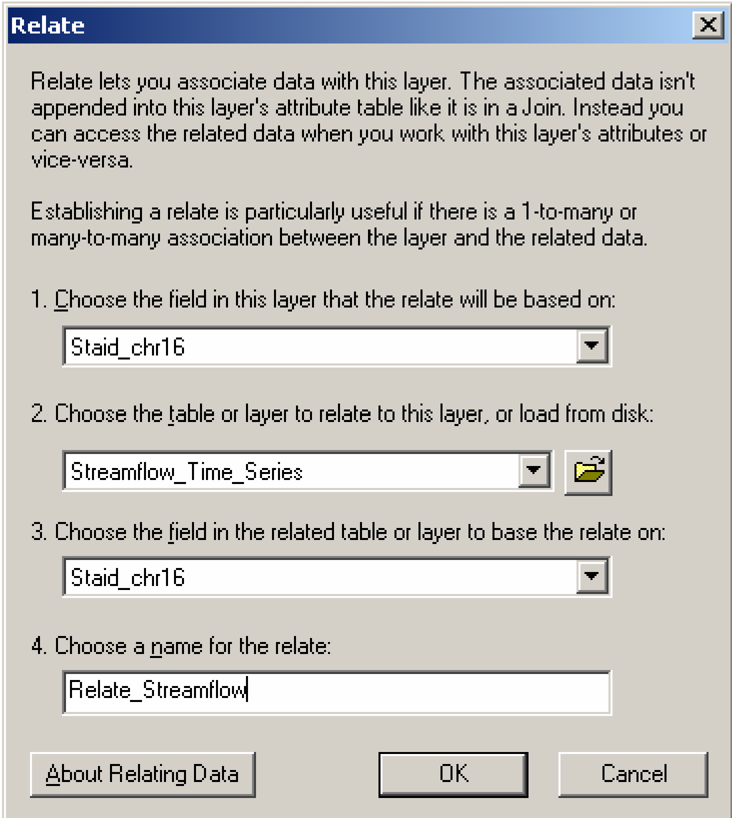

The station point GIS layer includes:

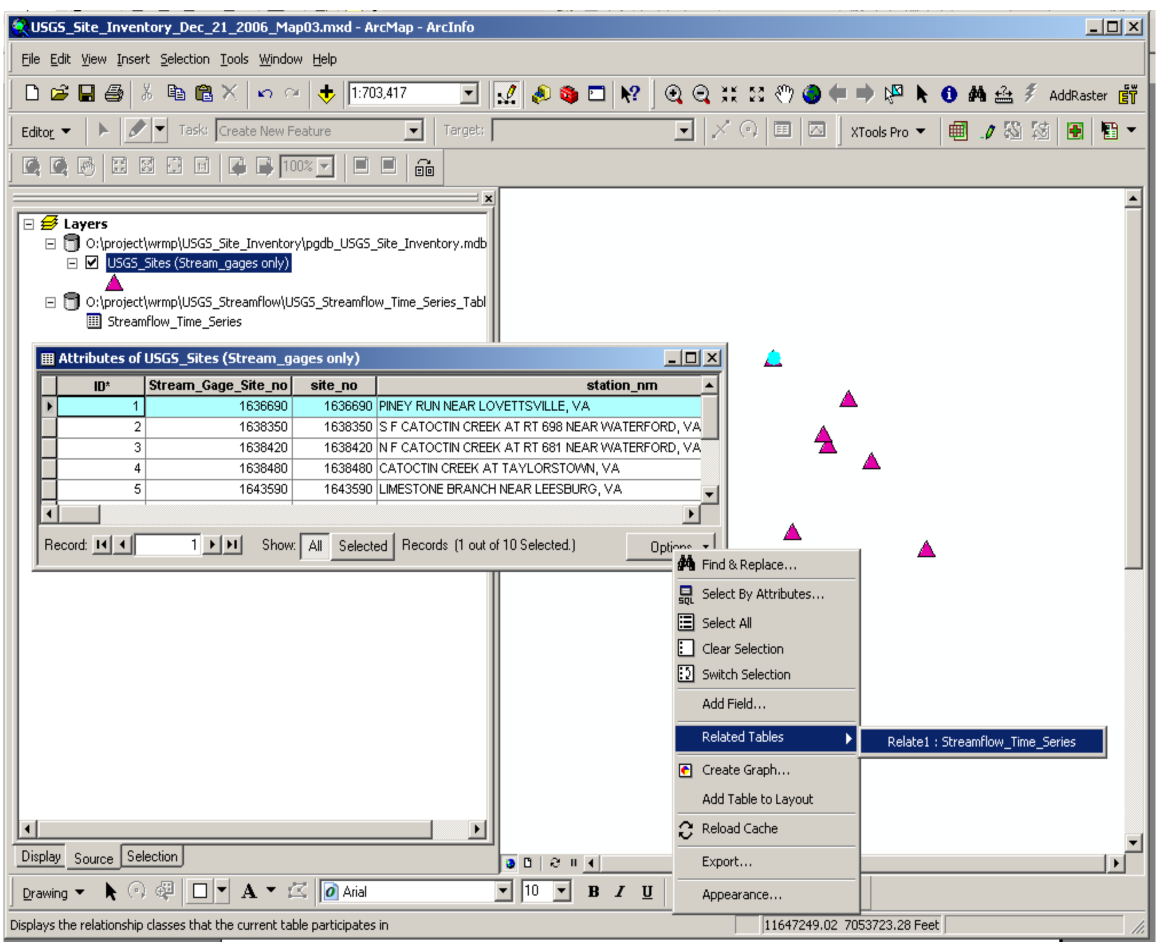



The streamflow time series tables contains:



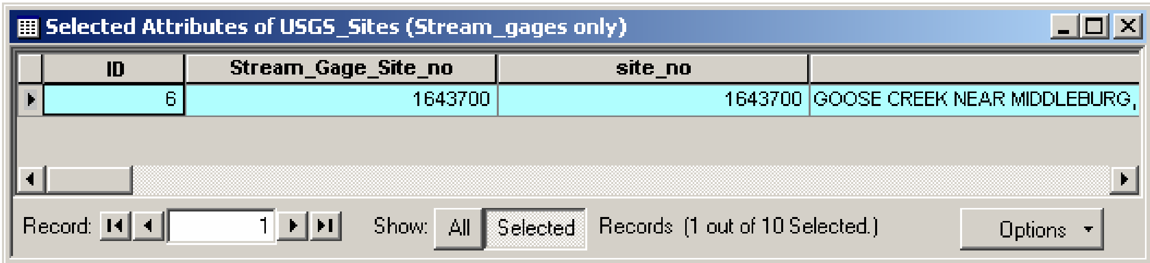

So we want to construct the relate as:


Relate
Relate lets you associate data with this layer. The associated data isn't appended into this layer's attribute table like it is in a Join. Instead you can access the related data when you work with this layer's attributes or vice-versa.
Establishing a relate is particularly useful if there is a 1-to-many or many-to-many association between the layer and the related data.
1. Choose the field in this layer that the relate will be based on:
Staid_chr16
2. Choose the table or layer to relate to this layer, or load from disk:
Streamflow_Time_Series
3. Choose the field in the related table or layer to base the relate on:
Staid_chr16
4. Choose a name for the relate:
Relate_Streamflow
About Relating Data
OK
Cancel


USGS_Site_Inventory_Dec_21_2006_Map03.mxd - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
1:703,417
AddRaster
Editor
Task: Create New Feature
Target:
XTools Pro
Layers
O:\project\wrmp\USGS_Site_Inventory\pgdb_USGS_Site_Inventory.mdb
USGS_Sites (Stream_gages only)
O:\project\wrmp\USGS_Streamflow\USGS_Streamflow_Time_Series_Tabl
Streamflow_Time_Series
Attributes of USGS_Sites (Stream_gages only)
ID* | Stream_Gage_Site_no | site_no | station_nm
1 | 1636690 | 1636690 | PINEY RUN NEAR LOVETTSVILLE, VA
2 | 1638350 | 1638350 | S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA
3 | 1638420 | 1638420 | N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA
4 | 1638480 | 1638480 | CATOCTIN CREEK AT TAYLORSTOWN, VA
5 | 1643590 | 1643590 | LIMESTONE BRANCH NEAR LEESBURG, VA
Record: 1 Show: All Selected Records (1 out of 10 Selected.)
Options
Find & Replace...
Select By Attributes...
Select All
Clear Selection
Switch Selection
Add Field...
Related Tables
Relate1 : Streamflow_Time_Series
Create Graph...
Add Table to Layout
Reload Cache
Export...
Appearance...
Display Source Selection
Drawing
Arial
10
Displays the relationship classes that the current table participates in
11647249.02 7053723.28 Feet

One can select one of the 10 stations and view the related records with that one station, as shown below.

Select one station:

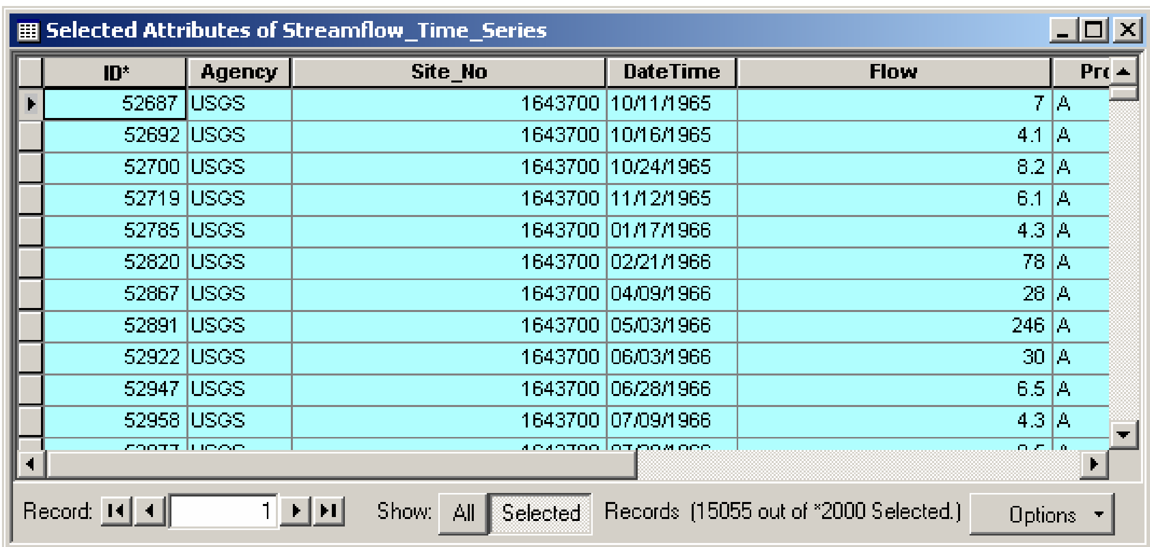


Selected Attributes of USGS_Sites (Stream_gages only)

| ID | Stream_Gage_Site_no | site_no | |
|---|---|---|---|
| 6 | 1643700 | 1643700 | GOOSE CREEK NEAR MIDDLEBURG, |

Record: 1 Show: All Selected Records (1 out of 10 Selected.) Options

View related time series:



Selected Attributes of Streamflow_Time_Series

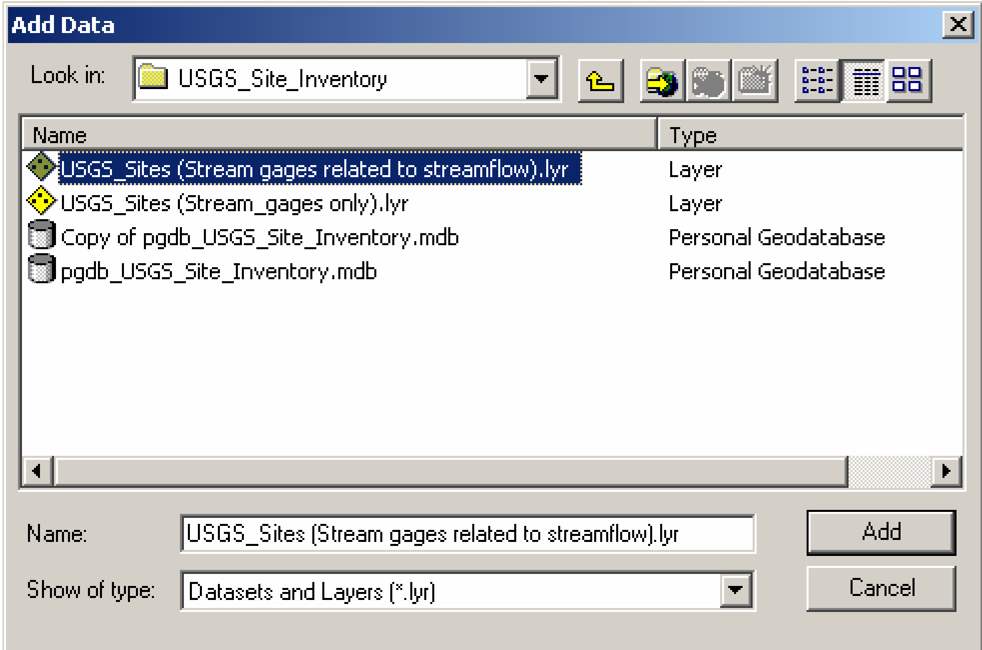
| ID* | Agency | Site_No | DateTime | Flow | Pro |
|---|---|---|---|---|---|
| 52687 | USGS | 1643700 | 10/11/1965 | 7 | A |
| 52692 | USGS | 1643700 | 10/16/1965 | 4.1 | A |
| 52700 | USGS | 1643700 | 10/24/1965 | 8.2 | A |
| 52719 | USGS | 1643700 | 11/12/1965 | 6.1 | A |
| 52785 | USGS | 1643700 | 01/17/1966 | 4.3 | A |
| 52820 | USGS | 1643700 | 02/21/1966 | 78 | A |
| 52867 | USGS | 1643700 | 04/09/1966 | 28 | A |
| 52891 | USGS | 1643700 | 05/03/1966 | 246 | A |
| 52922 | USGS | 1643700 | 06/03/1966 | 30 | A |
| 52947 | USGS | 1643700 | 06/28/1966 | 6.5 | A |
| 52958 | USGS | 1643700 | 07/09/1966 | 4.3 | A |

Record: 1 Show: All Selected Records (15055 out of *2000 Selected.) Options

This is done by right clicking on Options on bottom right section of the table window.

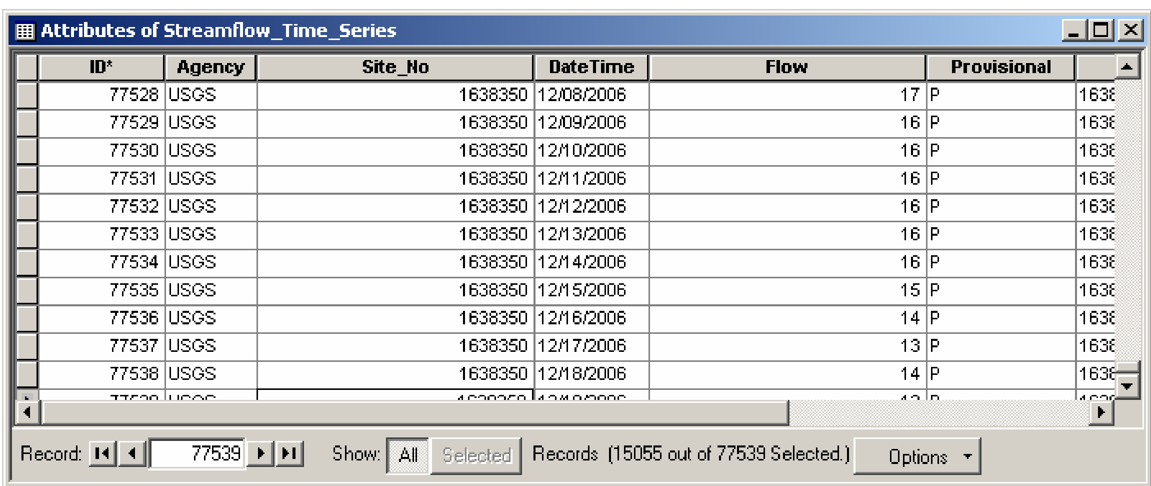
The relationship is saved with the .lyr file.

Now in future maps, just add the layer files as:




When you first add this, just the point data displays in Table of Contents, but once you open the table and "View Related Table", the related table is added to Table of Contents.

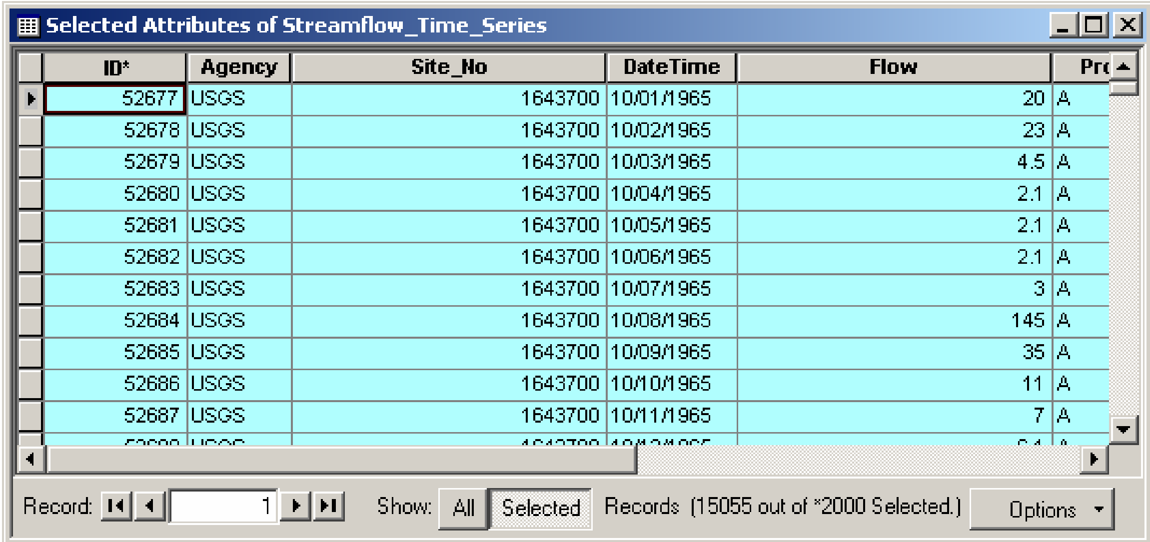
Oddly the related table does not allow one to view just those records that constitute the "relate"




| ID* | Agency | Site_No | DateTime | Flow | Provisional | |
|---|---|---|---|---|---|---|
| 77528 | USGS | 1638350 | 12/08/2006 | 17 | P | 1638 |
| 77529 | USGS | 1638350 | 12/09/2006 | 16 | P | 1638 |
| 77530 | USGS | 1638350 | 12/10/2006 | 16 | P | 1638 |
| 77531 | USGS | 1638350 | 12/11/2006 | 16 | P | 1638 |
| 77532 | USGS | 1638350 | 12/12/2006 | 16 | P | 1638 |
| 77533 | USGS | 1638350 | 12/13/2006 | 16 | P | 1638 |
| 77534 | USGS | 1638350 | 12/14/2006 | 16 | P | 1638 |
| 77535 | USGS | 1638350 | 12/15/2006 | 15 | P | 1638 |
| 77536 | USGS | 1638350 | 12/16/2006 | 14 | P | 1638 |
| 77537 | USGS | 1638350 | 12/17/2006 | 13 | P | 1638 |
| 77538 | USGS | 1638350 | 12/18/2006 | 14 | P | 1638 |

The "Selected" button is dimmed out – Why????????????????

This does not happen in the source .mxd where the "relate" was first created:



Selected Attributes of Streamflow_Time_Series

| ID* | Agency | Site_No | DateTime | Flow | Pro |
|---|---|---|---|---|---|
| 52677 | USGS | 1643700 | 10/01/1965 | 20 | A |
| 52678 | USGS | 1643700 | 10/02/1965 | 23 | A |
| 52679 | USGS | 1643700 | 10/03/1965 | 4.5 | A |
| 52680 | USGS | 1643700 | 10/04/1965 | 2.1 | A |
| 52681 | USGS | 1643700 | 10/05/1965 | 2.1 | A |
| 52682 | USGS | 1643700 | 10/06/1965 | 2.1 | A |
| 52683 | USGS | 1643700 | 10/07/1965 | 3 | A |
| 52684 | USGS | 1643700 | 10/08/1965 | 145 | A |
| 52685 | USGS | 1643700 | 10/09/1965 | 35 | A |
| 52686 | USGS | 1643700 | 10/10/1965 | 11 | A |
| 52687 | USGS | 1643700 | 10/11/1965 | 7 | A |

Record: 1 Show: All Selected Records (15055 out of *2000 Selected.) Options

- Let’s see about merging this together intop one feature class and create a relationship class with the pgdb

Using MS Access, manally merge :

Sites

(1) O:\project\wrmp\USGS_Site_Inventory\ pgdb_USGS_Site_Inventory.mdb

and

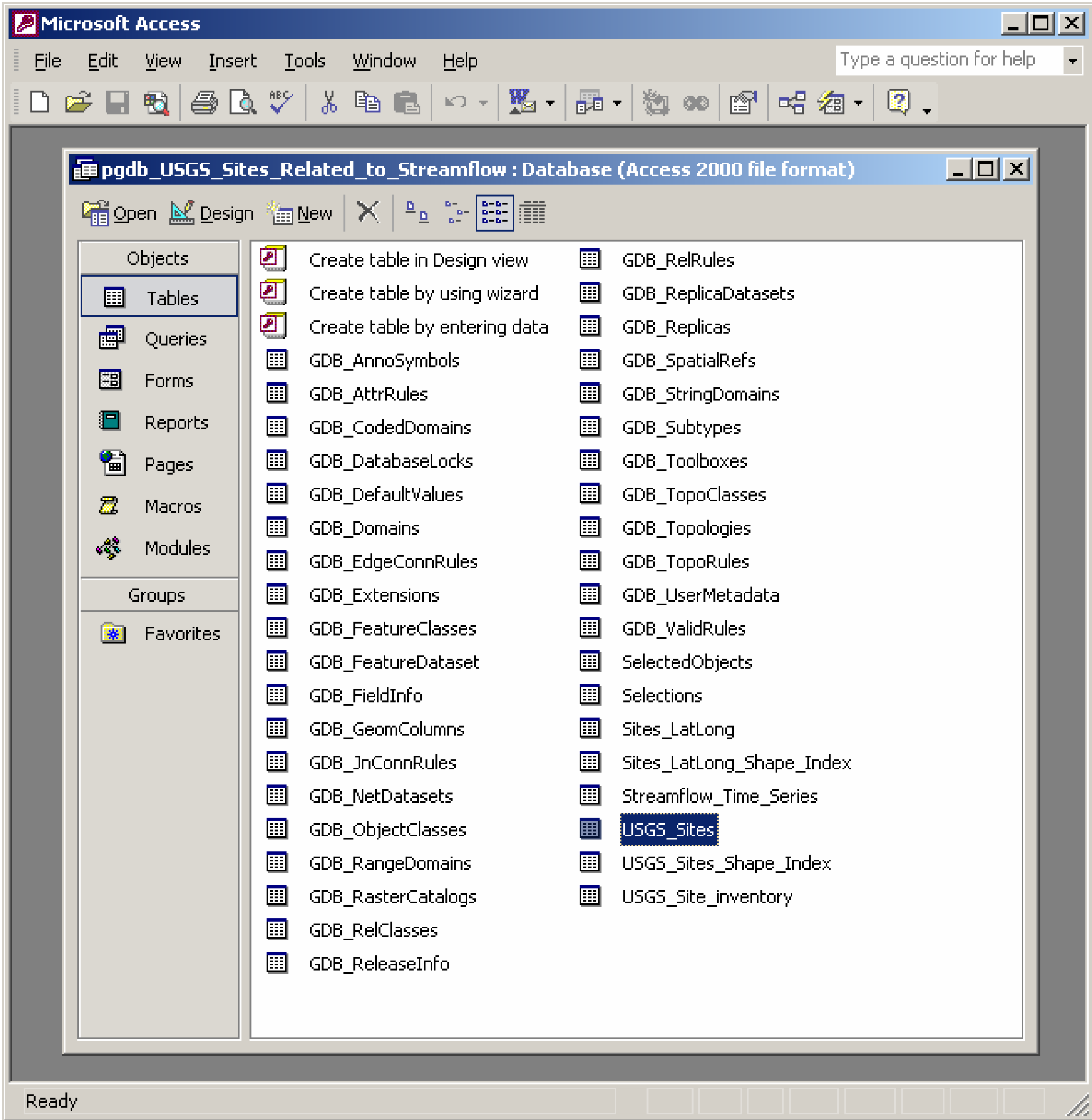
Time Series

(2) O:\project\wrmp\USGS_Streamflow\\USGS_Streamflow_Time_Series_Tables.mdb

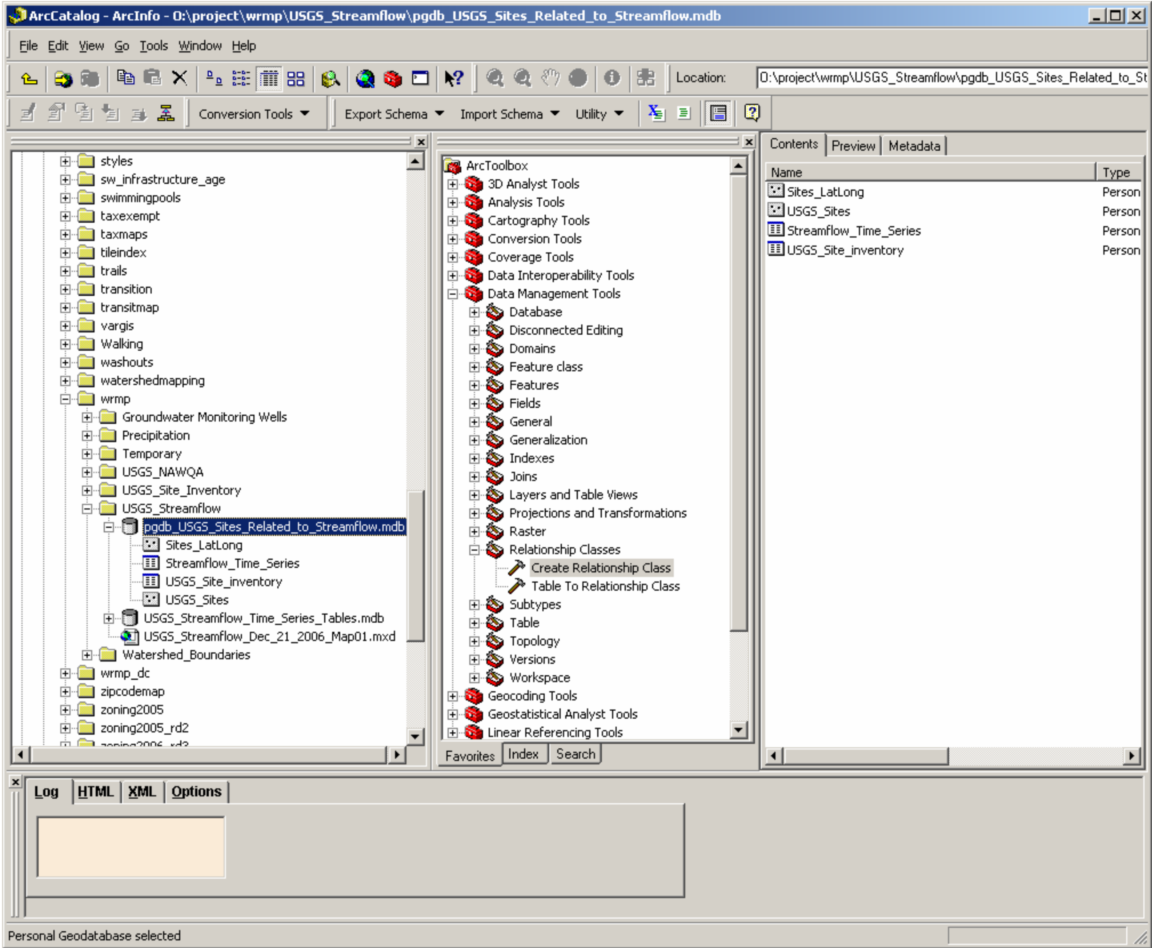
into

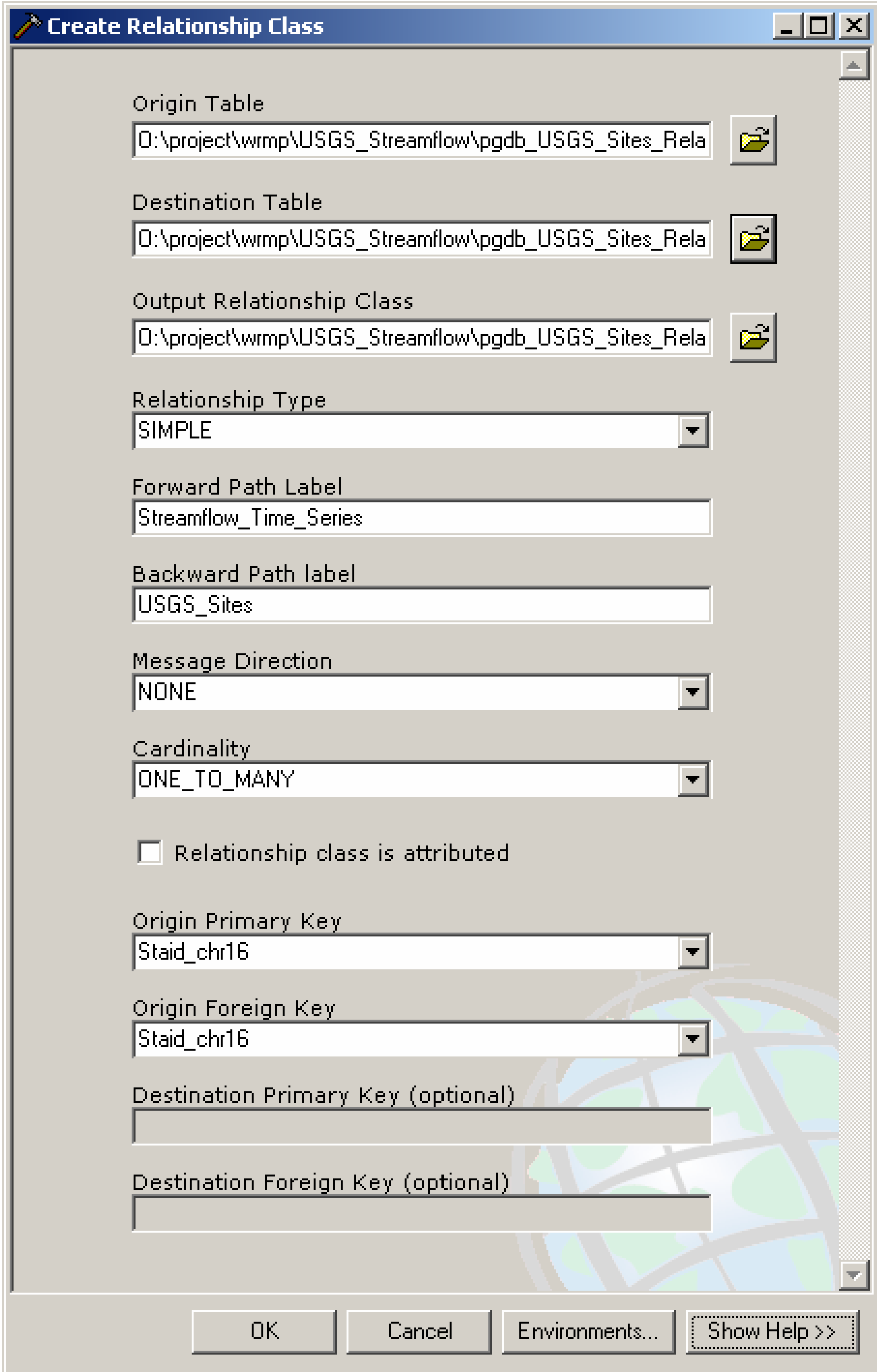
O:\project\wrmp\USGS_Streamflow\pgdb_USGS_Sites_Related_to_Streamflow.mdb

This contains:



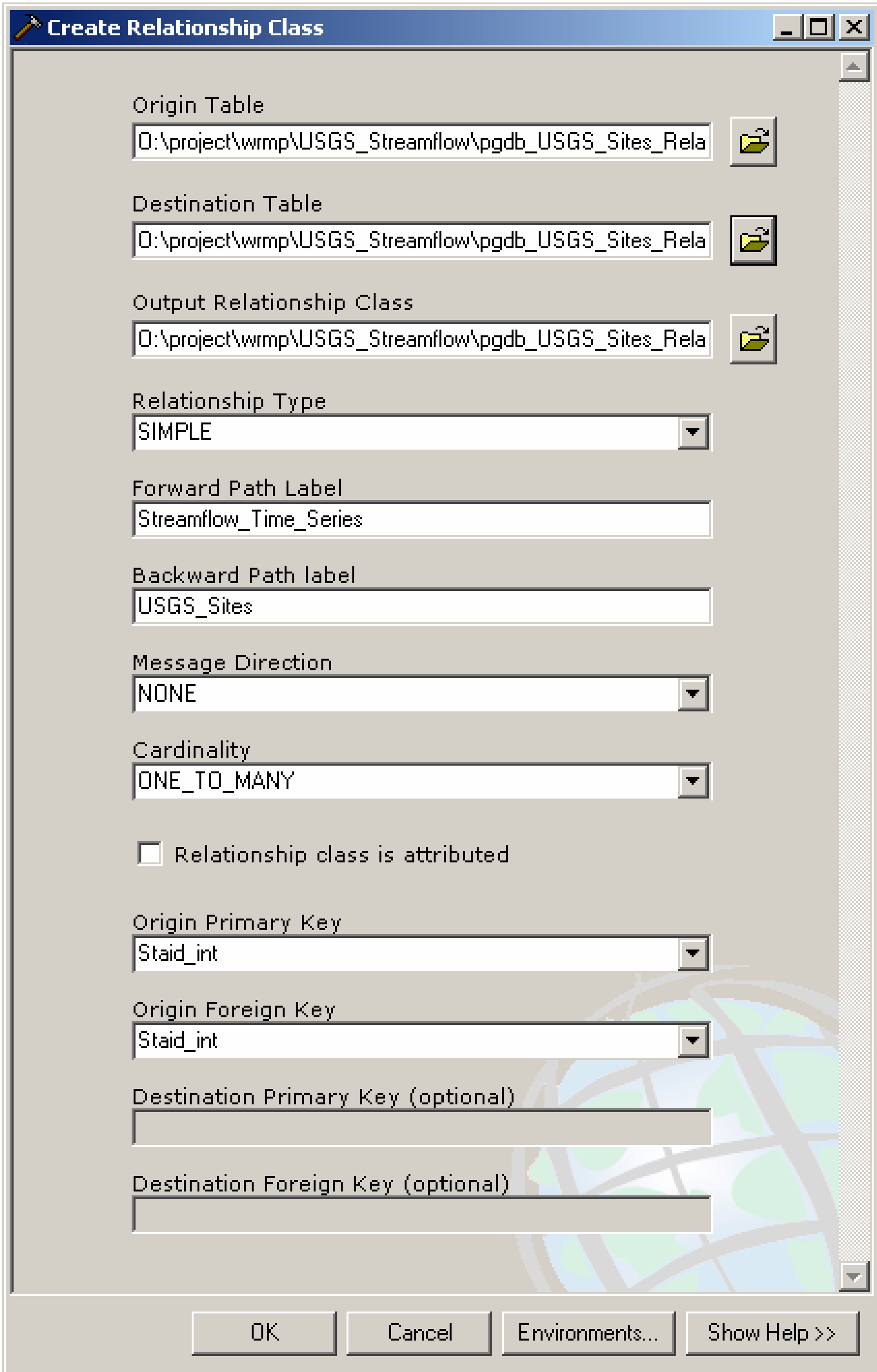

Go to ArcCatalog for ArcToolBox


ArcCatalog - ArcInfo - O:\project\wrmp\USGS_Streamflow\pgdb_USGS_Sites_Related_to_Streamflow.mdb
File Edit View Go Tools Window Help
Location: O:\project\wrmp\USGS_Streamflow\pgdb_USGS_Sites_Related_to_St
Conversion Tools
Export Schema
Import Schema
Utility
styles
sw_infrastructure_age
swimmingpools
taxexempt
taxmaps
tileindex
trails
transition
transitmap
vargis
Walking
washouts
watershedmapping
wrmp
Groundwater Monitoring Wells
Precipitation
Temporary
USGS_NAWQA
USGS_Site_Inventory
USGS_Streamflow
pgdb_USGS_Sites_Related_to_Streamflow.mdb
Sites_LatLong
Streamflow_Time_Series
USGS_Site_inventory
USGS_Sites
USGS_Streamflow_Time_Series_Tables.mdb
USGS_Streamflow_Dec_21_2006_Map01.mxd
Watershed_Boundaries
wrmp_dc
zipcodemap
zoning2005
zoning2005_rd2
ArcToolbox
3D Analyst Tools
Analysis Tools
Cartography Tools
Conversion Tools
Coverage Tools
Data Interoperability Tools
Data Management Tools
Database
Disconnected Editing
Domains
Feature class
Features
Fields
General
Generalization
Indexes
Joins
Layers and Table Views
Projections and Transformations
Raster
Relationship Classes
Create Relationship Class
Table To Relationship Class
Subtypes
Table
Topology
Versions
Workspace
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Favorites
Index
Search
Contents
Preview
Metadata
Name
Type
Sites_LatLong
Person
USGS_Sites
Person
Streamflow_Time_Series
Person
USGS_Site_inventory
Person
Log
HTML
XML
Options
Personal Geodatabase selected




This crashes!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

To rectify the situation, relating using a long integer is used. A field (long integer) named "Staid_int" is added to both the Site feature class and the time series table. These art related using



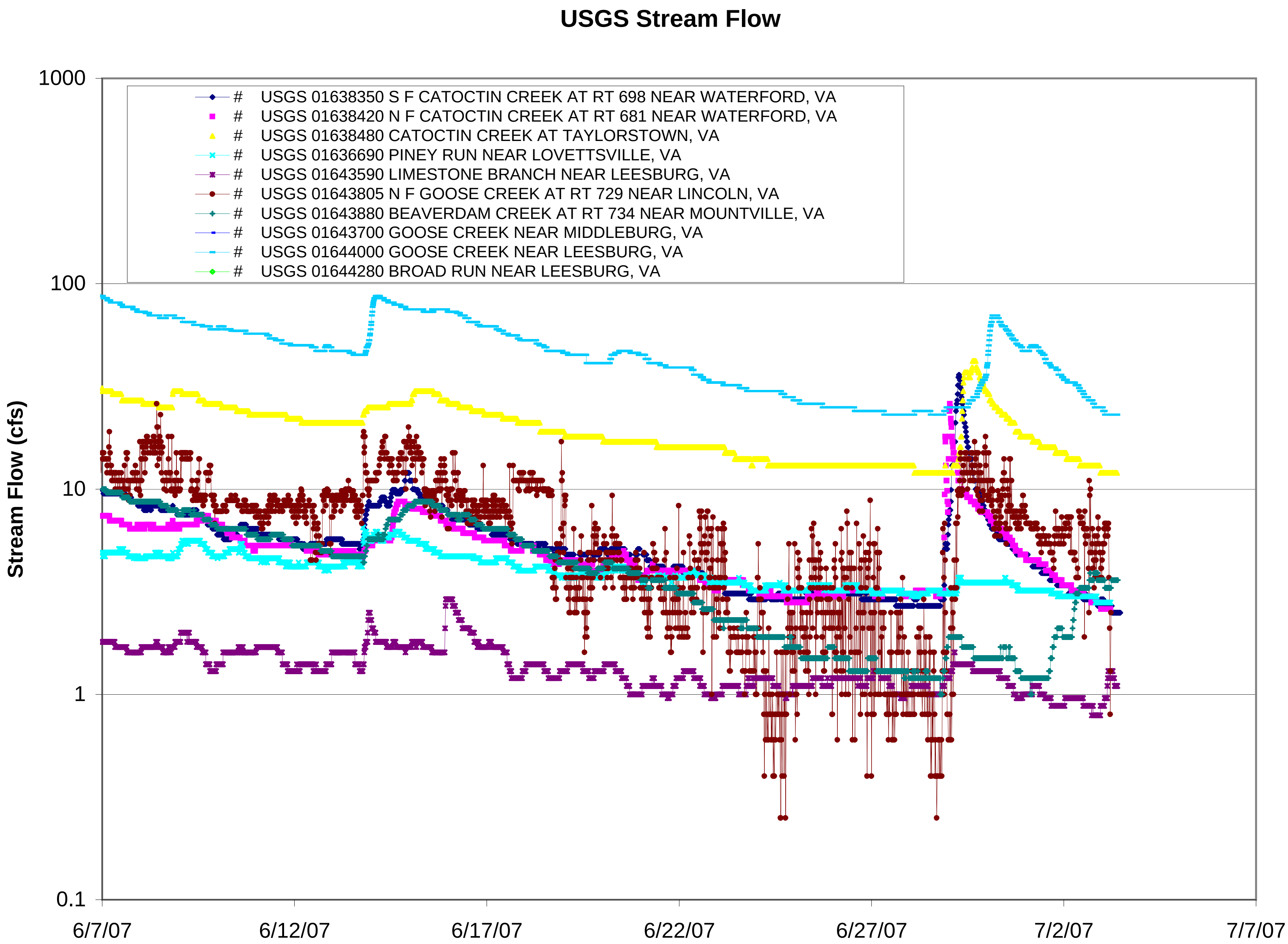

This also crashes?????????????????

**Summary and Conclusion:**

Manually create the relations in ArcMap and save the feature class as .lyr file.  When going to use the data, just add the station point file.  To view the related data, do not add to TOC, rather, open the stations table and in lower right under options, select related tables.  Now when you select a record, in stations, just the related table records are selected also.

| | |
|---|---|
| **USGS Real-time Streamflow** | |
| 15-minute readings | |
| Start Date | 11/19/06 |
| End Date | 08/16/07 |
| Number of Days | 270 |
| Readings per Day | 120 |
| Number of Stations | 10 |
| Number of Readings | 324,000 |

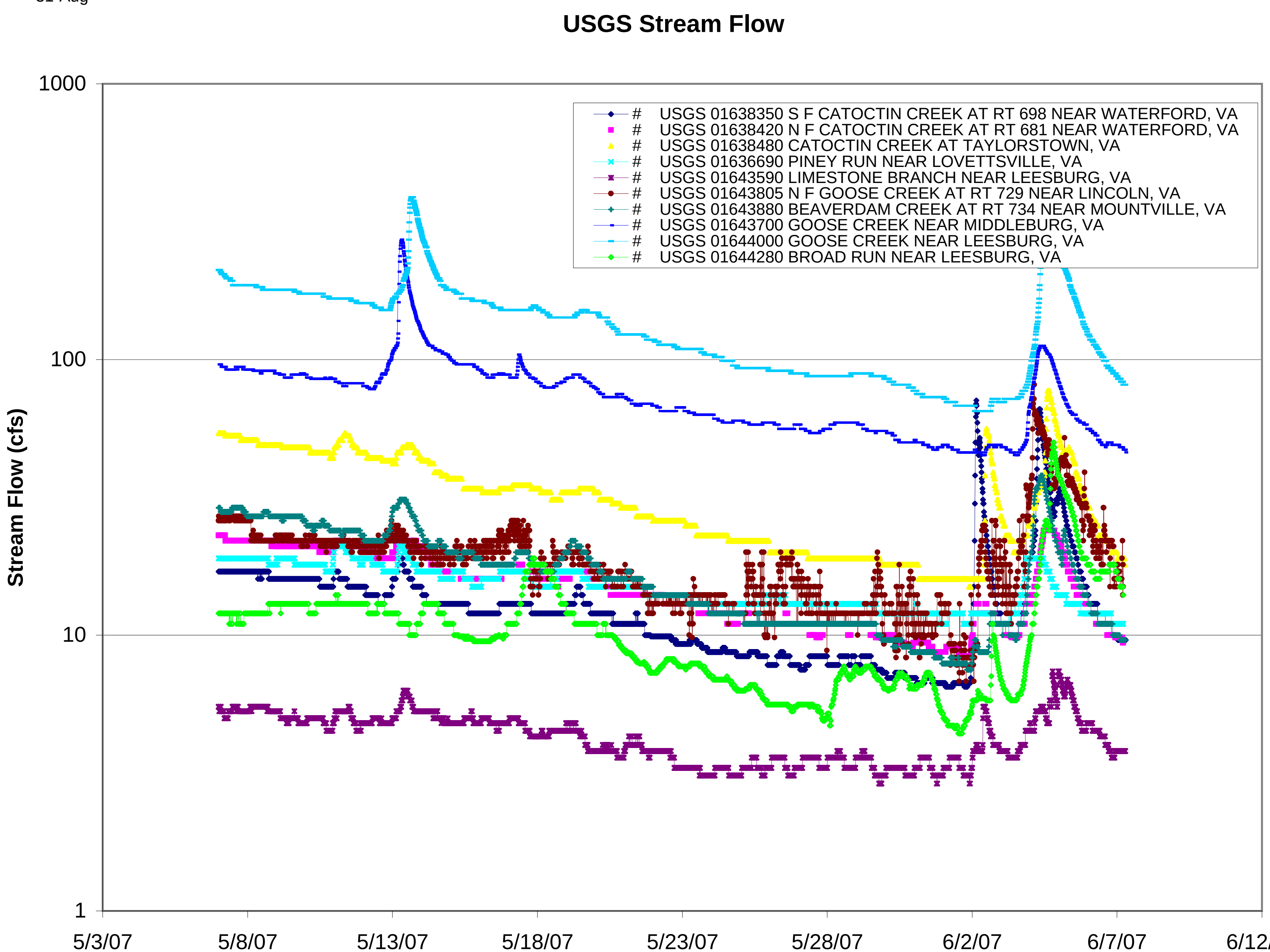
31-Aug-




G:\BLDG_DEV\Engineering\H2O Team\WRMP\USGSFlowData\web_query_all_dates_flow_only\RealTime_Archive\USGS_Streamflow_Web_Query_just_30_day_15_minute_June_July_2007_snapshot.xls

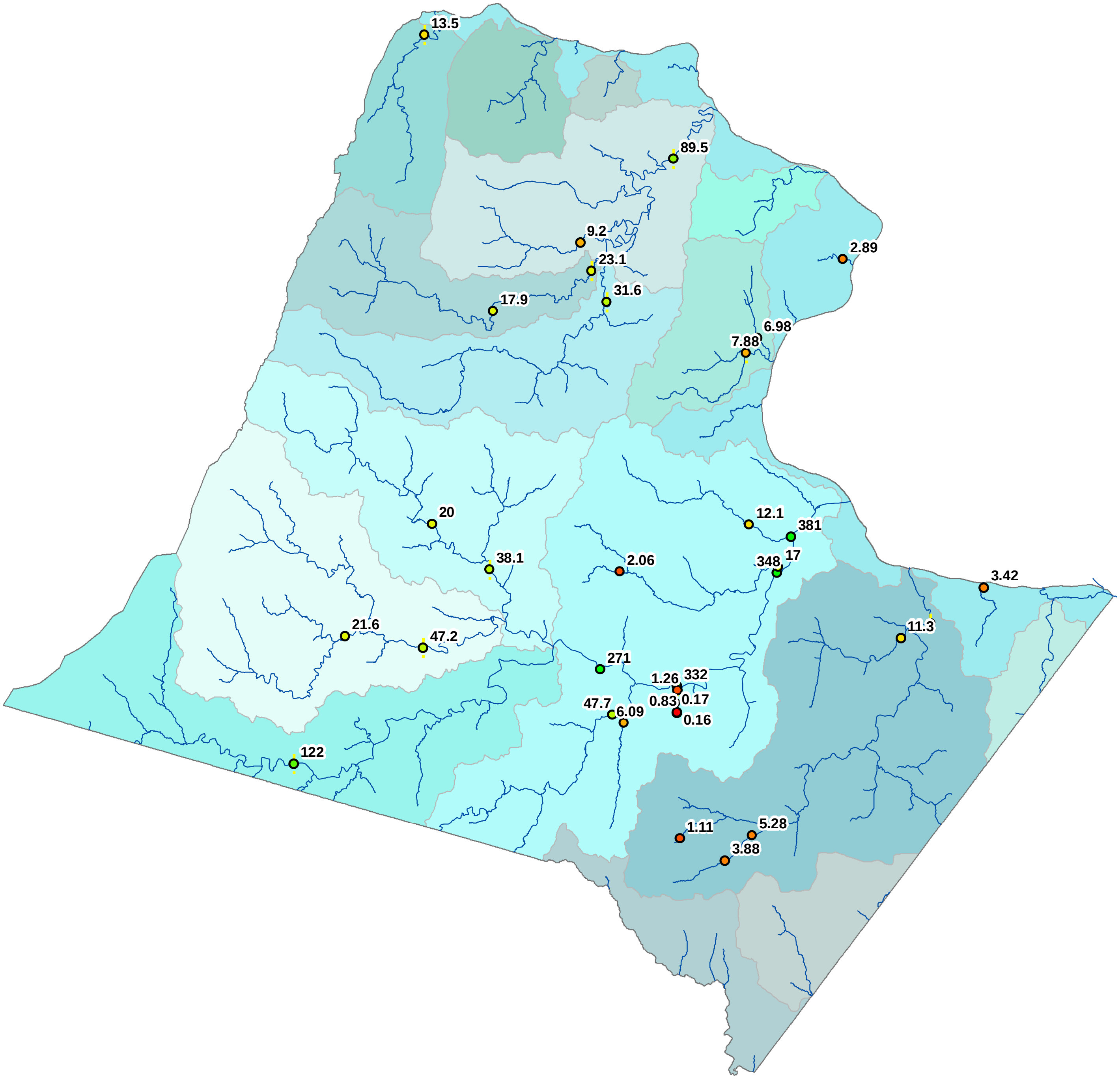
Cht_All_Sites

31-Aug-




G:\BLDG_DEV\Engineering\H2O Team\WRMP\USGSFlowData\web_query_all_dates_flow_only\RealTime_Archive\USGS_Streamflow_Web_Query_just_30_day_15_minute_May_June_2007_snapshot.xls

Cht_All_Sites




Drainage Area

USGS Stream Gages

Area in  sq miles

# Groundwater Recharge from Streamflow Records

## Background

Groundwater recharge can be calculated based on daily streamflow measurements. The USGS offers a computer program, RORA using the recession-curve displacement method. Also known as the Rorabaugh Method (Rorabaugh, 1964; Daniel, 1976), the method is based on the change in total potential ground-water discharge that is caused by each recharge event. The RORA program is intended for analyzing a ground-water-flow system that is characterized by diffuse areal recharge to the water table and ground-water discharge to a stream. The method is appropriate if all or most ground water in the basin discharges to the stream and if a streamflow-gaging station at the downstream end of the basin measures all or most outflow. The software program and documents are available from http://water.usgs.gov/ogw/rora/

"The computer program RORA (Rutledge, 1998, p. 5, 17–26) was used with the recession-curvedisplacement method to estimate ground-water recharge for each peak in streamflow during the period of record. The recession-curve-displacement method uses the pre-peak and post-peak recession periods to extrapolate the change in the total potential groundwater discharge as estimated at a critical time after the peak. Total potential base flow to the stream at the critical time when the streamflow hydrograph becomes log-linear again is about one-half of the total volume of water that recharged the ground-water system during the peak (Rutledge, 1998, p. 19). The method applies to flow systems driven by areally diffuse recharge that is roughly concurrent with peaks in streamflow (Rutledge, 1998, p. 3).

## Recharge Calculation

Data from ten stream gages in Loudoun County were downloaded from USGS NWIS web site and modified for input into the RORA program. To facilitate download, an Excel file, using an automated web query was used. Text files are created for input to RORA as a batch process. The RORA program provides monthly, seasons and yearly recharge estimates provided that complete records are available for the calendar year.

## Data Gaps

There was a problem with Catotin Creek at Taylorstown NWIS data in 1970 in which daily records needed to be manually deleted. Because Goose Creek Middleburg has a significant data gap 1977 to 2001, separate data sets were created.

## Evaluation of Recession Index

The RORA manual and recent article in Ground Water Journal, May/June 2007 by Rutledge suggest that RORA is generally insensitive to the recession index (RI) provided. The recession index is defined as the time required for the groundwater discharge to recede by one log-cycle when the recession becomes linear (or nearly linear) on a semilog hydrograph.

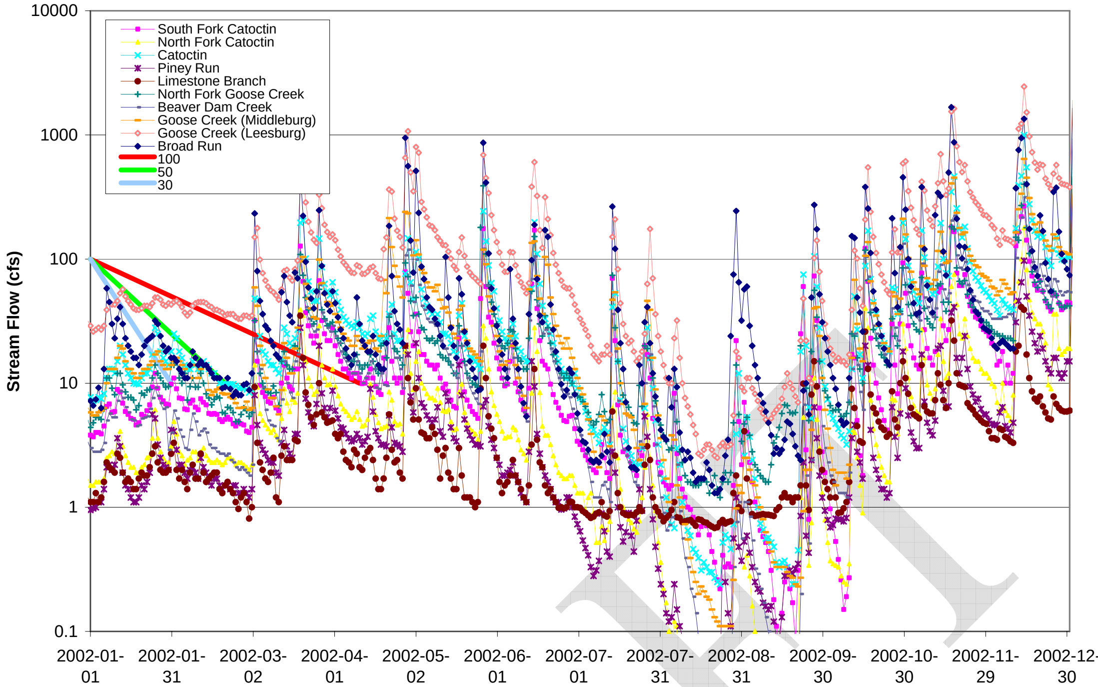
Daily streamflow data at the ten stationswere examined for the period 2002 to 2005. A graph of all ten stations included along with a one log-cycle drop for recession indexes with values of 100, 50 and 30 days. The closest fit for all streams appears to be between 30 and 60 days. The smallest RI appears to be Broad Run.

| Station | Estimated Recession Index |
|---|---|
| South Fork Catoctin | 50 |
| North Fork Catoctin | 50 |
| Catoctin | 60 |
| Piney Run | 60 |
| Limestone Branch | 40 |
| North Fork Goose Creek | 50 |
| Beaver Dam Creek | 50 |
| Goose Creek (Middleburg) | 50 |
| Goose Creek (Leesburg) | 50 |
| Broad Run | 30 |

The follow charts are the daily stream flow records for 2002, 2003, 2004 and 2005 used to interpret the baseflow index value above..

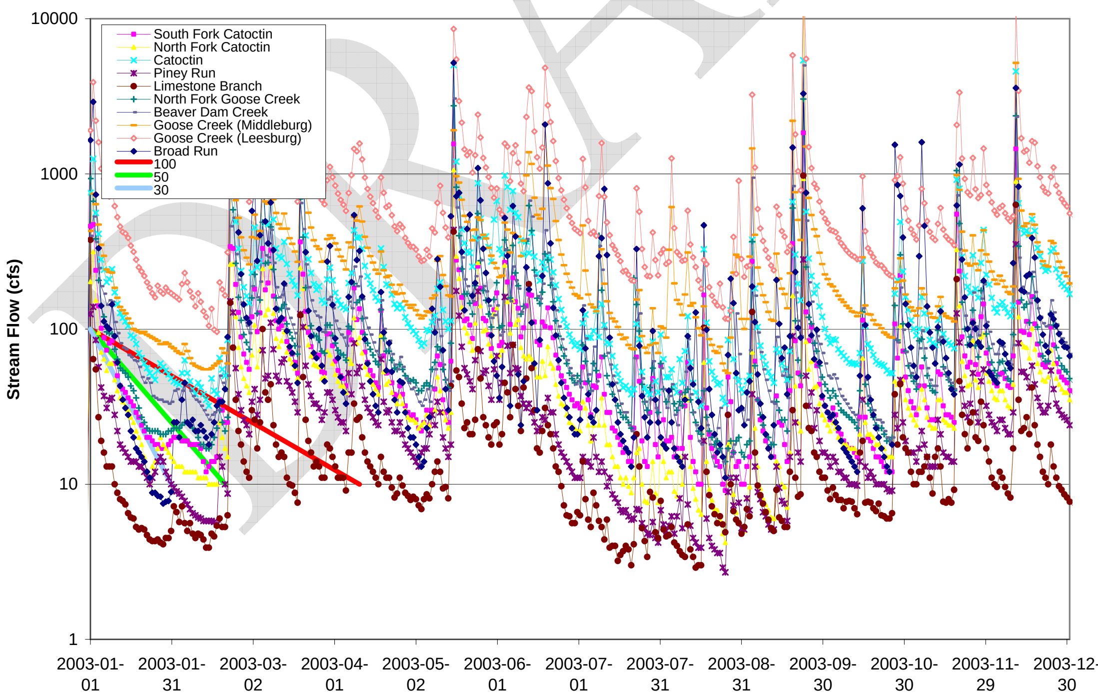
22-May-07

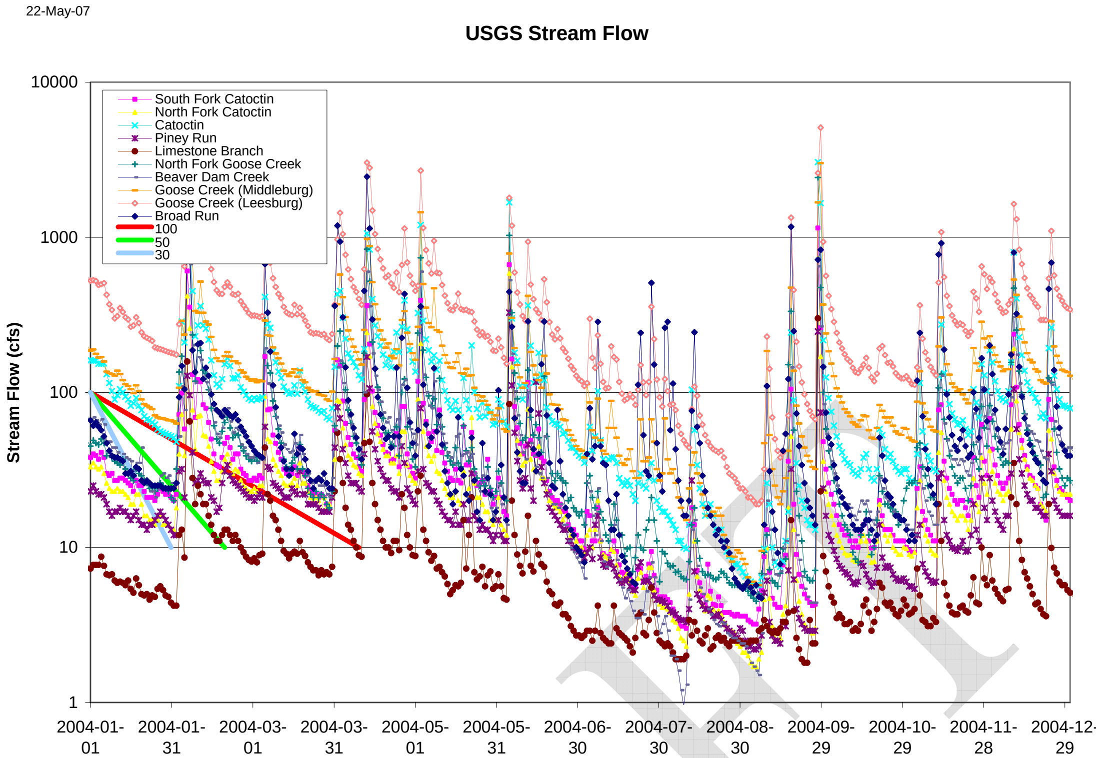
USGS Stream Flow

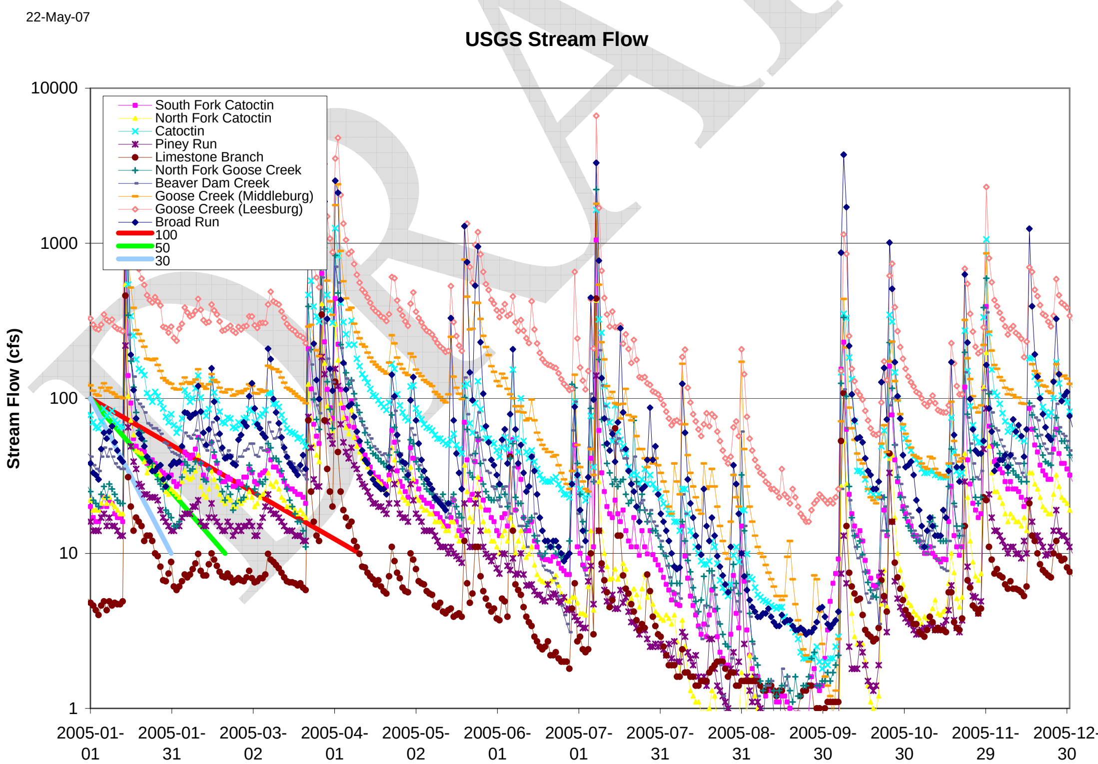



22-May-07

USGS Stream Flow








To check the sensitivity recharge due to RI RORA was used to evaluate Broad Run using RI of 30 and 50 days and Catoctin Creek at 60 and 100 days. The error introduced is 3 and 4.4%, respectively.

## Summary of Findings:

RORA offers annual, quarterly and monthly summary values of recharge.

### *Annual Recharge Summary:*

Because of missing data, the newer USGS stations do not offer sufficient data for reliable and representative annual averages. Therefore annual summaries are not presented. Data is generally limited to the period 2002 to 2005.

### *Quarterly Recharge Summary:*

The quarterly recharge estimates are listed below. The average recharge for all records averaged over all stations is approximately 12 inches per year.

Note that there is a break in the Goose Creek (Middleburg) calculations due to incomplete data for this station.

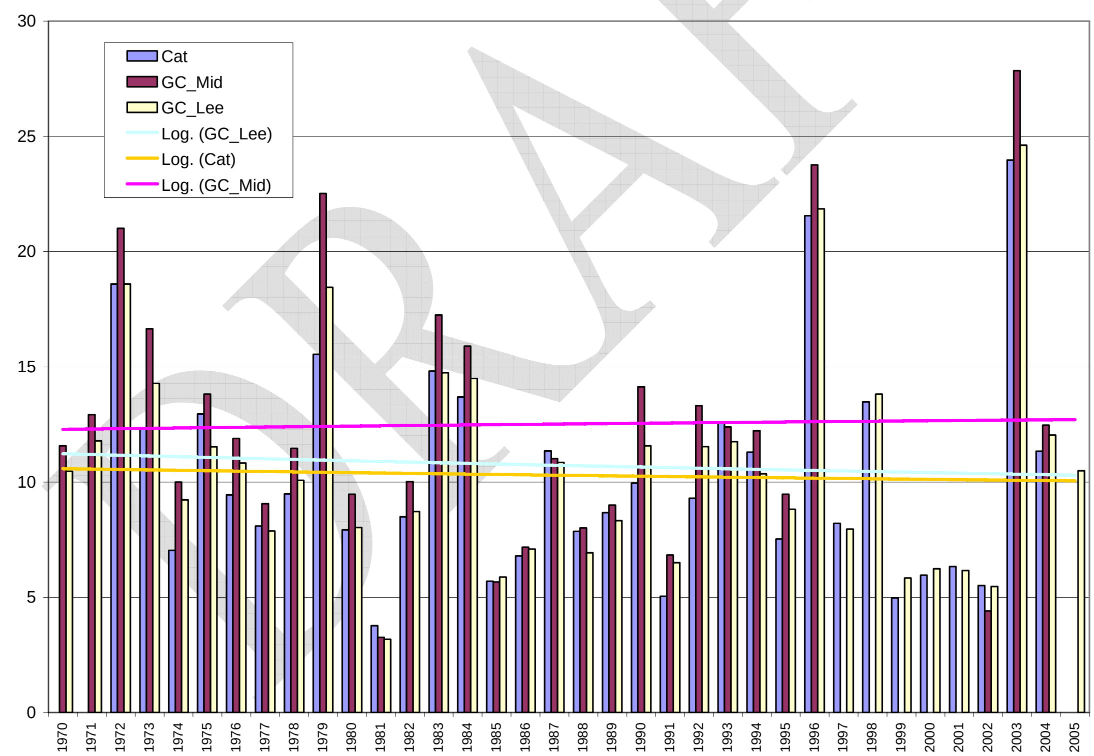
| Station | Station | Year | Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | Year Total |
|---|---|---|---|---|---|---|---|
| 1638350 South Fork Catoctin | SF_Cat | 2002 | 1.44 | 0.89 | 0.14 | 3.91 | 6.38 |
| 1638350 South Fork Catoctin | SF_Cat | 2003 | 7.52 | 7.47 | 2.72 | 5.06 | 22.77 |
| 1638350 South Fork Catoctin | SF_Cat | 2004 | 3.38 | 4.36 | 0.98 | 2.37 | 11.09 |
| 1638350 South Fork Catoctin | SF_Cat | 2005 | 5.8 | 1.21 | 0.52 | 2.91 | 10.44 |
| 1638420 North Fork Catoctin | NF_Cat | 2002 | 0.85 | 0.55 | 0.02 | 2.26 | 3.68 |
| 1638420 North Fork Catoctin | NF_Cat | 2003 | 7.71 | 7.77 | 2.2 | 6 | 23.68 |
| 1638420 North Fork Catoctin | NF_Cat | 2004 | 3.41 | 4.8 | 1.05 | 2.99 | 12.26 |
| 1638420 North Fork Catoctin | NF_Cat | 2005 | 6.29 | 1.33 | 0.25 | 1.96 | 9.83 |
| 1638480 Catoctin | Cat | 1972 | 5.96 | 8.04 | -1.21 | 5.82 | 18.6 |
| 1638480 Catoctin | Cat | 1973 | 4.13 | 5.14 | 0.67 | 2.42 | 12.36 |
| 1638480 Catoctin | Cat | 1974 | 3.1 | 1.7 | 0.43 | 1.81 | 7.04 |
| 1638480 Catoctin | Cat | 1975 | 5.15 | 2.13 | 3.31 | 2.36 | 12.95 |
| 1638480 Catoctin | Cat | 1976 | 3.61 | 1.9 | 0.48 | 3.46 | 9.45 |
| 1638480 Catoctin | Cat | 1977 | 2.5 | 1.52 | 0.18 | 3.89 | 8.09 |
| 1638480 Catoctin | Cat | 1978 | 5.83 | 2.25 | 0.47 | 0.94 | 9.48 |
| 1638480 Catoctin | Cat | 1979 | 5.65 | 1.95 | 3.18 | 4.76 | 15.54 |
| 1638480 Catoctin | Cat | 1980 | 5.04 | 2.2 | 0.33 | 0.35 | 7.92 |
| 1638480 Catoctin | Cat | 1981 | 1.44 | 1.65 | 0.21 | 0.48 | 3.77 |
| 1638480 Catoctin | Cat | 1982 | 3.8 | 3.57 | -0.25 | 1.37 | 8.49 |
| 1638480 Catoctin | Cat | 1983 | 5.52 | 5.41 | -0.11 | 4 | 14.81 |
| 1638480 Catoctin | Cat | 1984 | 9.03 | 1.89 | 0.94 | 1.83 | 13.69 |
| 1638480 Catoctin | Cat | 1985 | 2.33 | 0.77 | 0.2 | 2.41 | 5.7 |
| 1638480 Catoctin | Cat | 1986 | 4.14 | 0.75 | 0.04 | 1.86 | 6.79 |
| 1638480 Catoctin | Cat | 1987 | 3.61 | 3.68 | 1.54 | 2.52 | 11.35 |
| 1638480 Catoctin | Cat | 1988 | 3.28 | 3.65 | 0.3 | 0.63 | 7.86 |
| 1638480 Catoctin | Cat | 1989 | 4.1 | 3.59 | 0.33 | 0.67 | 8.68 |
| 1638480 Catoctin | Cat | 1990 | 3.13 | 2.46 | 0.58 | 3.79 | 9.96 |
| 1638480 Catoctin | Cat | 1991 | 4.36 | 0.22 | 0.04 | 0.43 | 5.05 |
| 1638480 Catoctin | Cat | 1992 | 2.76 | 2.28 | 0.46 | 3.8 | 9.3 |
| 1638480 Catoctin | Cat | 1993 | 9.34 | 0.58 | 0.05 | 2.61 | 12.58 |
| 1638480 Catoctin | Cat | 1994 | 9.35 | 0.13 | 0.42 | 1.39 | 11.3 |
| 1638480 Catoctin | Cat | 1995 | 3.5 | 1.02 | 0.36 | 2.65 | 7.53 |
| 1638480 Catoctin | Cat | 1996 | 6.36 | 4.44 | 4.32 | 6.44 | 21.56 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1638480 Catoctin | Cat | 1997 | 5.21 | 0.61 | 0.04 | 2.35 | 8.21 |
| 1638480 Catoctin | Cat | 1998 | 10.2 | 3.22 | -0.08 | 0.14 | 13.48 |
| 1638480 Catoctin | Cat | 1999 | 1.76 | 0.72 | 0.91 | 1.57 | 4.97 |
| 1638480 Catoctin | Cat | 2000 | 3.67 | 1.46 | 0.38 | 0.45 | 5.96 |
| 1638480 Catoctin | Cat | 2001 | 4.33 | 1.34 | 0.37 | 0.29 | 6.34 |
| 1638480 Catoctin | Cat | 2002 | 1.19 | 0.66 | 0.09 | 3.56 | 5.51 |
| 1638480 Catoctin | Cat | 2003 | 6.5 | 7.59 | 2.88 | 7 | 23.97 |
| 1638480 Catoctin | Cat | 2004 | 3.15 | 4.56 | 1.11 | 2.52 | 11.34 |
| 1636690 Piney Run | Piney | 2002 | 0.84 | 0.6 | 0.11 | 2.52 | 4.07 |
| 1636690 Piney Run | Piney | 2003 | 7.77 | 7.01 | 2.48 | 6.64 | 23.9 |
| 1636690 Piney Run | Piney | 2004 | 4.8 | 5.91 | 1.26 | 3.62 | 15.6 |
| 1636690 Piney Run | Piney | 2005 | 7.93 | 0.99 | 0.33 | 2.08 | 11.32 |
| 1643590 Limestone Branch | Lime | 2002 | 1.16 | 0.77 | 0.49 | 3.03 | 5.45 |
| 1643590 Limestone Branch | Lime | 2003 | 6.71 | 7.08 | 3.45 | 5.07 | 22.32 |
| 1643590 Limestone Branch | Lime | 2004 | 4.11 | 3.94 | 1.56 | 2.1 | 11.71 |
| 1643590 Limestone Branch | Lime | 2005 | 5.76 | 1.23 | 1.04 | 3.11 | 11.14 |
| 1643805 North Fork Goose Creek | NF_GC | 2002 | 1.48 | 1.39 | 0.42 | 3.75 | 7.04 |
| 1643805 North Fork Goose Creek | NF_GC | 2003 | 8.7 | 9.28 | 3.21 | 5.44 | 26.64 |
| 1643805 North Fork Goose Creek | NF_GC | 2004 | 3.61 | 4.69 | 1.25 | 2.69 | 12.24 |
| 1643805 North Fork Goose Creek | NF_GC | 2005 | 4.63 | 2.45 | 0.62 | 2.86 | 10.56 |
| 1643880 Beaver Dam Creek | Beaver | 2002 | 1 | 0.96 | 0.06 | 3.67 | 5.68 |
| 1643880 Beaver Dam Creek | Beaver | 2003 | 8.41 | 7.86 | 3.22 | 5.67 | 25.16 |
| 1643880 Beaver Dam Creek | Beaver | 2004 | 2.73 | 3.42 | 0.96 | 2.9 | 10.02 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1970 | 3.84 | 3.24 | 0.78 | 3.73 | 11.58 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1971 | 5.73 | 4.02 | 0.29 | 2.89 | 12.93 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1972 | 6.45 | 7.95 | -0.17 | 6.77 | 21.01 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1973 | 5.25 | 4.95 | 1.67 | 4.78 | 16.65 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1974 | 4.42 | 2.91 | 0.33 | 2.34 | 10 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1975 | 5.21 | 1.5 | 3.84 | 3.27 | 13.81 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1976 | 4.71 | 2.15 | 0.21 | 4.82 | 11.89 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1977 | 2.83 | 1.12 | 0.14 | 4.98 | 9.06 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1978 | 7.9 | 2.24 | 0.48 | 0.84 | 11.46 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1979 | 8.16 | 3.78 | 3.71 | 6.86 | 22.52 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1980 | 5.51 | 3.49 | 0.14 | 0.33 | 9.47 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1981 | 1.45 | 1.06 | 0.27 | 0.47 | 3.26 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1982 | 5.37 | 3.6 | 0.15 | 0.9 | 10.02 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1983 | 5.9 | 6.59 | -0.14 | 4.9 | 17.25 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1984 | 12.92 | 1.58 | 0.41 | 1 | 15.9 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1985 | 2.59 | 0.28 | 0 | 2.79 | 5.66 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1986 | 4.66 | 1.4 | 0.03 | 1.09 | 7.18 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1987 | 4.17 | 4.77 | 0.34 | 1.73 | 11.02 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1988 | 3.18 | 4.53 | -0.01 | 0.3 | 8.01 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1989 | 2.34 | 4.72 | 1.01 | 0.93 | 9 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1990 | 3.85 | 2.61 | 1.69 | 5.98 | 14.14 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1991 | 5.94 | 0.57 | 0 | 0.33 | 6.84 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1992 | 2.41 | 2.75 | 1.37 | 6.78 | 13.31 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1993 | 8.52 | 2.53 | -0.06 | 1.4 | 12.39 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1994 | 10.38 | 0.26 | 0.52 | 1.07 | 12.23 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1995 | 3.43 | 3.74 | -0.53 | 2.82 | 9.47 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1996 | 7.26 | 4.74 | 4.58 | 7.19 | 23.76 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 2001 | | | 0.12 | 0.26 | |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 2002 | 0.65 | 0.78 | 0.03 | 2.95 | 4.41 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 2003 | 8.33 | 8.78 | 4.83 | 5.91 | 27.85 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 2004 | 3.38 | 4.61 | 1.5 | 2.98 | 12.47 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1930 | 2.79 | 0.97 | -0.01 | 0.07 | 3.82 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1931 | 0.42 | 0.77 | 0.12 | 0.09 | 1.41 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1932 | 3.72 | 1.94 | 0.01 | 4.56 | 10.23 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1933 | 4.32 | 3.35 | 1.38 | 0.84 | 9.89 |

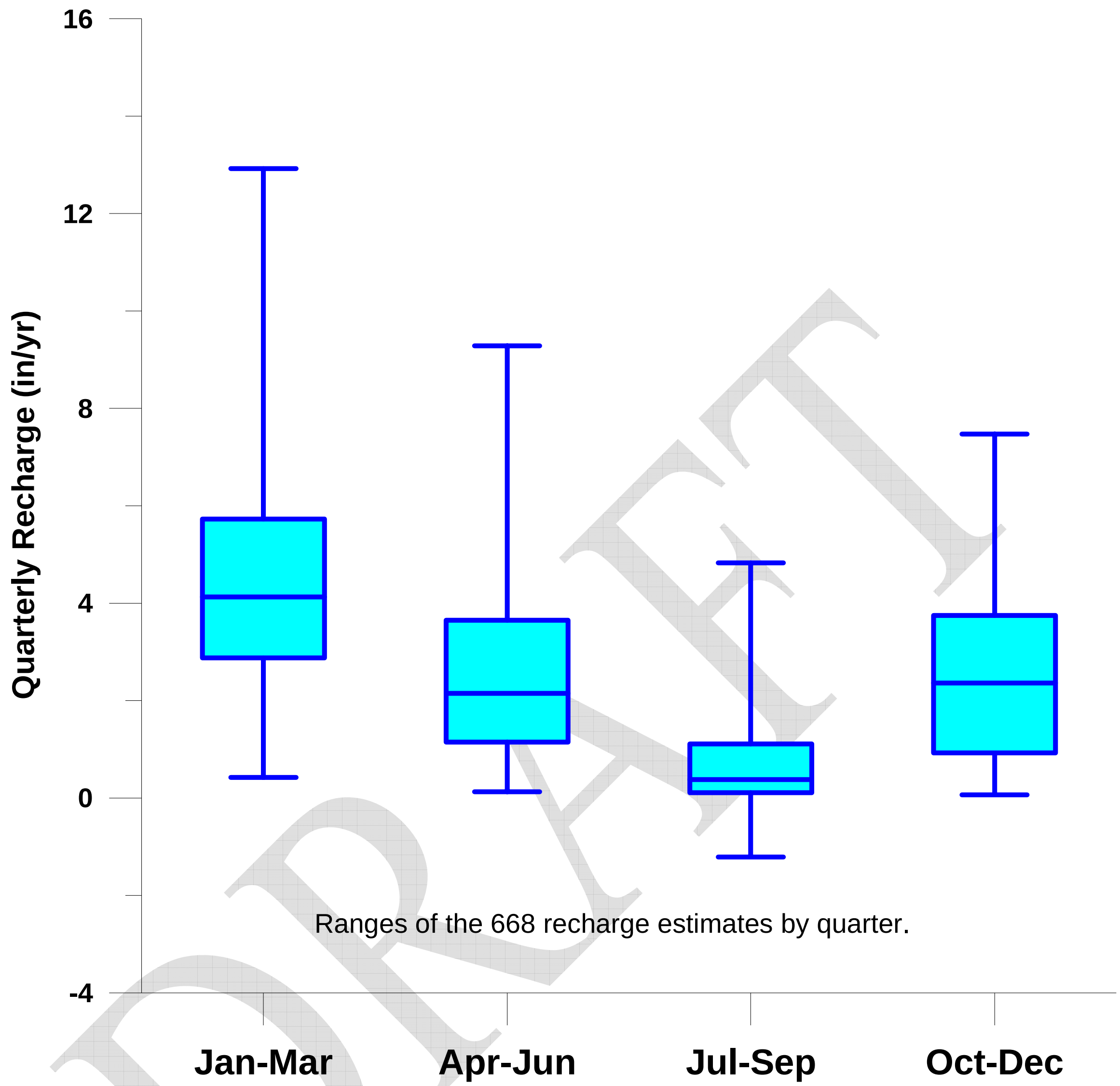
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1934 | 2.72 | 1.33 | 0.79 | 1.6 | 6.45 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1935 | 5.08 | 3.43 | 0.38 | 2 | 10.88 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1936 | 7.31 | 0.89 | 0.05 | 1.04 | 9.29 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1937 | 4.67 | 2.88 | 1.28 | 3.6 | 12.43 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1938 | 3.27 | 1.27 | 0.18 | 1.18 | 5.89 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1939 | 5.15 | 1.7 | 0.16 | 0.46 | 7.47 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1940 | 2.57 | 2.95 | 0.28 | 3.17 | 8.97 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1941 | 2.73 | 1.38 | 0.3 | 0.25 | 4.65 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1942 | 2.4 | 0.94 | 1.8 | 5.97 | 11.1 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1943 | 4.04 | 2.15 | 0.09 | 0.26 | 6.54 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1944 | 3.69 | 0.92 | 0.06 | 1.53 | 6.2 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1945 | 2.83 | 1.22 | 3.6 | 3.93 | 11.57 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1946 | 3.83 | 2.43 | 0.55 | 1.1 | 7.92 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1947 | 2.77 | 1.15 | 0.32 | 0.64 | 4.88 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1948 | 3.06 | 2.74 | 1.76 | 7.47 | 15.04 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1949 | 4.82 | 2.32 | 0.51 | 1.08 | 8.73 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1950 | 3.53 | 1.92 | 1.26 | 4.38 | 11.09 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1951 | 6.27 | 2.32 | 0.05 | 0.49 | 9.13 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1952 | 5.74 | 4.03 | 0.57 | 2.56 | 12.9 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1953 | 6.33 | 2.25 | 0.11 | 0.42 | 9.12 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1954 | 1.67 | 1.29 | 0.08 | 1.63 | 4.68 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1955 | 2.63 | 1.05 | 1.83 | 0.94 | 6.46 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1956 | 4.13 | 0.81 | 2.3 | 2.74 | 9.99 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1957 | 4.4 | 1.57 | 0.15 | 2.68 | 8.8 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1958 | 5.73 | 1.89 | 1.11 | 0.38 | 9.11 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1959 | 1.35 | 1.95 | 0.06 | 0.75 | 4.1 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1960 | 3.96 | 2.7 | 0.68 | 0.4 | 7.74 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1961 | 4.09 | 3.11 | 0.15 | 0.9 | 8.24 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1962 | 3.26 | 0.87 | 0.15 | 0.67 | 4.95 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1963 | 3.78 | 0.57 | 0.08 | 0.86 | 5.29 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1964 | 5.45 | 2.11 | 0.15 | 1.35 | 9.05 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1965 | 6.74 | 0.8 | 0.08 | 0.16 | 7.78 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1966 | 1.72 | 1.45 | 0.45 | 1.88 | 5.51 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1967 | 4.67 | 0.48 | 1.09 | 2.25 | 8.5 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1968 | 4.5 | 1.47 | 0.17 | 1.4 | 7.53 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1969 | 2.88 | 0.43 | 0.24 | 0.68 | 4.23 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1970 | 3.9 | 2.61 | 0.53 | 3.43 | 10.47 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1971 | 4.82 | 3.3 | 0.52 | 3.15 | 11.79 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1972 | 5.43 | 7.18 | -0.02 | 6.01 | 18.6 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1973 | 4.32 | 4.99 | 1.18 | 3.8 | 14.28 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1974 | 4.75 | 1.62 | 0.46 | 2.39 | 9.23 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1975 | 4.96 | 1.7 | 2.96 | 1.91 | 11.53 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1976 | 4.6 | 1.91 | 0.27 | 4.04 | 10.82 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1977 | 2.54 | 1.19 | 0.1 | 4.06 | 7.88 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1978 | 6.43 | 2.16 | 0.76 | 0.73 | 10.08 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1979 | 6.76 | 3.07 | 3.54 | 5.08 | 18.45 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1980 | 4.44 | 3.03 | 0.17 | 0.38 | 8.03 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1981 | 1.19 | 1.09 | 0.3 | 0.6 | 3.18 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1982 | 4.07 | 3.1 | 0.19 | 1.36 | 8.72 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1983 | 5.01 | 5.48 | -0.12 | 4.37 | 14.74 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1984 | 10.43 | 2.12 | 0.73 | 1.22 | 14.5 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1985 | 2.79 | 0.36 | 0.02 | 2.7 | 5.88 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1986 | 4.45 | 1.43 | 0.04 | 1.17 | 7.09 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1987 | 4.43 | 4.08 | 0.28 | 2.05 | 10.85 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1988 | 3.19 | 3.16 | 0.16 | 0.42 | 6.93 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1989 | 2.84 | 4.16 | 0.57 | 0.76 | 8.33 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1990 | 2.47 | 3.3 | 1.22 | 4.58 | 11.58 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1991 | 5.62 | 0.6 | 0.01 | 0.26 | 6.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1992 | 2.16 | 2.16 | 1.2 | 6.03 | 11.54 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1993 | 7.52 | 2.28 | 0.02 | 1.92 | 11.75 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1994 | 7.95 | 0.84 | 0.57 | 1 | 10.36 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1995 | 3.54 | 2.38 | 0.01 | 2.88 | 8.82 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1996 | 7.26 | 4.41 | 3.77 | 6.42 | 21.86 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1997 | 5.72 | 0.75 | 0.06 | 1.42 | 7.96 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1998 | 10.63 | 3.12 | -0.08 | 0.13 | 13.81 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1999 | 2.31 | 0.6 | 1.33 | 1.58 | 5.84 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2000 | 3.23 | 1.75 | 0.61 | 0.65 | 6.24 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2001 | 4.06 | 1.4 | 0.35 | 0.35 | 6.16 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2002 | 0.9 | 1.08 | 0.07 | 3.42 | 5.47 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2003 | 7.1 | 7.52 | 3.55 | 6.46 | 24.62 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2004 | 3.01 | 4.44 | 1.32 | 3.27 | 12.04 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2005 | 3.02 | 4.08 | 0.75 | 2.65 | 10.49 |
| 1644280 Broad Run | BR | 2002 | 1.1 | 1.14 | 0.48 | 2.97 | 5.7 |
| 1644280 Broad Run | BR | 2003 | 3.2 | 4.91 | 1.46 | 4.25 | 13.81 |
| 1644280 Broad Run | BR | 2004 | 2.3 | 2.09 | 1.16 | 1.77 | 7.33 |
| 1644280 Broad Run | BR | 2005 | 3.48 | 1.39 | 0.73 | 2.4 | 8.01 |

Below is a graph of annual recharge for three stations from 1970 to present. The Excel trend line indicates a slight decrease in recharge at Catoctin Creek and Goose Creek Leesburg stations.



Recharge varies seasonally with lowest recharge occurring in the summer months (July-September). In the following graph, all 668 recharges estimates are shown.

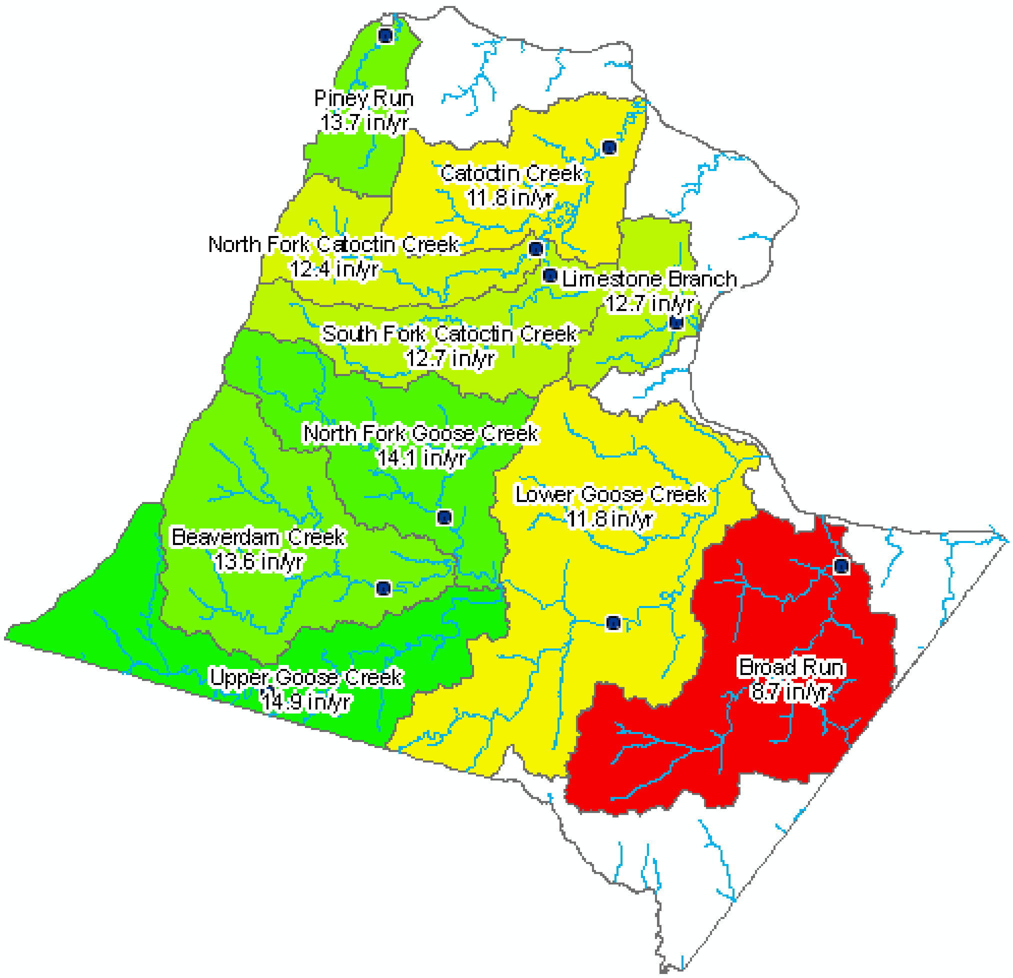


Taking annual averages for each station from the above quarterly data range from a high of over 14 inches per year in the headwaters of Goose Creek (North Fork Goose Creek) to a low of less than 9 inches per year at Broad Run.

| **Name** | **Abbreviation** | **Site_no** | **Year of First Complete Record** | **Annual Average for Entire Record (in/yr)** | **Annual Average for Recent 2002-2005 (in/yr)** |
|---|---|---|---|---|---|
| South Fork Catoctin | SF_Cat | 1638350 | 2002 | 12.67 | 12.67 |
| North Fork Catoctin | NF_Cat | 1638420 | 2002 | 12.36 | 12.36 |
| Catoctin | Cat | 1638480 | 1972 | 10.29 | 11.79 |
| Piney Run | Piney | 1636690 | 2002 | 13.72 | 13.72 |
| Limestone Branch | Lime | 1643590 | 2002 | 12.66 | 12.66 |
| North Fork Goose Creek | NF_GC | 1643805 | 2002 | 14.12 | 14.12 |
| Beaver Dam Creek | Beaver | 1643880 | 2002 | 13.62 | 13.62 |
| Goose Creek (Middleburg) | GC_Middle | 1643700 | 1970 | 12.49 | 14.91 |
| Goose Creek (Leesburg) | GC_Lee | 1644000 | 1930 | 9.26 | 11.76 |
| Broad Run | BR | 1644280 | 2002 | 8.71 | 8.71 |
| **Average** | | | | **11.99** | **12.63** |

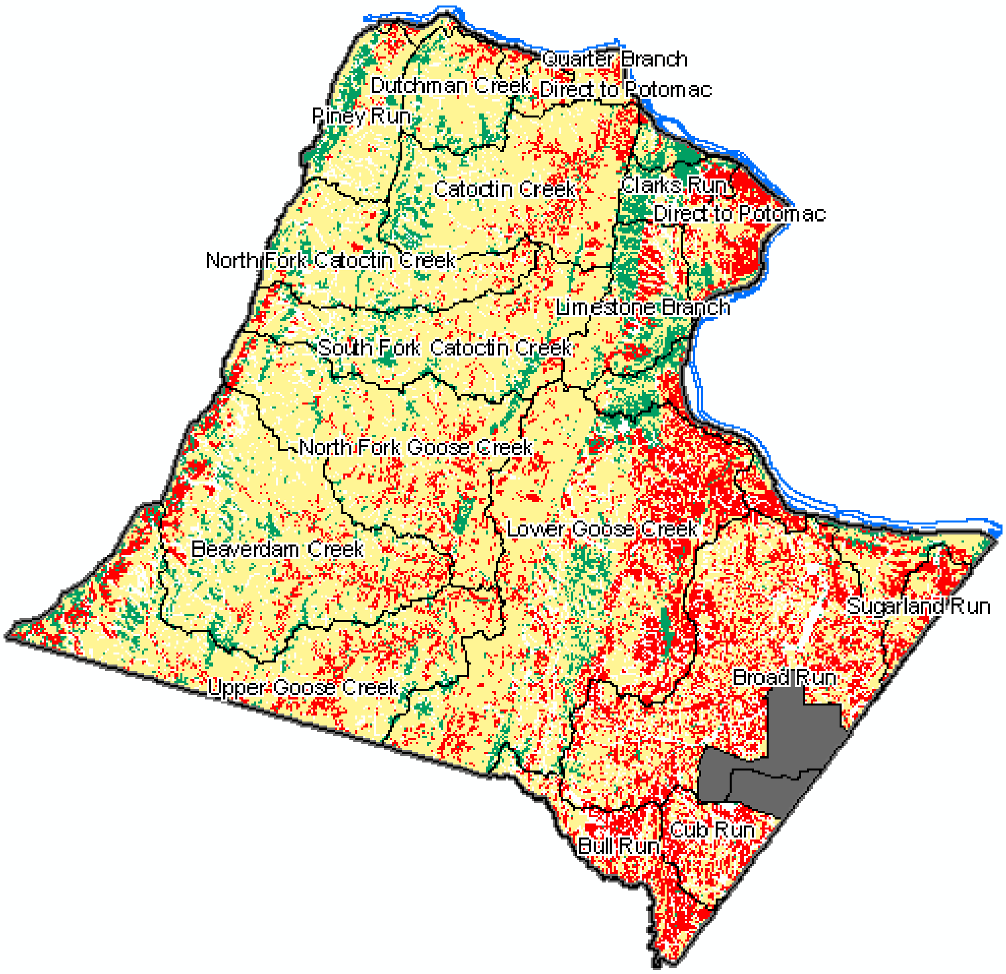
## Spatial Distribution:

Stream gages cover most of the major watershed in Loudoun County. The highest recharge is generally observed in the headwater subwatersheds. The lowest recharge is in Broad Run, due to a combination on increased imperviousness, stormwater infrastructure, lesser terrain slope and soil types. The spatial distribution of the recent (2002-2005) data are shown in the below figure.




O:\project\wrmp\Recharge\ Recharge_Analysis_Map06.mxd

Based on soil type, a "potential" groundwater recharge classification has been established. There is general agreement between the recharge calculated from streamflow and recharge "potential" east of Bull Run fault where there is less recharge in the Broad Run watershed.




O:\project\wrmp\Recharge\ Recharge_Analysis_Map07.mxd

## Published Recharge Estimates

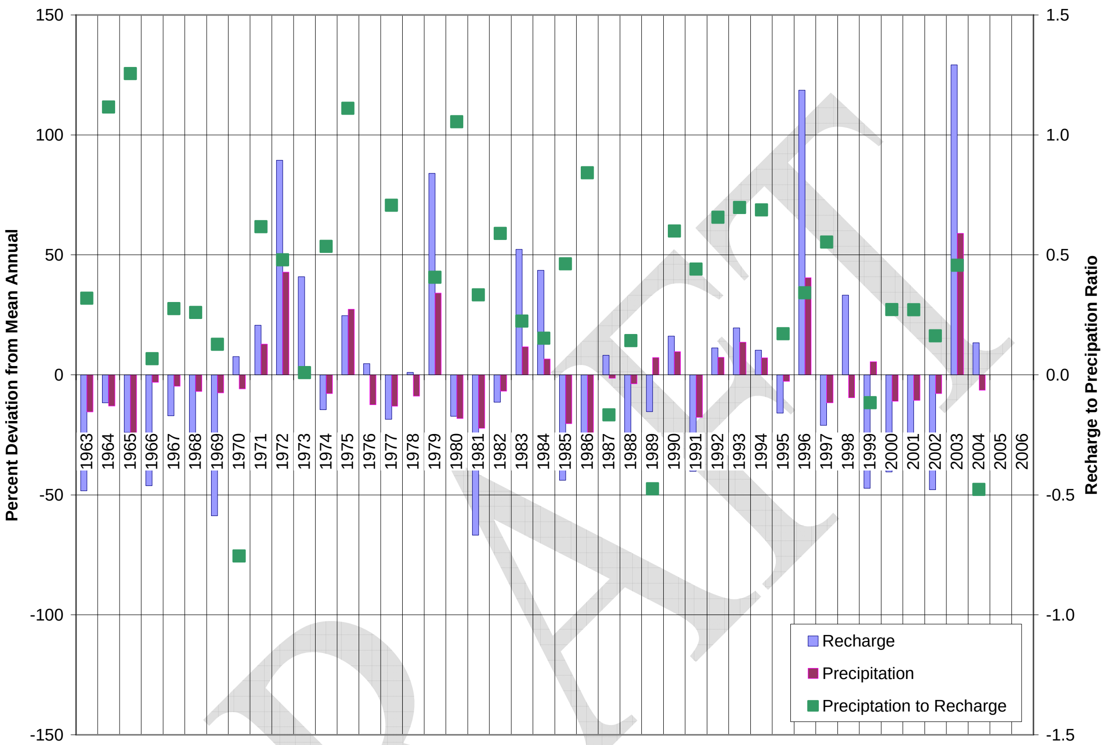
The USGS has published recharge estimates at selected sites in Loudoun County. Calculations were performed using partial records (PR) using 9 to 11 stream flow measurements and from complete records (CR) where longer term gaging stations had been established. Published data appear in publications Hayes, 1991 and Nelms, et al, 1977.

| Published USGS | | | | | Calculations using RORA | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Station number | Station name | Period of record | Site type | Effective recharge (in/yr) | Period of record | Effective recharge (in/yr) | Period of record | Days in Record | Effective recharge (in/yr) |
| 1636690 | Piney Run near Lovettsville | Prior to 1997 | PR | 8.67 | | | 2003-2007 | 1,825 | 13.72 |
| 1638480 | Catoctin Creek at Taylorstown | 1973-84 | CR | 9.18 | 1973-84 | 10.94 | 1973-2007 | 12,782 | 10.29 |
| 1643700 | Goose Creek near Middleburg | 1967-84 | CR | 10.72 | 1967-84 | 13.12 | 1967-2007 | 14,974 | 12.49 |
| 1644000 | Goose Creek near Leesburg | 1931-84 | CR | 7.79 | 1931-84 | 8.91 | 1911-2007 | 35,428 | 9.263 |

Overall the published effective recharge values in 1984 are less than those calculated using the RORA program. The reason is likely the methodology used.

## Comparison with Precipitation

The recharge estimates are compared with monthly precipitation data from Dulles Airport for the period 1963 to 2006. Expectedly, above average precipitation correlates with above average recharge, however, using mean annual values, magnitude of the recharge deviations from the average is greater than those for precipitation.




The ration of recharge to precipitation to often between 0.1 to 0.7 which implies that precipitation is typically 1.5 to 10 times the calculated recharge. There are occasionally years when precipitation is below average and recharge is above average and visa versa.

## Temporal Changes in Recharge

Have there been temporal changes in recharge? We can't examine all ten gages as seven have limited data. Using simple Excel trend fit shows that the three gages are trending downwards somewhat. We need to examine recharge concurrent with precipitation. How about cumulative recharge versus cumulative rainfall?

## References


Hayes, D. C., 1971, Low-Flow Characteristics of Streams in Virginia, USGS Water Supply Paper WSP 2374, 69 p.

Nelms, D. L., G. E. Harlow and D. C. Hayes, 1977, Base-Flow Characteristics of Streams in the Valley and Ridge, the Blue Ridge and the Piedmont Physiographic Provinces of Virginia, USGS Water Supply Paper WSP 2457, 48 p.

Rutledge, A. T., 1998, Computer programs for describing the recession of ground-water discharge and for estimating mean ground-water recharge and discharge from streamflow data – update: U.S. Geological Survey Water-Resources Investigations Report 98-4148, 43 p.

Rutledge, A. T., 2000, Considerations for use of the RORA program to estimate ground-water recharge from streamflow records: U.S. Geological Survey Open-File Report 00-156, 44 p.

Rutledge, A. T., 2003, Use of RORA for complex ground-water flow conditions: U.S. Geological Survey Water-Resources Investigations Report 03-4304, 5 p.

Rutledge, A. T., 2007, Update on the Use of the RORA Program for Recharge Estimation, Ground Water: 45 (3), 374–382.

Low Flow and Baseflow Statistics from Streamflow Records

## Background

Low-flow, base-flow, and mean-flow characteristics are an important part of assessing water resources in a watershed. These streamflow characteristics can be used by watershed planners and regulators to determine water availability, water use allocations, assimilative capacities of streams, and aquatic-habitat needs. Streamflow characteristics are commonly predicted by use of regression equations when a nearby streamflow-gaging station is not available.

Low flow and base flow are measures of streamflow that can help to identify environmentally vulnerable (stressed) watershed A more complete definition of stress includes streamflow quantity, quality and habitat factors.

In the 1999 work plan for the Massachusetts Water Resource Commission (WRC), these stresses are defined as:

**Quantity:** A significant reduction in streamflow is defined as a decrease in key low and high streamflow statistics. Low flows in most of Massachusetts reflect ground water levels and are a good indicator of the health of a system. Reduced low flows can impact aquatic habitat and water quality. In addition, low flows are often the first indicator of environmental impacts.

**Quality:** A degraded water quality is defined as water in a stream that does not meet surface water quality standards.

**Habitat Factors:** A degraded habitat is defined as a river reach in which key habitat factors, such as temperature, quality, cover, substrate and accessibility, necessary to sustain a biologically diverse community are degraded. The stress can be due to a lack of streamflow, quality degradation, presence of dams, channel modifications, culverting and other factors. Indicators of stressed habitat include the absence or degradation of a target fish or other aquatic community or the absence of the ability of fish to move between multiple habitats necessary to their life cycles. Factors that limit movement include lack of flow, or reaches with no flow, and the presence of dams or other restrictions that prevent passage.

Low flow statistics often include the “7Q10” value (defined below).

**7Q10:** The streamflow that occurs over 7 consecutive days and has a 10-year recurrence interval period, or a 1 in 10 chance of occurring in any one year. Daily streamflows in the 7Q10 range are general indicators of prevalent drought conditions which normally cover large areas. 7Q10 values are also used by the State for regulating water withdrawals and discharges into streams.

**30Q2 :** The streamflow that occurs over 30 consecutive days and has a 2-year recurrence interval period, or a 1 in 2 chance of occurring in any one year. Daily streamflows in the 30Q2 range are general indicators of initial drought conditions which may cover large areas, and may be used by State regulators in determining water-use restrictions.

http://ga2.er.usgs.gov/lowflow/helplowflowstats.cfm

EPA has found that: "In 1986, the EPA determined that the hydrological-based 7Q10 design flow was similar to the biologically-based 4B3 design flow and recommended the use of either design flow for water quality standards and toxic wasteload allocation studies relating to chronic effects on aquatic life. Although the 7Q10 is used by about half the states in the nation, the 7Q10 is sometimes characterized as being either overprotective or under-protected of aquatic life in various areas of the country. States regularly propose alternative hydrologically-based design flow statistics for their water quality standards (in the form of xQy where x is the duration and y is the frequency). For example, one state currently uses the 3Q2 statistic for conventional pollutants and several other states use a 7Q2 statistic. States often justify the use of a design flow other than 7Q10 on the basis of different hydrogeology. States sometimes suggest the use of a percentile flow (e.g., the 4th percentile) on the basis of ease of calculation and communication with the public."
(http://www.epa.gov/waterscience/models/dflow/apps.htm)

In Massachussetts, both the 7Q10 and August Median flows for the sub-basin are used in their assessment of stressed streams.

In PA, Q7,10; Q7,2; Q30,10; Q30,2; and Q90,10 low-flow characteristics have been studied. http://pubs.usgs.gov/sir/2006/5130/pdf/sir2006-5130.pdf

**Seasonal Streamflow Conditions and Historic Droughts in Virginia**
(From http://va.water.usgs.gov/drought/histcond.htm)

In a typical year, highest streamflows occur during the winter months, decreasing through the spring and summer, with lowest streamflows occurring during the fall months. During the winter of 1998, above average precipitation recharged the ground-water system, which in turn, maintained streamflows in the above normal range of flows. Even though there was below average precipitation during the spring and summer of 1998, streamflows did not fall below normal until September of that year because of the high ground-water storage. With continued dry conditions in the fall, ground-water storage became depleted, and streamflows continued to decline to levels near those observed in past droughts. Streamflows remained in the below normal range during the winter of 1999 because precipitation was insufficient to fully recharge the ground-water system. During base-flow conditions (non-storm runoff), streams had about one-third of the flow during the winter of 1999 than they had during the winter of 1998. The already depleted ground-water storage conditions combined with less than normal precipitation during the past three months has resulted in continued low streamflows. June streamflows are

already at or near typical annual low flow values, and streamflows are expected to continue to decline through the summer.

There have been four major Statewide droughts since the early 1900's. The drought of 1930-32 was one of the most severe droughts recorded in the State. Recurrence intervals ranged from 30 years to greater than 80 years. The droughts of 1938-42 and 1962-71 were less severe; however, the cumulative streamflow deficit for the 1962-71 drought was the greatest of the four droughts because of the duration of this drought. The drought of 1980-82 was the least severe and had the shortest duration. Recurrence intervals in the 1980-82 drought ranged from 15 years across most of the State to greater than 80 years in the James River Basin.
Last modified: 03/12/02

**Base and Low flow in Loudoun County**

In Loudoun County, there are three stream gages with long periods of record (more than 20 years) and seven gages with only a few years of data. Because it is not possible to calculate 7Q10 on the newer stream gages, other statistics are be analyzed also.

**August Median Flows:**

(Need to rewrite) "August median flows at streamgaging stations can be determined by two methods. The U.S. Fish and Wildlife Service (USFWS) (1981) recommends calculating August median streamflows as the median value of the annual series of August monthly mean streamflows for the period of record at a gaging station. The USFWS uses the August median flow calculated in this manner as the minimum streamflow required for summertime maintenance of habitat for biota in New England streams."

"Charles Ritzi and Associates (1987) suggested calculating August median flows as the median of the daily mean flows for all complete Augusts during the period of record at a streamgaging station. Kulik (1990) and Ries (1997) also used this method for calculating August median flows. This method typically results in values of August median flows that are somewhat lower than those determined by use of the method suggested by the USFWS. The monthly mean values used by the USFWS to calculate August median flows tend to be skewed by infrequent storm events that cause the monthly means to be larger than the medians, thus "the median is a more useful statistic than the mean for describing the central tendency" of the daily data (Kulik, 1990)." page 9
http://pubs.usgs.gov/wri/wri004135/pdf/report.pdf

**Importance of minimum base flow**

0.50 ft3/s/mi2, the ABF low-flow value recommended to "sustain and perpetuate indigenous aquatic fauna" (U.S. Fish and Wildlife Service, 1981). page 63
http://pubs.usgs.gov/wri/wri034330/pdf/wrir034330.pdf and
http://des.nh.gov/Rivers/instream/Archive/lang_policy.pdf

## References:

U.S. Fish and Wildlife Service, 1981, Interim regional policy for New England streamflow recommendations: Newton Corner, MA, U.S. Fish and Wildlife Service, 3 p.

# Streamflow Drainage Areas at USGS Stream Monitoring Sites

## Background

For each stream gaging station it is important to know the drainage or contributing area. The area is subsequently used in streamflow analysis such as recharge calculation from recession curves using the RORA computer program. The USGS provides calculations of the drainage area for each of the ten stream stations in Loudoun.

## Summary of Primary Loudoun Stations:

The drainage area, in square miles, is included in the GIS for the 39 USGS station locations. Note that most of these stations are generally inactive, but are listed in the USGS inventory of sites.

Additionally, the USGS has rechecked and verified these calculations for all 39 stations in Virginia in the report:

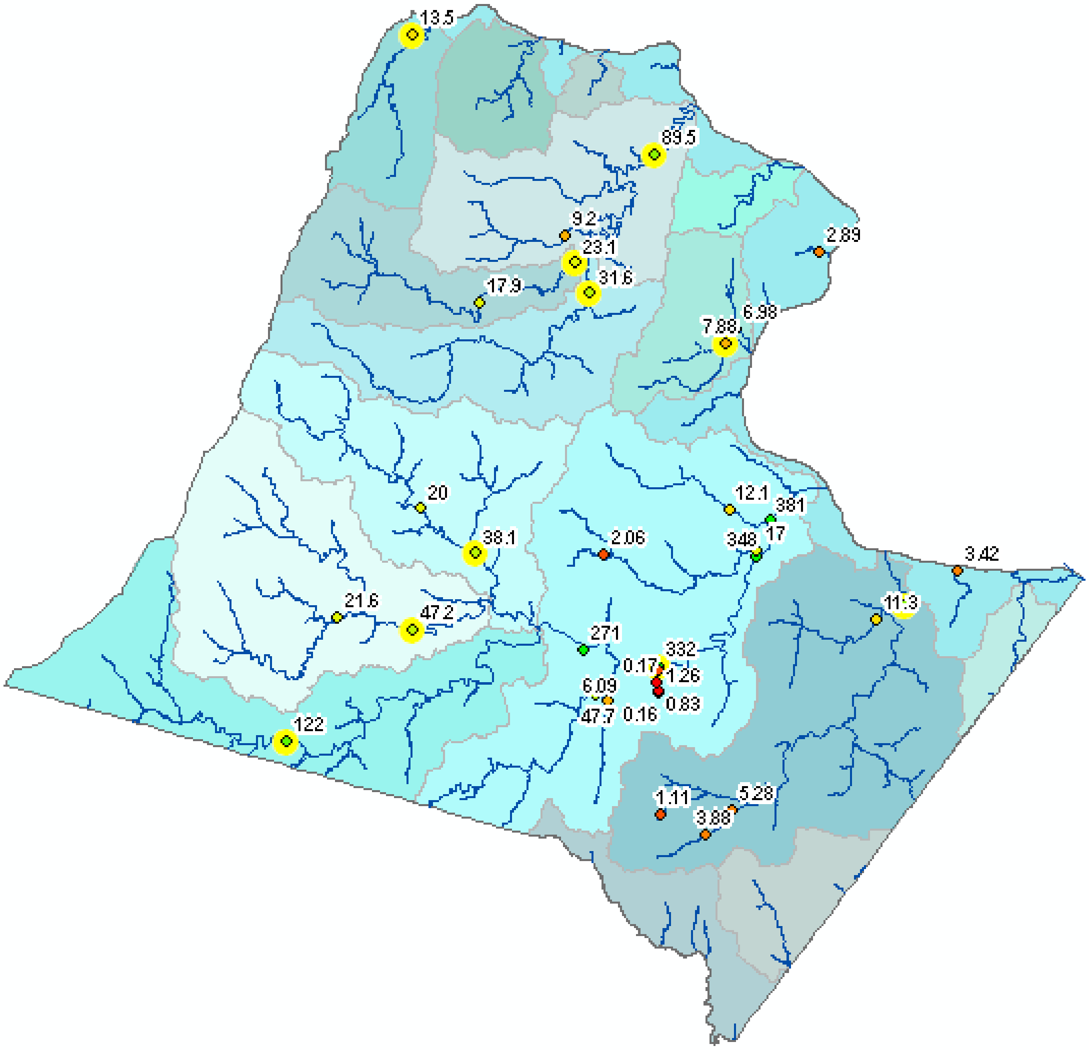
> Hayes, D. C. and U, Wiegand, 2006, USGS Open-File Report 2006-1308, "Drainage Areas of Selected Streams in Virginia", http://pubs.usgs.gov/of/2006/1308/

The drainage area is tabulated as:

| Station Number | Station Name | Drainage Area (sq miles) |
|---|---|---|
| 1636690 | PINEY RUN NEAR LOVETTSVILLE, VA | 13.50 |
| 1638350 | S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA | 31.60 |
| 1638420 | N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA | 23.10 |
| 1638480 | CATOCTIN CREEK AT TAYLORSTOWN, VA | 89.50 |
| 1643590 | LIMESTONE BRANCH NEAR LEESBURG, VA | 7.88 |
| 1643700 | GOOSE CREEK NEAR MIDDLEBURG, VA | 122.00 |
| 1643805 | N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA | 38.10 |
| 1643880 | BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA | 47.20 |
| 1644000 | GOOSE CREEK NEAR LEESBURG, VA | 332.00 |
| 1644280 | BROAD RUN NEAR LEESBURG, VA | 76.10 |
| 1638400 | N F CATOCTIN CREEK AT RT 9 NEAR HILLSBORO, VA | 17.90 |
| 1638450 | RICHARD CREEK NEAR WATERFORD, VA | 9.20 |
| 1643585 | POTOMAC RIVER TRIB NO 1 NEAR LUCKETTS, VA | 2.89 |
| 1643587 | LIMESTONE BR TRIB NO. 2 AT PVT RD NR LUCKETTS, VA | |
| 1643600 | LIMESTONE BRANCH TRIB NO 1 NEAR LEESBURG, VA | 6.98 |

| | | |
|---|---|---|
| 1643610 | BIG SPRING NEAR LEESBURG, VA | |
| 1643800 | NORTH FORK GOOSE CREEK NEAR LINCOLN, VA | 20.00 |
| 164380375 | CROOKED RUN NEAR LINCOLN, VA | |
| 1643820 | BEAVERDAM CREEK NEAR UNISON, VA | 21.60 |
| 1643950 | GOOSE CREEK AT OATLANDS, VA | 271.00 |
| 1643988 | LITTLE RIVER NEAR OATLANDS, VA | 47.70 |
| 1643990 | HOWSERS BRANCH NEAR OATLANDS, VA | 6.09 |
| 1644005 | BLACK BRANCH ABOVE TRIBUTARY NO. 1 NEAR WATSON, VA | |
| 1644010 | BLACK BRANCH TRIB NO 1 NEAR WATSON, VA | 0.16 |
| 1644015 | BLACK BRANCH NEAR WATSON, VA | 0.83 |
| 1644020 | BLACK BRANCH TRIB NO 2 NEAR WATSON, VA | 0.17 |
| 1644025 | BLACK BRANCH BELOW RT 860 NEAR WATSON, VA | 1.26 |
| 1644090 | GOOSE CREEK AB SYCOLIN CREEK NEAR LEESBURG, VA | 348.00 |
| 1644100 | S F SYCOLIN CREEK NEAR LEESBURG, VA | 2.06 |
| 1644110 | SYCOLIN CREEK NEAR LEESBURG, VA | 17.00 |
| 1644115 | DRY MILL BRANCH ALONG RT 699 NEAR LEESBURG, VA | |
| 1644120 | TUSCARORA CREEK ABOVE STP NEAR LEESBURG, VA | 12.10 |
| 1644133 | GOOSE CREEK AT ROUTE 7 NEAR ASHBURN, VA | 381.00 |
| 1644200 | LENAH RUN AT LENAH, VA | 1.11 |
| 1644250 | S F BROAD RUN NEAR ARCOLA, VA | 3.88 |
| 1644255 | S F BROAD RUN AT ARCOLA, VA | 5.28 |
| 1644272 | MERRYBROOK RUN (EAST BRANCH) NEAR HERNDON, VA | |
| 1644277 | BEAVERDAM RUN NEAR ASHBURN, VA | 11.30 |
| 1644283 | POTOMAC RIVER TRIB NO 2 NEAR STERLING, VA | 3.42 |

Below is a map with the ten primary stations highlighted:




REF: O:\project\wrmp\USGS_Site_Inventory\  and
O:\project\wrmp\USGS_Streamflow\USGS_Streamflow_Drainage_Area_Map01.mxd

Note:  The GIS polygons of drainage area for each station has not been obtained.

| Published USGS | | | | | Calculations using RORA | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Station number | Station name | Period of record | Site type | Effective recharge (in/yr) | Period of record | Effective recharge (in/yr) | Period of record | Days in Record | Effective recharge (in/yr) |
| 1636690 | Piney Run near Lovettsville | Prior to 1997 | PR | 8.67 | | | 2003-2007 | 1,825 | 13.72 |
| 1638480 | Catoctin Creek at Taylorstown | 1973-84 | CR | 9.18 | 1973-84 | 10.94 | 1973-2007 | 12,782 | 10.29 |
| 1643700 | Goose Creek near Middleburg | 1967-84 | CR | 10.72 | 1967-84 | 13.12 | 1967-2007 | 14,974 | 12.49 |
| 1644000 | Goose Creek near Leesburg | 1931-84 | CR | 7.79 | 1931-84 | 8.91 | 1911-2007 | 35,428 | 9.263 |

[Latitude and longitude are reported in degrees, minutes, and seconds; PR, partial-record gaging station; CR, continuous-record gaging station; mi2, square mile; ft3/s, cubic foot per second; in/yr, inch per year; Q50, Q90, and Q95, indicate the 50-, 90-, and 95-percent discharge on the streamflow-duration curve, respectively; 7Q2 and 7Q10, indicate the annual minimum average 7-consecutive-day low-flow discharge having 2-year and 10-year recurrence intervals, respectively; dashes (-) indicate value could not be determined]

http://va.water.usgs.gov/vadeq_data/citycount_scroll.htm

Generally there is a decrease in the baseflow calculations in the recent calculations as compared to the older historic one calculated in mid 1980's.  Exceptions are Piney and Broad Run in which the recent stream flow measurements are higher accuracy, but only a short period of record.

The decline in baseflow may be associated with suburban development and changes in land use.

| Previously Published | | | | | | | | | | Current Calculations using DFLOW3 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station number | Station name | Period of record | Site type | Number of Discharge Values | Drainage area (mi2) | Mean base flow (ft3/s) | 7Q2 (ft3/s) Historic | 7Q10 (ft3/s) Historic | Base-flow variability index | Stream Gages | Station_ID | Period of record | Days in Record | 7Q2 (ft3/s) Current | 7Q10 (ft3/s) Current |
| 1636690 | Piney Run near Lovettsville | Prior to 1997 | PR | 11 | 13.7 | 8.75 | 0.53 | 0.11 | 0.93 | Piney Run | 1636690 | 2003-2007 | 1,825 | 1.03 | |
| | | | | | | | | | | South Fork Catoctin | 1638350 | 2003-2007 | 1,825 | 1.78 | |
| | | | | | | | | | | North Fork Catoctin | 1638420 | 2003-2007 | 1,825 | 0.56 | |
| 1638480 | Catoctin Creek at Taylorstown | 1973-84 | CR | - | 89.6 | 60.6 | 6.8 | 2.9 | 0.75 | Catoctin | 1638480 | 1973-2007 | 12,782 | 4.81 | 0.63 |
| 1643585 | Potomac River Tributary No 1 near Lucketts | Prior to 1997 | PR | - | 2.95 | | 0.1 | 0.04 | 0.65 | | | | | | |
| | | | | | | | | | | Limestone Branch | 1643590 | 2003-2007 | 1,825 | 1.43 | |
| 1643600 | Limestone Branch Tributary No 1 near Leesburg | Prior to 1997 | PR | - | 6.82 | | 1.2 | 0.6 | 0.39 | | | | | | |
| 1643700 | Goose Creek near Middleburg | 1967-84 | CR | | 123 | 97.1 | 6 | 0.71 | 0.91 | Goose Creek (Middleburg) | 1643700 | 1967-2007 | 14,974 | 4.56 | 0.02 |
| 1643800 | North Fork Goose Creek at Route 722 near Lincoln | Prior to 1997 | PR | 9 | 24 | | 1.1 | 0.34 | | North Fork Goose Creek | 1643805 | 2003-2007 | 1,825 | 3.07 | |
| 1643950 | Goose Creek at Oatlands | Prior to 1997 | PR | 9 | 276 | 138 | 12 | 2.9 | 0.82 | | | | | | |
| 1643988 | Little River near Oatlands | Prior to 1997 | PR | - | 47.7 | 26 | 2.1 | 0.5 | 0.81 | | | | | | |
| | | | | | | | | | | Beaverdam Creek | 1643880 | 2003-2007 | 1,825 | 0.31 | |
| 1643990 | Howsers Branch near Oatlands | Prior to 1997 | PR | - | 5.98 | | 0 | 0 | | | | | | | |
| 1644000 | Goose Creek near Leesburg | 1931-84 | CR | | 332 | 191 | 12 | 2.5 | 0.91 | Goose Creek (Leesburg) | 1644000 | 1911-2007 | 35,428 | 10.4 | 1.77 |
| 1644255 | South Fork Broad Run at Arcola | Prior to 1997 | PR | - | 5.31 | 0.8 | 0.01 | 0 | 1.76 | | | | | | |
| 1644277 | Beaverdam Run near Ashburn | Prior to 1997 | PR | - | 11.2 | | 0 | 0 | | | | | | | |
| 1644280 | Broad Run near Leesburg | Prior to 1997 | PR | - | 76.1 | | 0.28 | 0.02 | | Broad Run | 1644280 | 2003-2007 | 1,825 | 4.03 | |
| 1644283 | Potomac River Tributary No 2 near Sterling | Prior to 1997 | PR | - | 3.47 | | 0 | 0 | | | | | | | |

Prepared by: David Ward
Date: Feb 8, 2007, Updated 5/23/2007 and 6/28/2007

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Reference:

http://water.usgs.gov/ogw/rora/

**RORA: The recession-curve-displacement method for estimating recharge**

This web site includes information about the use of the RORA computer program for analyzing a streamflow record. The version at this site will read streamflow data in the format that is available from USGS web sites.

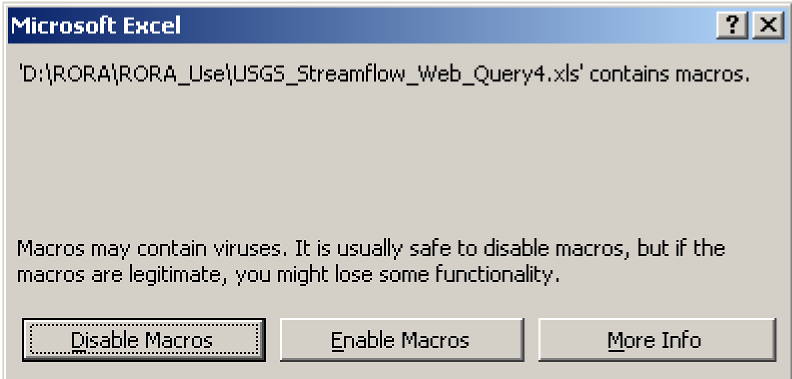
The computer program RORA estimates ground-water recharge using the recession-curve-displacement method. The method is based on the change in total potential ground-water discharge that is caused by each recharge event.

- Download software executable files and sample data sets (690kb ZIP file, updated January 2007)
  - Download README file describing files included in ZIP file
  - Download fortran source code (ZIP file)
  - Download user's manual (PDF file)
- **Background Literature**
  - Computer programs for describing the recession of ground-water discharge and for estimating mean ground-water recharge and discharge from streamflow records: USGS WRIR 98-4148.
  - Considerations for use of the RORA program to estimate ground-water recharge from streamflow records: USGS OFR 00-156.
  - Testing an automated method to estimate ground-water recharge from streamflow records: Ground Water, vol. 32, no. 2, pp. 180-189, 1994.
  - Use of RORA for complex ground-water flow conditions: USGS WRIR 03-4304

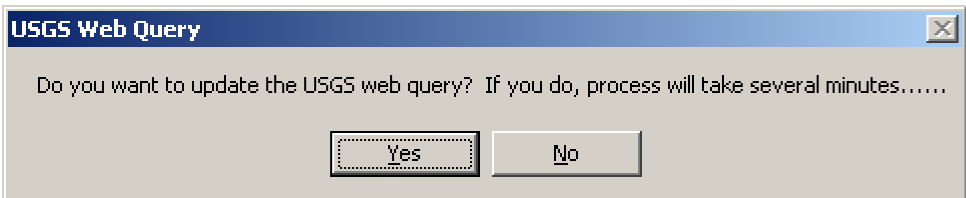
**Instructions:**

Start by copying and opening the USGS stream flow web query. The master files is located at “G:\BLDG_DEV\Engineering\H2O Team\WRMP\USGSFlowData\web_query_all_dates_flow_only”

Select yes, to: “Enable Macros”:

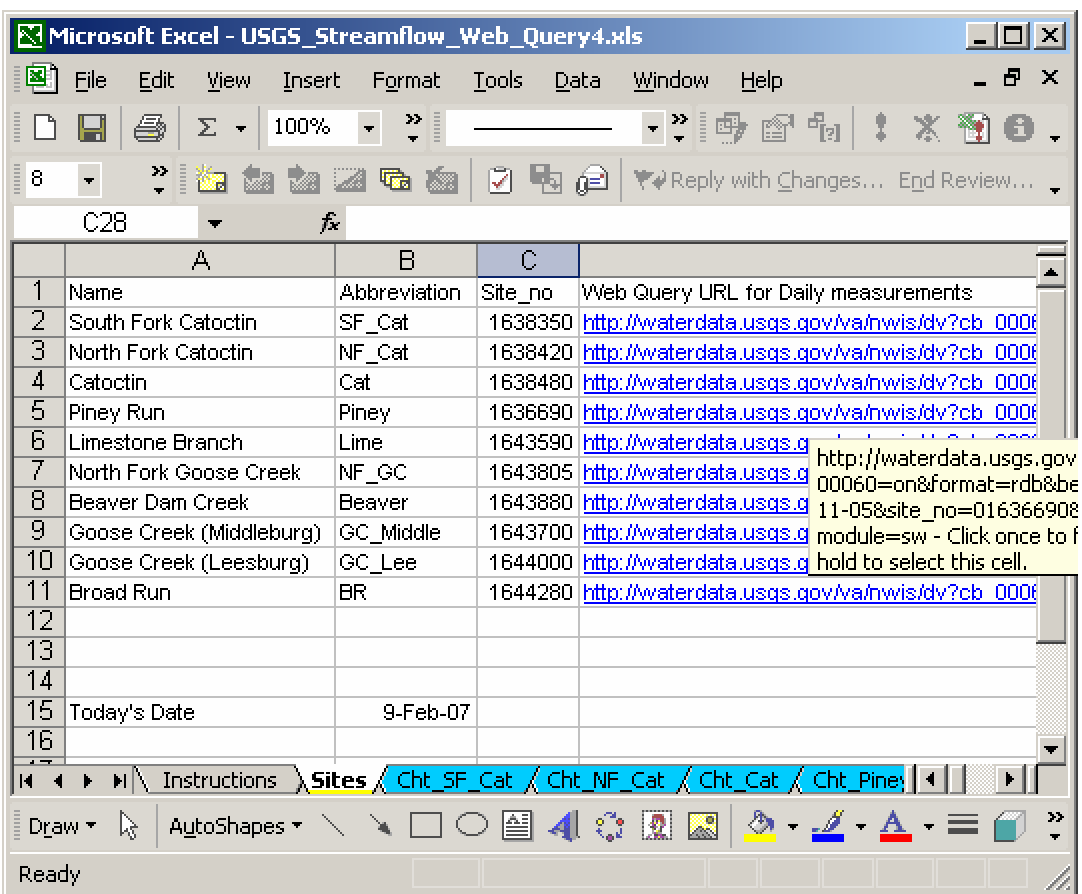



Select "Yes" to update data in which all historic data will be loaded.

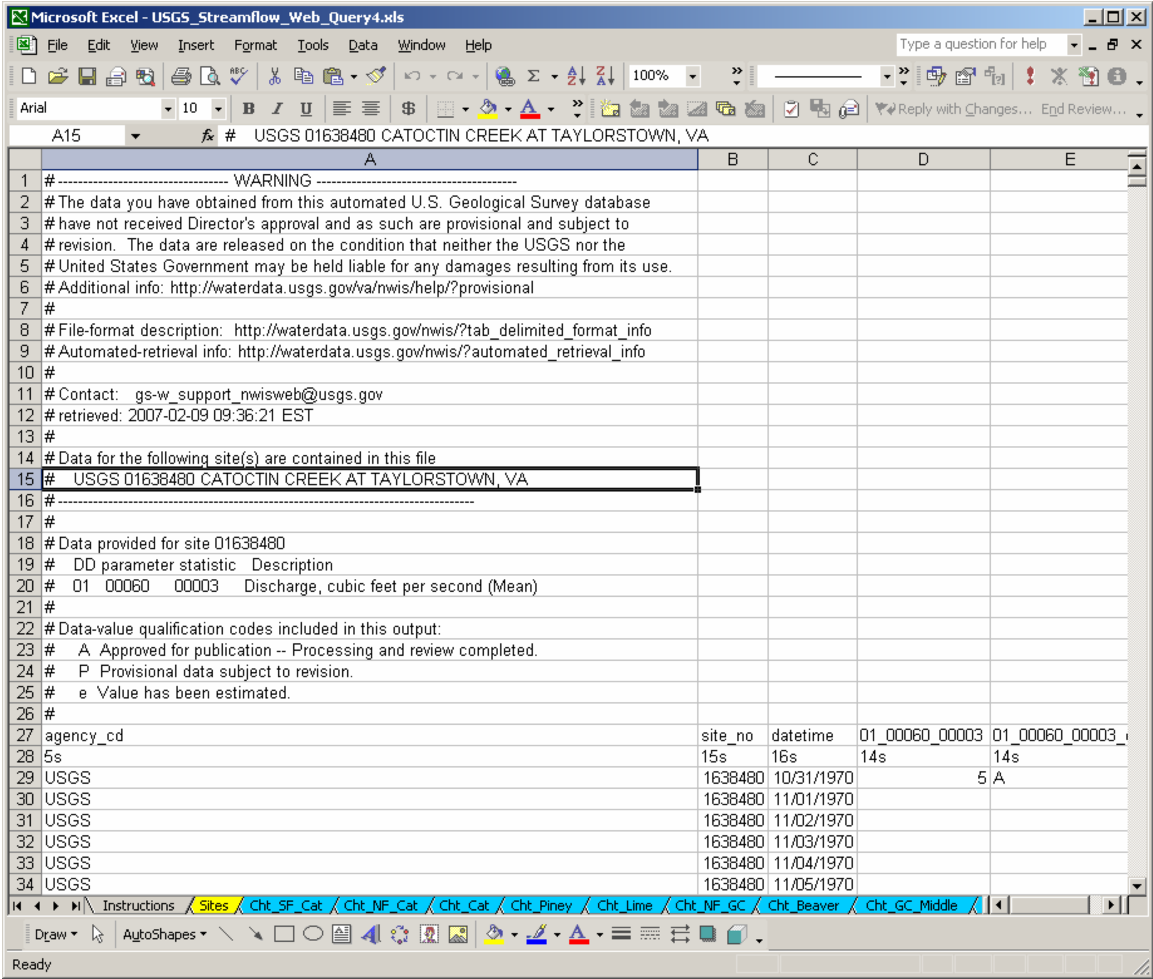



Wait a while. In lower left corner you will see the spreadsheet hitting the USGS NWIS file server for the ten gages.

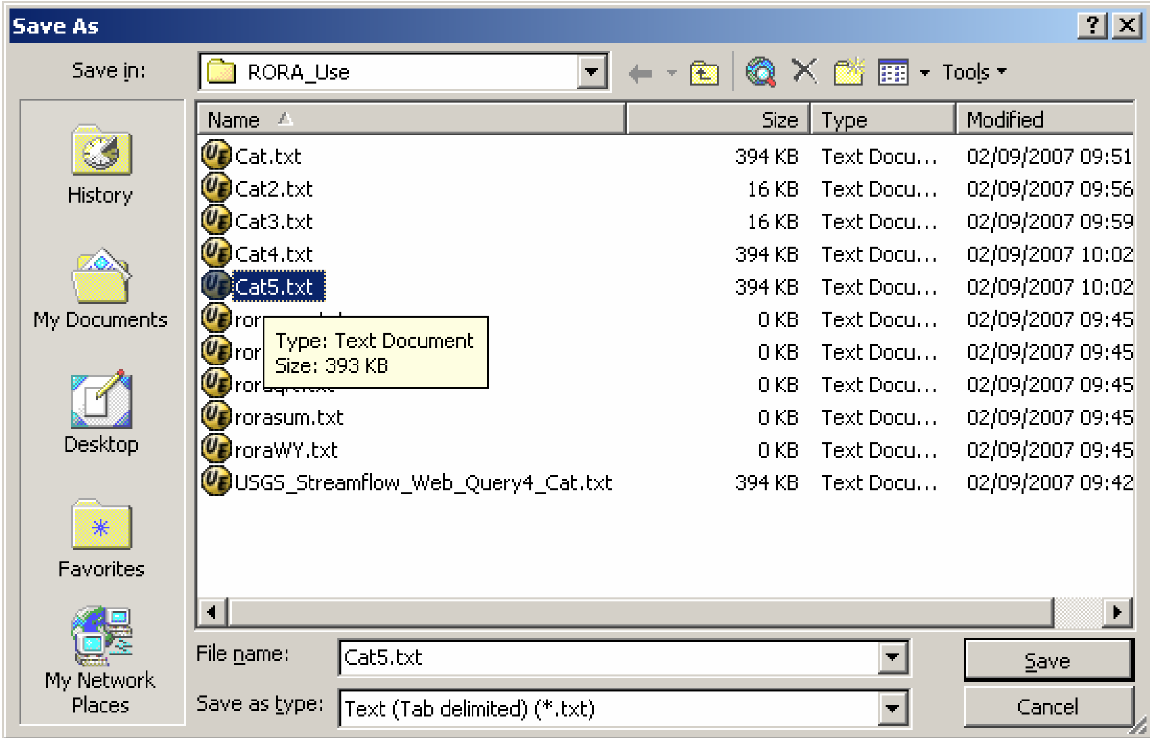
This will result in a spreadsheet with 10 tabs for the 10 gages which may be saved as tab-delimited text files.



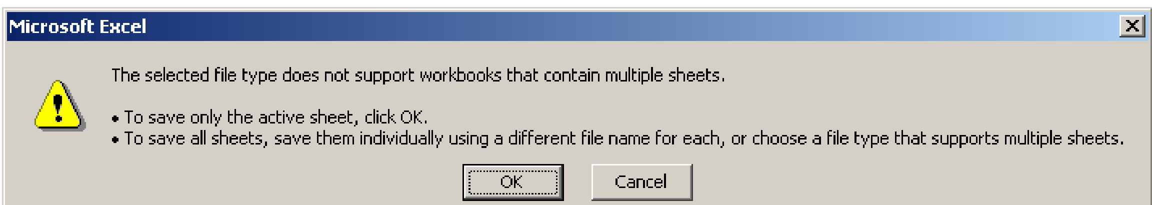
For example go to the tab “Cat”.



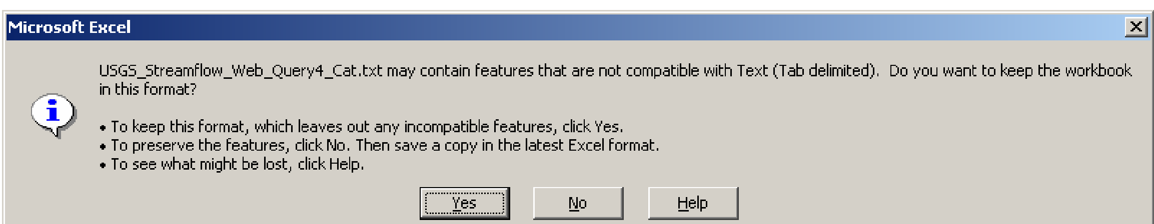

Now save a tab-delimited file using short file name (less than 12 characters.



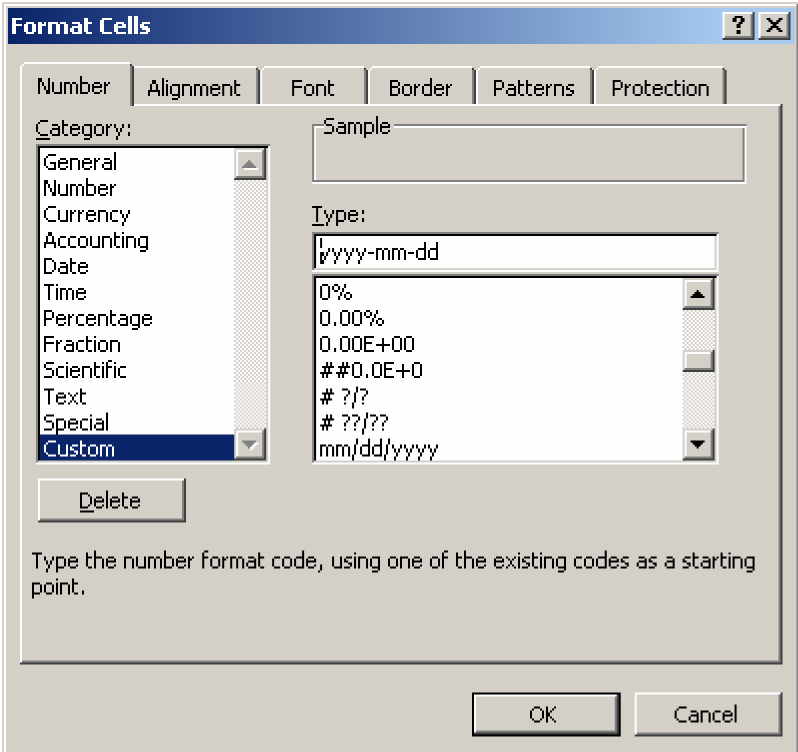

Select “OK”



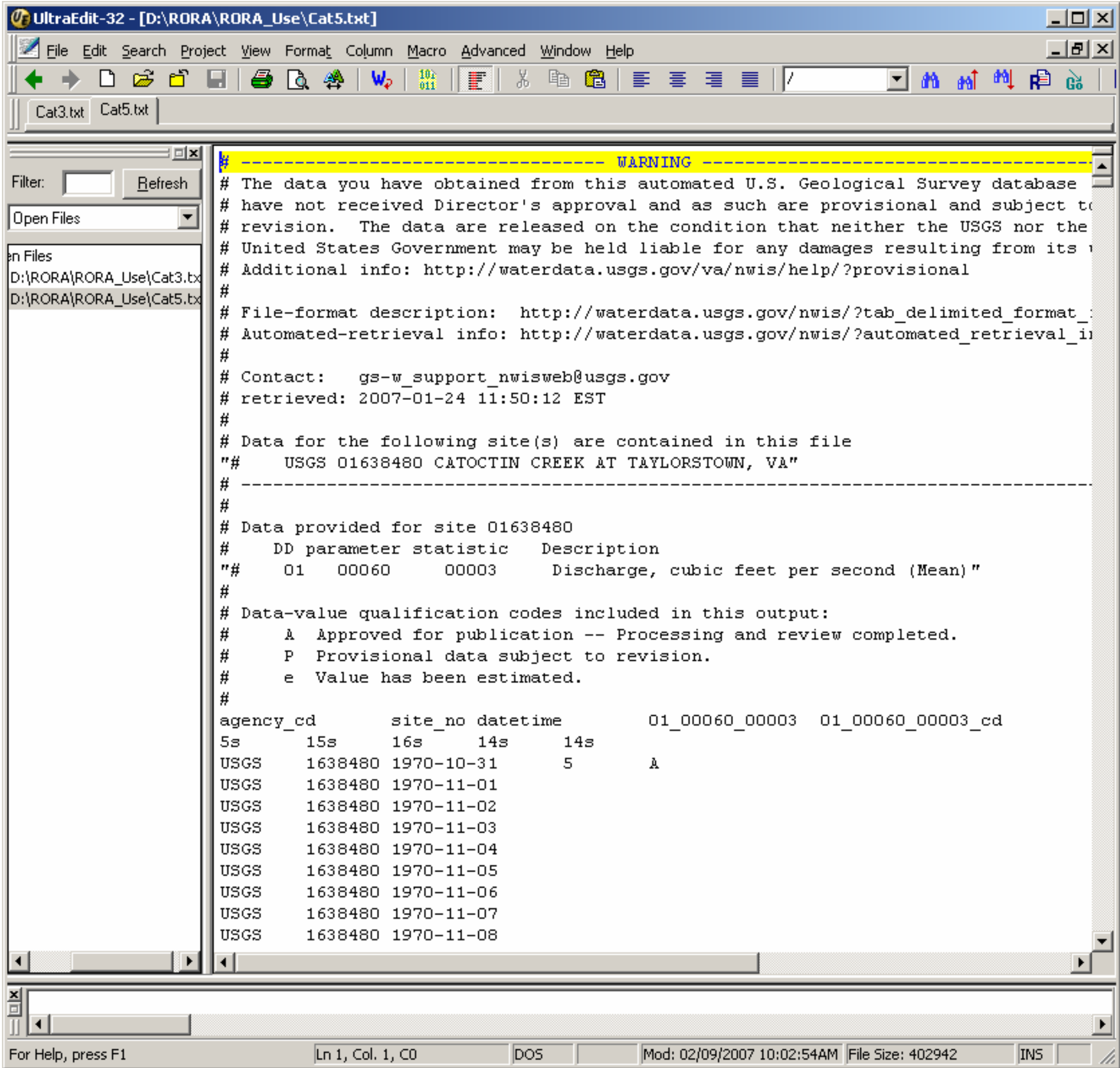

and “Yes”




Note how the date filed is formatted:

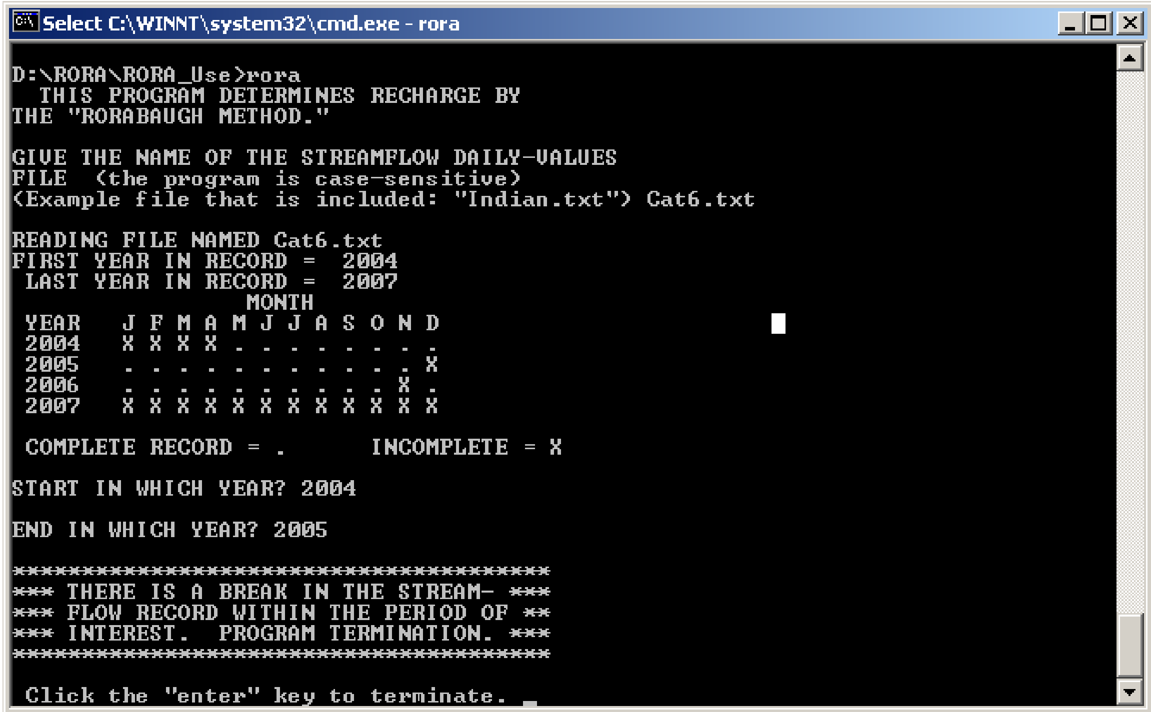



We can check the file contents:

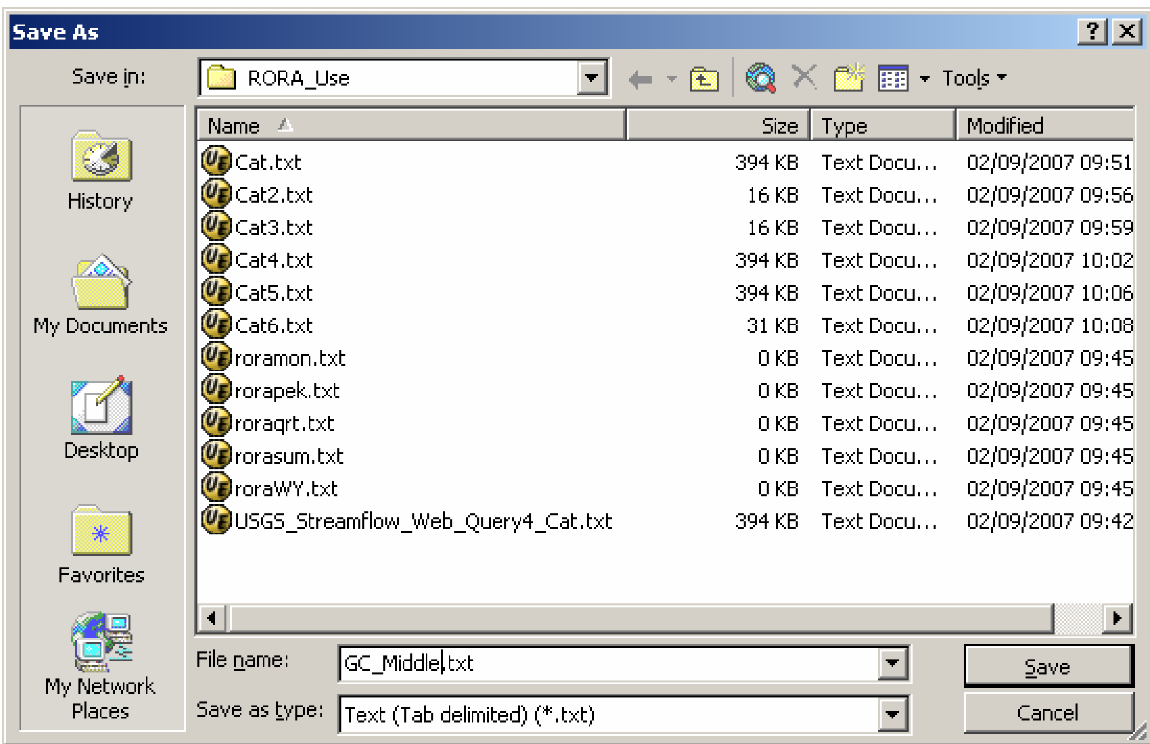


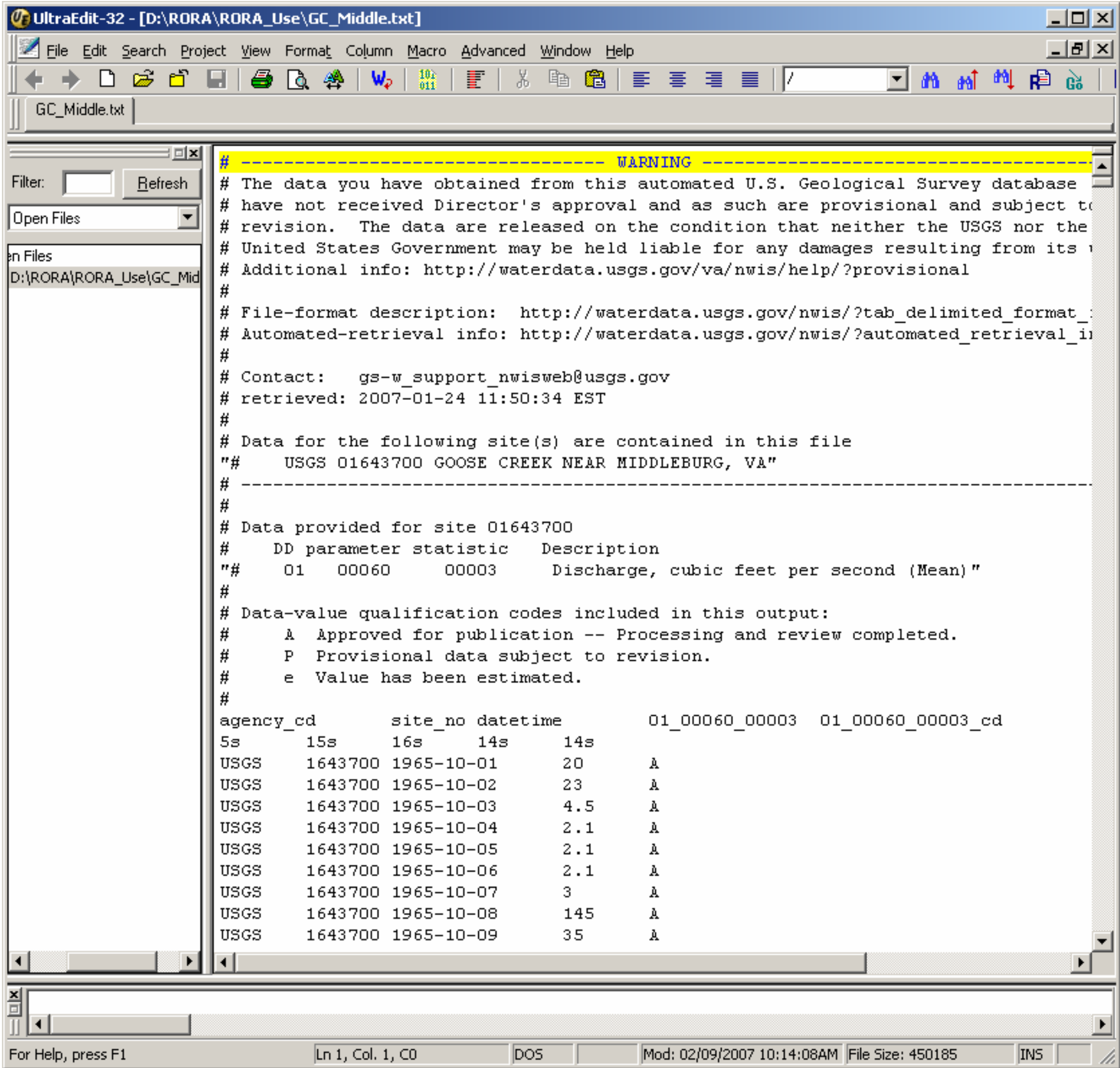

```
# -------------------------------- WARNING ----------------------------------
# The data you obtained from this automated U.S. Geological Survey database
# have not received Director's approval and as such are provisional and subject to
# revision.  The data are released on the condition that neither the USGS nor the
# United States Government may be held liable for any damages resulting from its u
# Additional info: http://waterdata.usgs.gov/va/nwis/help/?provisional
#
# File-format description:  http://waterdata.usgs.gov/nwis/?tab_delimited_format_i
# Automated-retrieval info: http://waterdata.usgs.gov/nwis/?automated_retrieval_in
#
# Contact:   gs-w_support_nwisweb@usgs.gov
# retrieved: 2007-01-24 11:50:12 EST
#
# Data for the following site(s) are contained in this file
"#    USGS 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA"
# ---------------------------------------------------------------------------
#
# Data provided for site 01638480
#    DD parameter statistic   Description
"#    01   00060     00003     Discharge, cubic feet per second (Mean)"
#
# Data-value qualification codes included in this output:
#     A  Approved for publication -- Processing and review completed.
#     P  Provisional data subject to revision.
#     e  Value has been estimated.
#
agency_cd       site_no datetime        01_00060_00003  01_00060_00003_cd
5s      15s     16s     14s     14s
USGS    1638480 1970-10-31      5       A
USGS    1638480 1970-11-01
USGS    1638480 1970-11-02
USGS    1638480 1970-11-03
USGS    1638480 1970-11-04
USGS    1638480 1970-11-05
USGS    1638480 1970-11-06
USGS    1638480 1970-11-07
USGS    1638480 1970-11-08
```

Now double click on “roar.exe” to execute the program.




The program is supposed to handle breaks in the record, but this doesn't work ????





```
# ---------------------------------- WARNING -------------------------------------
# The data you obtained from this automated U.S. Geological Survey database
# have not received Director's approval and as such are provisional and subject tc
# revision.  The data are released on the condition that neither the USGS nor the
# United States Government may be held liable for any damages resulting from its u
# Additional info: http://waterdata.usgs.gov/va/nwis/help/?provisional
#
# File-format description:  http://waterdata.usgs.gov/nwis/?tab_delimited_format_i
# Automated-retrieval info: http://waterdata.usgs.gov/nwis/?automated_retrieval_in
#
# Contact:   gs-w_support_nwisweb@usgs.gov
# retrieved: 2007-01-24 11:50:34 EST
#
# Data for the following site(s) are contained in this file
"#    USGS 01643700 GOOSE CREEK NEAR MIDDLEBURG, VA"
# -------------------------------------------------------------------------------
#
# Data provided for site 01643700
#    DD parameter statistic   Description
"#    01   00060     00003     Discharge, cubic feet per second (Mean)"
#
# Data-value qualification codes included in this output:
#     A  Approved for publication -- Processing and review completed.
#     P  Provisional data subject to revision.
#     e  Value has been estimated.
#
agency_cd       site_no datetime        01_00060_00003  01_00060_00003_cd
5s      15s     16s     14s     14s
USGS    1643700 1965-10-01      20      A
USGS    1643700 1965-10-02      23      A
USGS    1643700 1965-10-03      4.5     A
USGS    1643700 1965-10-04      2.1     A
USGS    1643700 1965-10-05      2.1     A
USGS    1643700 1965-10-06      2.1     A
USGS    1643700 1965-10-07      3       A
USGS    1643700 1965-10-08      145     A
USGS    1643700 1965-10-09      35      A
```

Need to remove the apostrophes in first column where it appears twice.

Execution

To use RORA, one can simply double click on RORA.exe and a DOS windows will open.

For repeatbility, batch files were created including "Execute_all.bat" which has:

```
call batch_execute BR
call batch_execute Beaver
call batch_execute Cat
call batch_execute GC_Lee
call batch_execute GC_Mid
call batch_execute Lime
call batch_execute NF_Cat
call batch_execute NF_GC
call batch_execute Piney
call batch_execute SF_Cat
```

and the file "batch_execute.bat" which contains:

```
rora < %1.inp
rename roraqrt.txt %1_qrt.txt
rename roramon.txt %1_mon.txt
```

Note that there are ten .inp files creates, one for each station. For example, the file "SF_Cat.inp" contains:

```
SF_Cat.txt
2002
2005
n
100
```

in which the responses are the start and ending year and other options, including the recession index value (100 days).

Need to pay attention to case in the file names. The system also uses the "Station.txt" file which contains:

```
File "station.txt"
This file is read by programs PREP, RECESS, RORA, and PART, to
obtain the drainage area.  Note: This file should have ten header
lines.  The streamflow file name should be 12 characters or less.  Note:  Needs to be
A12, F8 fields even though manual says free-format  DSW (2/8/07)
----------------------------------------------------------------
              Drainage
Name of       area             The space below, after drainage area, is
streamflow    (Square          for optional information that is not read
file          miles)           by the programs.  This is free-form.
------------  ----------       ------------------------------------------
SF_Cat.txt    31.61                   South Fork Catoctin
NF_Cat.txt    23.11                   North Fork Catoctin
Cat.txt       89.51                   Catoctin
Piney.txt     13.51                   Piney Run
Lime.txt      7.881                   Limestone Branch
NF_GC.txt     38.11                   North Fork Goose Creek
Beaver.txt    47.21                   Beaver Dam Creek
GC_Mid.txt    122.0                   Goose Creek (Middleburg)
GC_Lee.txt    332.0                   Goose Creek (Leesburg)
BR.txt        76.11                   Broad Run
```

These are predefined file naming.

Below is the screem shot for simply executing RORA.exe directly and manually supplying the responses. Note that you can’t end in 2006 as data is missing for this station.

```
C:\WINDOWS\system32\cmd.exe - Rora.exe
FILE  (the program is case-sensitive)
(Example file that is included: "Indian.txt") SF_Cat.txt

READING FILE NAMED SF_Cat.txt
FIRST YEAR IN RECORD =  2001
 LAST YEAR IN RECORD =  2007
                 MONTH
 YEAR    J F M A M J J A S O N D
 2001    X X X X X X . . . . . .
 2002    . . . . . . . . . . . .
 2003    . . . . . . . . . . . .
 2004    . . . . . . . . . . . .
 2005    . . . . . . . . . . . .
 2006    . . . . . . X . X . . .
 2007    X X X X X X X X X X X X

 COMPLETE RECORD = .       INCOMPLETE = X

START IN WHICH YEAR? 2002

END IN WHICH YEAR? 2005

NUMBER OF DAYS (WITH DATA) COUNTED =             1461
NUMBER OF DAYS THAT SHOULD BE IN THIS INTERVAL = 1461

READING FILE NAMED station.txt
FILE NAME:SF_Cat.txt
DRAINAGE AREA: 31.6100006

DO YOU WANT TO OBTAIN THE RECESSION INDEX
FROM FILE index.txt?  ONLY ANSWER "y" IF
THERE IS A LINE IN "index.txt" THAT GIVES
THE RECESSION INDEX FOR THIS STATION.
           (ENTER y OR n)                  n

ENTER RECESSION INDEX (DAYS/LOGQ):100


DO YOU WANT THE PROGRAM TO EXECUTE USING THE
DEFAULT VALUE FOR THE REQUIREMENT OF ANTECEDENT
RECESSION?
               (y or n)

 FINDING DAYS OF SUFFICIENT ANTECEDENT RECESSION
 LOCATING FIRST RECESSION PERIOD
 LOCATING PEAKS + REMAINING RECESSION PERIODS
NUMBER OF PEAKS= 195


SUMMARY RESULTS WRITTEN TO FILE "rorasum.txt"


MONTHLY RESULTS ARE WRITTEN TO FILE "roramon.txt"
...AND QUARTER-YEAR RESULTS TO FILE "roraqrt.txt"

 Click the "enter" key to terminate.
```

There is a problem with Catotin at Taylorstown NWIS data data in 1970 (i.e. “Cat.txt”). You need to manually delete stream daily records for which there is no data.

There is a small problem with Goose Creek Middleburg with a significant data gap 1977 to 2001. To resolve this a second data set GC_Mid2.txt was created.

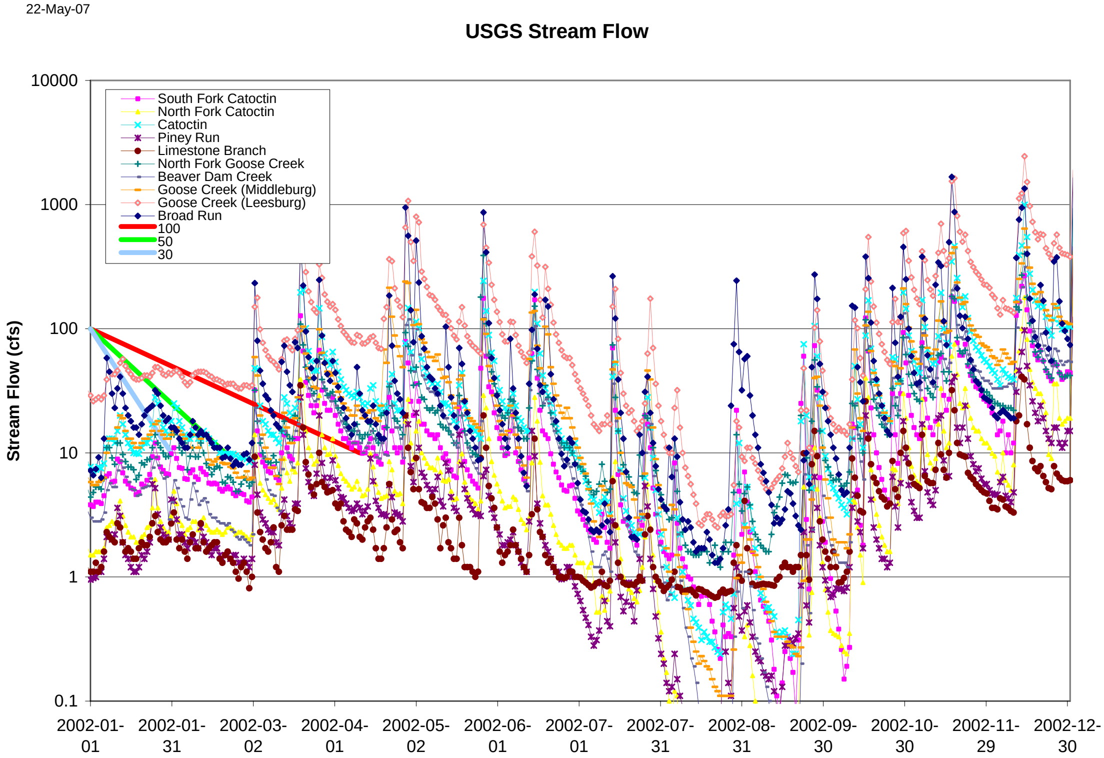
**Evaluation of Recession Index:**

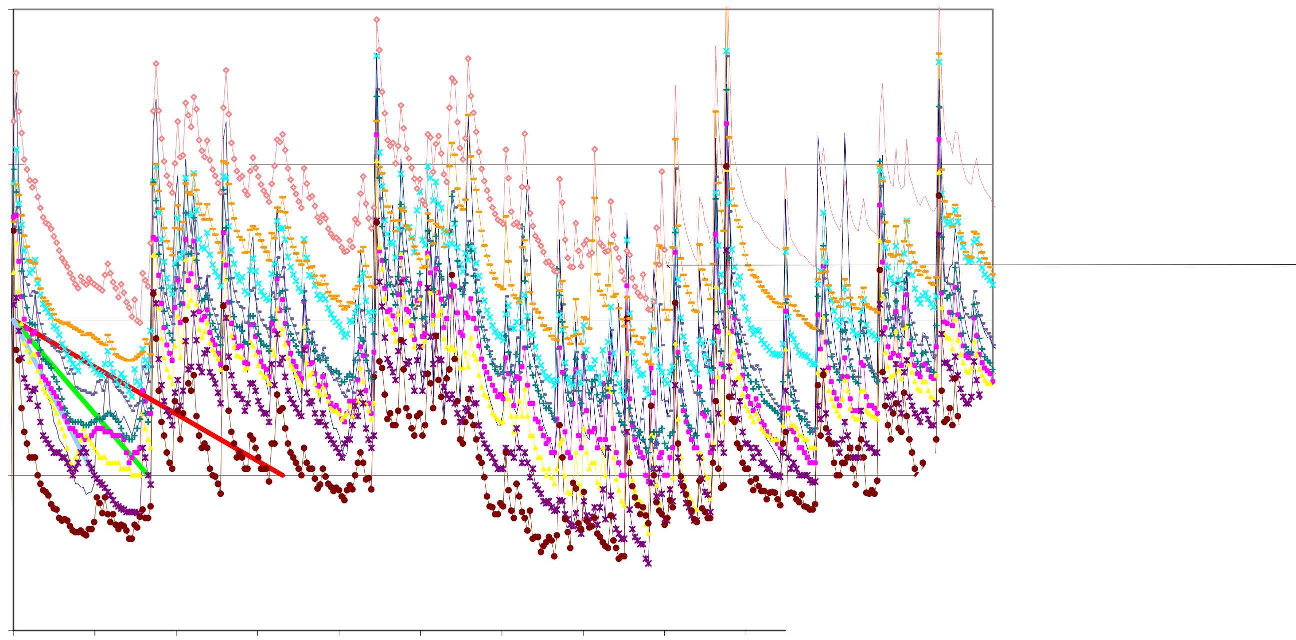
The RORA manual and recent article in Ground Water Journal, May/June 2007 by Rutledge suggest that RORA is generally insensitive to the recession index (RI) provided. The recession index is defined as the time required for the groundwater discharge to recede by one log-cycle when the recession becomes linear (or nearly linear) on a semilog hydrograph.

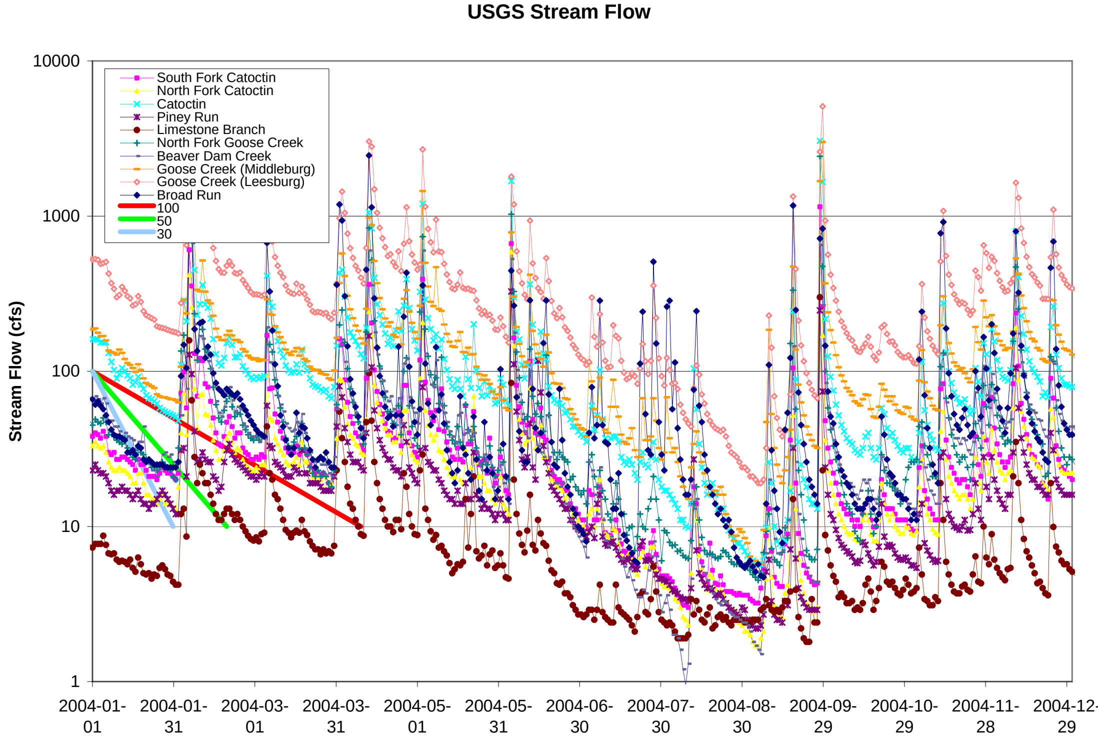
Let's look at years 2002 to 2005. A graph of all ten stations in included along with a one log-cycle drop for recession indexes with values of 100, 50 and 30 days. The closest fit for all stream appears to be between 30 and 60 days. The smallest RI appears to be Broad Run.

| Chart labels (below) | Estimated Recession Index |
|---|---|
| South Fork Catoctin | 50 |
| North Fork Catoctin | 50 |
| Catoctin | 60 |
| Piney Run | 60 |
| Limestone Branch | 40 |
| North Fork Goose Creek | 50 |
| Beaver Dam Creek | 50 |
| Goose Creek (Middleburg) | 50 |
| Goose Creek (Leesburg) | 50 |
| Broad Run | 30 |

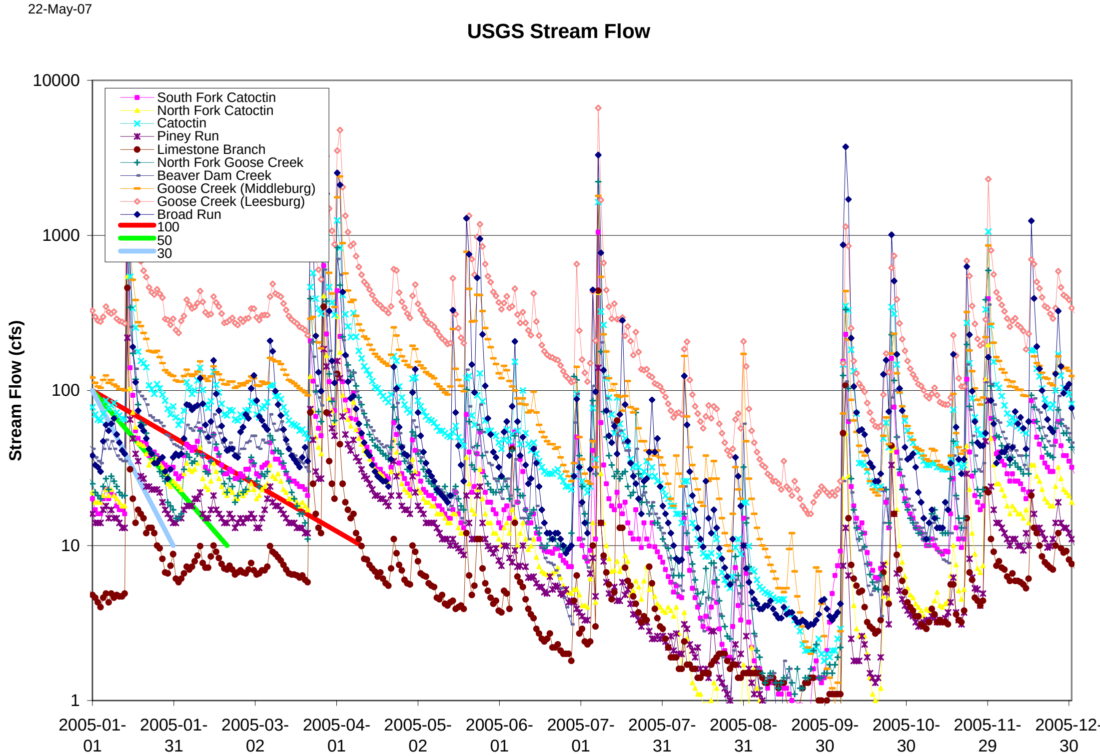
22-May-07


USGS Stream Flow
10000
1000
100
10
1
0.1
Stream Flow (cfs)
South Fork Catoctin
North Fork Catoctin
Catoctin
Piney Run
Limestone Branch
North Fork Goose Creek
Beaver Dam Creek
Goose Creek (Middleburg)
Goose Creek (Leesburg)
Broad Run
100
50
30
2002-01-01
2002-01-31
2002-03-02
2002-04-01
2002-05-02
2002-06-01
2002-07-01
2002-07-31
2002-08-31
2002-09-30
2002-10-30
2002-11-29
2002-12-30






22-May-07




To check the sensitivity recharge due to RI RORA was used to evaluate Broad Run using RI of 30 and 50 days and Catoctin at 60 and 100 days. The error introduced is 3 and 4.4%, respectively.

## Check on Contributing Area

It is important to ensure that USGS provides correct values of the drainage area for each gage. This was checked and found to be correct. Below is working spreadsheet

| File_Name | USGS Area (sq mi) | Watershed | Calculated from DRC for entire subshed (acres) | Majshed summaries (acres) | Truncated by County boundary | Comments |
|---|---|---|---|---|---|---|
| SF_Cat.txt | 31.61 | South Fork Catoctin | | 33.08 | no | Good match as expected - gage is near outlet |
| NF_Cat.txt | 23.11 | North Fork Catoctin | | 23.30 | no | Good match as expected - gage is near outlet |
| Cat.txt | 89.51 | Catoctin | 92.46 | 92.53 | no | Good match as expected - gage is near outlet |
| Piney.txt | 13.51 | Piney Run | | 14.91 | no | Good match as expected - gage is near outlet |
| Lime.txt | 7.881 | Limestone Branch | | 16.16 | no | Varies as gages is not near watershed outlet |
| NF_GC.txt | 38.11 | North Fork Goose Creek | | | | |
| Beaver.txt | 47.21 | Beaver Dam Creek | | | | |
| GC_Mid.txt | 122 | Goose Creek (Middleburg) | | | yes | |
| GC_Lee.txt | 332 | Goose Creek (Leesburg) | | | yes | |
| BR.txt | 76.11 | Broad Run | 77.92 | 63.52 | yes | |

Because there is a limited number of watersheds that are fully within the County boundaries, it is difficult to fully check the contributing areas. Nonetheless it appears that the USGS offers reasonably accurate contributing areas which are slightly less than the total watershed boundary. In other words, the USGS provides good estimates of the actual contributing area for each of the gaging stations.

Also see http://pubs.usgs.gov/of/2006/1308/ for more station drainage areas.

**Summary of Findings:**

RORA offers annual, quarterly and monthly summary values of recharge.

***Annual Recharge Summary:***

Because of missing data, the newer USGS stations do not offer sufficient data for annual averages. Therefore annual; summaries are not presented. Data is generally limited to the period 2002 to 2005.

***Quarterly Recharge Summary:***

The quarterly recharge estimates are listed below. The average recharge for all records averaged over all stations is 9.34 inches per year.

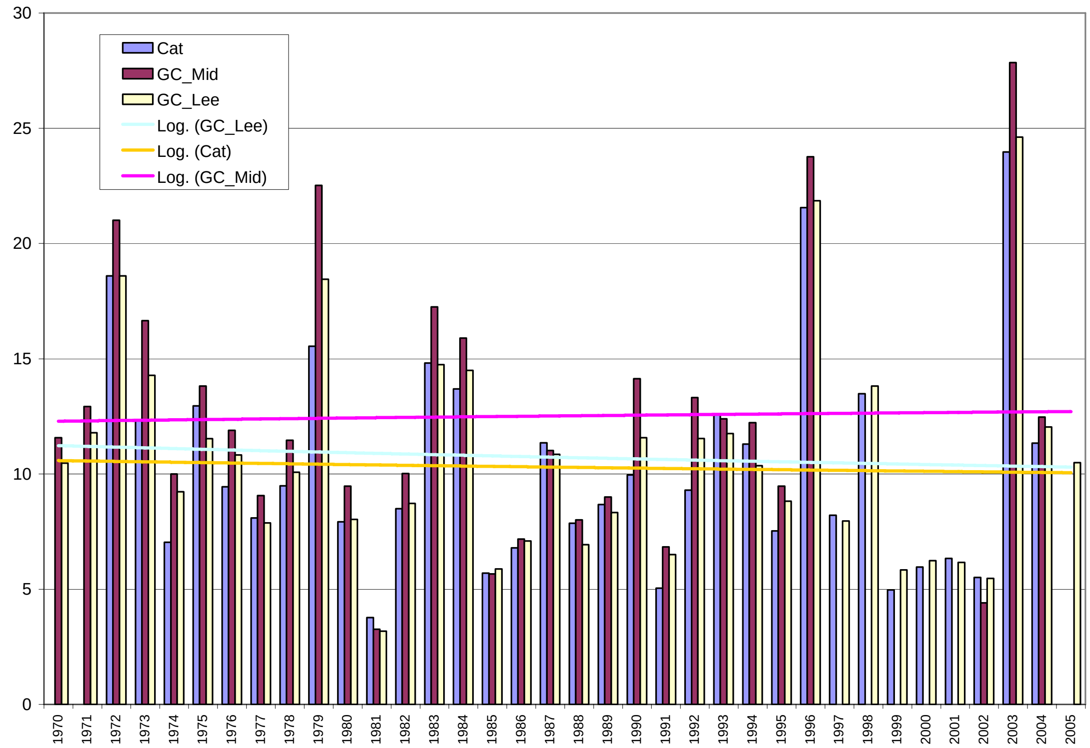
Note that there is a break in the Goose Creek (Middleburg) calculations due to incomplete data for this station.

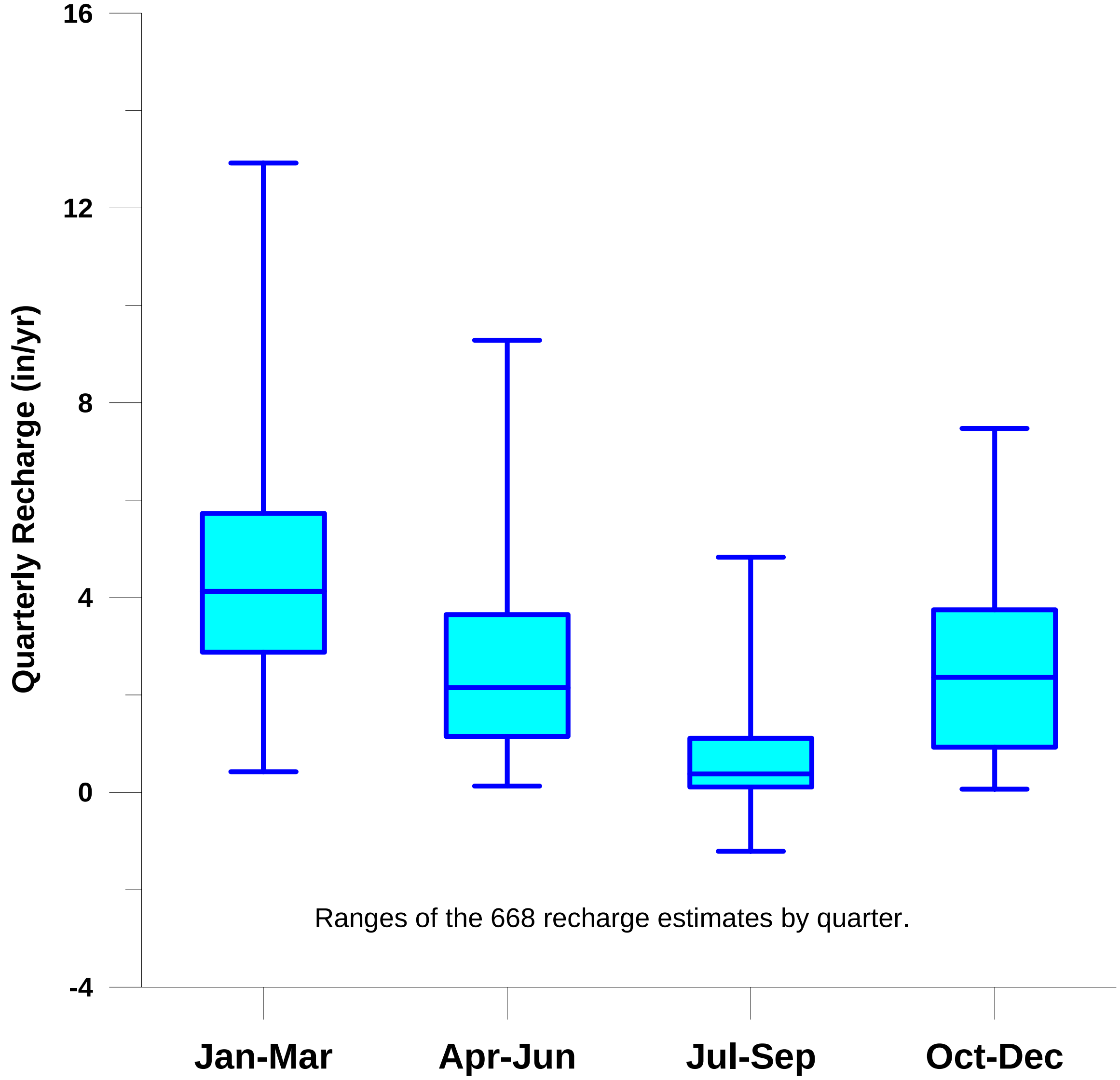
| Station | Station | Year | Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | Year Total |
|---|---|---|---|---|---|---|---|
| 1638350 South Fork Catoctin | SF_Cat | 2002 | 1.44 | 0.89 | 0.14 | 3.91 | 6.38 |
| 1638350 South Fork Catoctin | SF_Cat | 2003 | 7.52 | 7.47 | 2.72 | 5.06 | 22.77 |
| 1638350 South Fork Catoctin | SF_Cat | 2004 | 3.38 | 4.36 | 0.98 | 2.37 | 11.09 |
| 1638350 South Fork Catoctin | SF_Cat | 2005 | 5.8 | 1.21 | 0.52 | 2.91 | 10.44 |
| 1638420 North Fork Catoctin | NF_Cat | 2002 | 0.85 | 0.55 | 0.02 | 2.26 | 3.68 |
| 1638420 North Fork Catoctin | NF_Cat | 2003 | 7.71 | 7.77 | 2.2 | 6 | 23.68 |
| 1638420 North Fork Catoctin | NF_Cat | 2004 | 3.41 | 4.8 | 1.05 | 2.99 | 12.26 |
| 1638420 North Fork Catoctin | NF_Cat | 2005 | 6.29 | 1.33 | 0.25 | 1.96 | 9.83 |
| 1638480 Catoctin | Cat | 1972 | 5.96 | 8.04 | -1.21 | 5.82 | 18.6 |
| 1638480 Catoctin | Cat | 1973 | 4.13 | 5.14 | 0.67 | 2.42 | 12.36 |
| 1638480 Catoctin | Cat | 1974 | 3.1 | 1.7 | 0.43 | 1.81 | 7.04 |
| 1638480 Catoctin | Cat | 1975 | 5.15 | 2.13 | 3.31 | 2.36 | 12.95 |
| 1638480 Catoctin | Cat | 1976 | 3.61 | 1.9 | 0.48 | 3.46 | 9.45 |
| 1638480 Catoctin | Cat | 1977 | 2.5 | 1.52 | 0.18 | 3.89 | 8.09 |
| 1638480 Catoctin | Cat | 1978 | 5.83 | 2.25 | 0.47 | 0.94 | 9.48 |
| 1638480 Catoctin | Cat | 1979 | 5.65 | 1.95 | 3.18 | 4.76 | 15.54 |
| 1638480 Catoctin | Cat | 1980 | 5.04 | 2.2 | 0.33 | 0.35 | 7.92 |
| 1638480 Catoctin | Cat | 1981 | 1.44 | 1.65 | 0.21 | 0.48 | 3.77 |
| 1638480 Catoctin | Cat | 1982 | 3.8 | 3.57 | -0.25 | 1.37 | 8.49 |
| 1638480 Catoctin | Cat | 1983 | 5.52 | 5.41 | -0.11 | 4 | 14.81 |
| 1638480 Catoctin | Cat | 1984 | 9.03 | 1.89 | 0.94 | 1.83 | 13.69 |
| 1638480 Catoctin | Cat | 1985 | 2.33 | 0.77 | 0.2 | 2.41 | 5.7 |
| 1638480 Catoctin | Cat | 1986 | 4.14 | 0.75 | 0.04 | 1.86 | 6.79 |
| 1638480 Catoctin | Cat | 1987 | 3.61 | 3.68 | 1.54 | 2.52 | 11.35 |
| 1638480 Catoctin | Cat | 1988 | 3.28 | 3.65 | 0.3 | 0.63 | 7.86 |
| 1638480 Catoctin | Cat | 1989 | 4.1 | 3.59 | 0.33 | 0.67 | 8.68 |
| 1638480 Catoctin | Cat | 1990 | 3.13 | 2.46 | 0.58 | 3.79 | 9.96 |
| 1638480 Catoctin | Cat | 1991 | 4.36 | 0.22 | 0.04 | 0.43 | 5.05 |
| 1638480 Catoctin | Cat | 1992 | 2.76 | 2.28 | 0.46 | 3.8 | 9.3 |
| 1638480 Catoctin | Cat | 1993 | 9.34 | 0.58 | 0.05 | 2.61 | 12.58 |
| 1638480 Catoctin | Cat | 1994 | 9.35 | 0.13 | 0.42 | 1.39 | 11.3 |
| 1638480 Catoctin | Cat | 1995 | 3.5 | 1.02 | 0.36 | 2.65 | 7.53 |
| 1638480 Catoctin | Cat | 1996 | 6.36 | 4.44 | 4.32 | 6.44 | 21.56 |
| 1638480 Catoctin | Cat | 1997 | 5.21 | 0.61 | 0.04 | 2.35 | 8.21 |
| 1638480 Catoctin | Cat | 1998 | 10.2 | 3.22 | -0.08 | 0.14 | 13.48 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1638480 Catoctin | Cat | 1999 | 1.76 | 0.72 | 0.91 | 1.57 | 4.97 |
| 1638480 Catoctin | Cat | 2000 | 3.67 | 1.46 | 0.38 | 0.45 | 5.96 |
| 1638480 Catoctin | Cat | 2001 | 4.33 | 1.34 | 0.37 | 0.29 | 6.34 |
| 1638480 Catoctin | Cat | 2002 | 1.19 | 0.66 | 0.09 | 3.56 | 5.51 |
| 1638480 Catoctin | Cat | 2003 | 6.5 | 7.59 | 2.88 | 7 | 23.97 |
| 1638480 Catoctin | Cat | 2004 | 3.15 | 4.56 | 1.11 | 2.52 | 11.34 |
| 1636690 Piney Run | Piney | 2002 | 0.84 | 0.6 | 0.11 | 2.52 | 4.07 |
| 1636690 Piney Run | Piney | 2003 | 7.77 | 7.01 | 2.48 | 6.64 | 23.9 |
| 1636690 Piney Run | Piney | 2004 | 4.8 | 5.91 | 1.26 | 3.62 | 15.6 |
| 1636690 Piney Run | Piney | 2005 | 7.93 | 0.99 | 0.33 | 2.08 | 11.32 |
| 1643590 Limestone Branch | Lime | 2002 | 1.16 | 0.77 | 0.49 | 3.03 | 5.45 |
| 1643590 Limestone Branch | Lime | 2003 | 6.71 | 7.08 | 3.45 | 5.07 | 22.32 |
| 1643590 Limestone Branch | Lime | 2004 | 4.11 | 3.94 | 1.56 | 2.1 | 11.71 |
| 1643590 Limestone Branch | Lime | 2005 | 5.76 | 1.23 | 1.04 | 3.11 | 11.14 |
| 1643805 North Fork Goose Creek | NF_GC | 2002 | 1.48 | 1.39 | 0.42 | 3.75 | 7.04 |
| 1643805 North Fork Goose Creek | NF_GC | 2003 | 8.7 | 9.28 | 3.21 | 5.44 | 26.64 |
| 1643805 North Fork Goose Creek | NF_GC | 2004 | 3.61 | 4.69 | 1.25 | 2.69 | 12.24 |
| 1643805 North Fork Goose Creek | NF_GC | 2005 | 4.63 | 2.45 | 0.62 | 2.86 | 10.56 |
| 1643880 Beaver Dam Creek | Beaver | 2002 | 1 | 0.96 | 0.06 | 3.67 | 5.68 |
| 1643880 Beaver Dam Creek | Beaver | 2003 | 8.41 | 7.86 | 3.22 | 5.67 | 25.16 |
| 1643880 Beaver Dam Creek | Beaver | 2004 | 2.73 | 3.42 | 0.96 | 2.9 | 10.02 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1970 | 3.84 | 3.24 | 0.78 | 3.73 | 11.58 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1971 | 5.73 | 4.02 | 0.29 | 2.89 | 12.93 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1972 | 6.45 | 7.95 | -0.17 | 6.77 | 21.01 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1973 | 5.25 | 4.95 | 1.67 | 4.78 | 16.65 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1974 | 4.42 | 2.91 | 0.33 | 2.34 | 10 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1975 | 5.21 | 1.5 | 3.84 | 3.27 | 13.81 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1976 | 4.71 | 2.15 | 0.21 | 4.82 | 11.89 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1977 | 2.83 | 1.12 | 0.14 | 4.98 | 9.06 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1978 | 7.9 | 2.24 | 0.48 | 0.84 | 11.46 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1979 | 8.16 | 3.78 | 3.71 | 6.86 | 22.52 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1980 | 5.51 | 3.49 | 0.14 | 0.33 | 9.47 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1981 | 1.45 | 1.06 | 0.27 | 0.47 | 3.26 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1982 | 5.37 | 3.6 | 0.15 | 0.9 | 10.02 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1983 | 5.9 | 6.59 | -0.14 | 4.9 | 17.25 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1984 | 12.92 | 1.58 | 0.41 | 1 | 15.9 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1985 | 2.59 | 0.28 | 0 | 2.79 | 5.66 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1986 | 4.66 | 1.4 | 0.03 | 1.09 | 7.18 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1987 | 4.17 | 4.77 | 0.34 | 1.73 | 11.02 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1988 | 3.18 | 4.53 | -0.01 | 0.3 | 8.01 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1989 | 2.34 | 4.72 | 1.01 | 0.93 | 9 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1990 | 3.85 | 2.61 | 1.69 | 5.98 | 14.14 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1991 | 5.94 | 0.57 | 0 | 0.33 | 6.84 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1992 | 2.41 | 2.75 | 1.37 | 6.78 | 13.31 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1993 | 8.52 | 2.53 | -0.06 | 1.4 | 12.39 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1994 | 10.38 | 0.26 | 0.52 | 1.07 | 12.23 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1995 | 3.43 | 3.74 | -0.53 | 2.82 | 9.47 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 1996 | 7.26 | 4.74 | 4.58 | 7.19 | 23.76 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 2001 | | | 0.12 | 0.26 | |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 2002 | 0.65 | 0.78 | 0.03 | 2.95 | 4.41 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 2003 | 8.33 | 8.78 | 4.83 | 5.91 | 27.85 |
| 1643700 Goose Creek (Middleburg) | GC_Mid | 2004 | 3.38 | 4.61 | 1.5 | 2.98 | 12.47 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1930 | 2.79 | 0.97 | -0.01 | 0.07 | 3.82 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1931 | 0.42 | 0.77 | 0.12 | 0.09 | 1.41 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1932 | 3.72 | 1.94 | 0.01 | 4.56 | 10.23 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1933 | 4.32 | 3.35 | 1.38 | 0.84 | 9.89 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1934 | 2.72 | 1.33 | 0.79 | 1.6 | 6.45 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1935 | 5.08 | 3.43 | 0.38 | 2 | 10.88 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1936 | 7.31 | 0.89 | 0.05 | 1.04 | 9.29 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1937 | 4.67 | 2.88 | 1.28 | 3.6 | 12.43 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1938 | 3.27 | 1.27 | 0.18 | 1.18 | 5.89 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1939 | 5.15 | 1.7 | 0.16 | 0.46 | 7.47 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1940 | 2.57 | 2.95 | 0.28 | 3.17 | 8.97 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1941 | 2.73 | 1.38 | 0.3 | 0.25 | 4.65 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1942 | 2.4 | 0.94 | 1.8 | 5.97 | 11.1 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1943 | 4.04 | 2.15 | 0.09 | 0.26 | 6.54 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1944 | 3.69 | 0.92 | 0.06 | 1.53 | 6.2 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1945 | 2.83 | 1.22 | 3.6 | 3.93 | 11.57 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1946 | 3.83 | 2.43 | 0.55 | 1.1 | 7.92 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1947 | 2.77 | 1.15 | 0.32 | 0.64 | 4.88 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1948 | 3.06 | 2.74 | 1.76 | 7.47 | 15.04 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1949 | 4.82 | 2.32 | 0.51 | 1.08 | 8.73 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1950 | 3.53 | 1.92 | 1.26 | 4.38 | 11.09 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1951 | 6.27 | 2.32 | 0.05 | 0.49 | 9.13 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1952 | 5.74 | 4.03 | 0.57 | 2.56 | 12.9 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1953 | 6.33 | 2.25 | 0.11 | 0.42 | 9.12 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1954 | 1.67 | 1.29 | 0.08 | 1.63 | 4.68 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1955 | 2.63 | 1.05 | 1.83 | 0.94 | 6.46 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1956 | 4.13 | 0.81 | 2.3 | 2.74 | 9.99 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1957 | 4.4 | 1.57 | 0.15 | 2.68 | 8.8 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1958 | 5.73 | 1.89 | 1.11 | 0.38 | 9.11 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1959 | 1.35 | 1.95 | 0.06 | 0.75 | 4.1 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1960 | 3.96 | 2.7 | 0.68 | 0.4 | 7.74 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1961 | 4.09 | 3.11 | 0.15 | 0.9 | 8.24 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1962 | 3.26 | 0.87 | 0.15 | 0.67 | 4.95 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1963 | 3.78 | 0.57 | 0.08 | 0.86 | 5.29 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1964 | 5.45 | 2.11 | 0.15 | 1.35 | 9.05 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1965 | 6.74 | 0.8 | 0.08 | 0.16 | 7.78 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1966 | 1.72 | 1.45 | 0.45 | 1.88 | 5.51 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1967 | 4.67 | 0.48 | 1.09 | 2.25 | 8.5 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1968 | 4.5 | 1.47 | 0.17 | 1.4 | 7.53 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1969 | 2.88 | 0.43 | 0.24 | 0.68 | 4.23 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1970 | 3.9 | 2.61 | 0.53 | 3.43 | 10.47 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1971 | 4.82 | 3.3 | 0.52 | 3.15 | 11.79 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1972 | 5.43 | 7.18 | -0.02 | 6.01 | 18.6 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1973 | 4.32 | 4.99 | 1.18 | 3.8 | 14.28 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1974 | 4.75 | 1.62 | 0.46 | 2.39 | 9.23 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1975 | 4.96 | 1.7 | 2.96 | 1.91 | 11.53 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1976 | 4.6 | 1.91 | 0.27 | 4.04 | 10.82 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1977 | 2.54 | 1.19 | 0.1 | 4.06 | 7.88 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1978 | 6.43 | 2.16 | 0.76 | 0.73 | 10.08 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1979 | 6.76 | 3.07 | 3.54 | 5.08 | 18.45 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1980 | 4.44 | 3.03 | 0.17 | 0.38 | 8.03 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1981 | 1.19 | 1.09 | 0.3 | 0.6 | 3.18 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1982 | 4.07 | 3.1 | 0.19 | 1.36 | 8.72 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1983 | 5.01 | 5.48 | -0.12 | 4.37 | 14.74 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1984 | 10.43 | 2.12 | 0.73 | 1.22 | 14.5 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1985 | 2.79 | 0.36 | 0.02 | 2.7 | 5.88 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1986 | 4.45 | 1.43 | 0.04 | 1.17 | 7.09 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1987 | 4.43 | 4.08 | 0.28 | 2.05 | 10.85 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1988 | 3.19 | 3.16 | 0.16 | 0.42 | 6.93 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1989 | 2.84 | 4.16 | 0.57 | 0.76 | 8.33 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1990 | 2.47 | 3.3 | 1.22 | 4.58 | 11.58 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1991 | 5.62 | 0.6 | 0.01 | 0.26 | 6.5 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1992 | 2.16 | 2.16 | 1.2 | 6.03 | 11.54 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1993 | 7.52 | 2.28 | 0.02 | 1.92 | 11.75 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1994 | 7.95 | 0.84 | 0.57 | 1 | 10.36 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1995 | 3.54 | 2.38 | 0.01 | 2.88 | 8.82 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1996 | 7.26 | 4.41 | 3.77 | 6.42 | 21.86 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1997 | 5.72 | 0.75 | 0.06 | 1.42 | 7.96 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1998 | 10.63 | 3.12 | -0.08 | 0.13 | 13.81 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 1999 | 2.31 | 0.6 | 1.33 | 1.58 | 5.84 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2000 | 3.23 | 1.75 | 0.61 | 0.65 | 6.24 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2001 | 4.06 | 1.4 | 0.35 | 0.35 | 6.16 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2002 | 0.9 | 1.08 | 0.07 | 3.42 | 5.47 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2003 | 7.1 | 7.52 | 3.55 | 6.46 | 24.62 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2004 | 3.01 | 4.44 | 1.32 | 3.27 | 12.04 |
| 1644000 Goose Creek (Leesburg) | GC_Lee | 2005 | 3.02 | 4.08 | 0.75 | 2.65 | 10.49 |
| 1644280 Broad Run | BR | 2002 | 1.1 | 1.14 | 0.48 | 2.97 | 5.7 |
| 1644280 Broad Run | BR | 2003 | 3.2 | 4.91 | 1.46 | 4.25 | 13.81 |
| 1644280 Broad Run | BR | 2004 | 2.3 | 2.09 | 1.16 | 1.77 | 7.33 |
| 1644280 Broad Run | BR | 2005 | 3.48 | 1.39 | 0.73 | 2.4 | 8.01 |




16
12
8
4
0
-4
Quarterly Recharge (in/yr)
Ranges of the 668 recharge estimates by quarter.
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec

Taking annual averages for each station from the above quarterly data yields:

| Name | Abbreviation | Site_no | Year of First Complete Record | Annual Average for Entire Record (in/yr) | Annual Average for Recent 2002-2005 (in/yr) |
|---|---|---|---|---|---|
| South Fork Catoctin | SF_Cat | 1638350 | 2002 | 12.67 | 12.67 |
| North Fork Catoctin | NF_Cat | 1638420 | 2002 | 12.36 | 12.36 |
| Catoctin | Cat | 1638480 | 1972 | 10.29 | 11.79 |
| Piney Run | Piney | 1636690 | 2002 | 13.72 | 13.72 |
| Limestone Branch | Lime | 1643590 | 2002 | 12.66 | 12.66 |
| North Fork Goose Creek | NF_GC | 1643805 | 2002 | 14.12 | 14.12 |
| Beaver Dam Creek | Beaver | 1643880 | 2002 | 13.62 | 13.62 |
| Goose Creek (Middleburg) | GC_Middle | 1643700 | 1970 | 12.49 | 14.91 |
| Goose Creek (Leesburg) | GC_Lee | 1644000 | 1930 | 9.26 | 11.76 |
| Broad Run | BR | 1644280 | 2002 | 8.71 | 8.71 |
| **Average** | | | | **11.99** | **12.63** |

Low Flow and Baseflow Statistics from Streamflow Records

## Background

Low-flow, base-flow, and mean-flow characteristics are an important part of assessing water resources in a watershed. These streamflow characteristics can be used by watershed planners and regulators to determine water availability, water use allocations, assimilative capacities of streams, and aquatic-habitat needs. Streamflow characteristics are commonly predicted by use of regression equations when a nearby streamflow-gaging station is not available.

Low flow and base flow are measures of streamflow that can help to identify environmentally vulnerable (stressed) watershed A more complete definition of stress includes streamflow quantity, quality and habitat factors.

In the 1999 work plan for the Massachusetts Water Resource Commission (WRC), these stresses are defined as:

> **Quantity:** A significant reduction in streamflow is defined as a decrease in key low and high streamflow statistics. Low flows in most of Massachusetts reflect ground water levels and are a good indicator of the health of a system. Reduced low flows can impact aquatic habitat and water quality. In addition, low flows are often the first indicator of environmental impacts.
>
> **Quality:** A degraded water quality is defined as water in a stream that does not meet surface water quality standards.
>
> **Habitat Factors:** A degraded habitat is defined as a river reach in which key habitat factors, such as temperature, quality, cover, substrate and accessibility, necessary to sustain a biologically diverse community are degraded. The stress can be due to a lack of streamflow, quality degradation, presence of dams, channel modifications, culverting and other factors. Indicators of stressed habitat include the absence or degradation of a target fish or other aquatic community or the absence of the ability of fish to move between multiple habitats necessary to their life cycles. Factors that limit movement include lack of flow, or reaches with no flow, and the presence of dams or other restrictions that prevent passage.

Low flow statistics often include the “7Q10” value (defined below).

**7Q10:** The streamflow that occurs over 7 consecutive days and has a 10-year recurrence interval period, or a 1 in 10 chance of occurring in any one year. Daily streamflows in the 7Q10 range are general indicators of prevalent drought conditions which normally cover large areas. 7Q10 values are also used by the State for regulating water withdrawals and discharges into streams.

**30Q2 :** The streamflow that occurs over 30 consecutive days and has a 2-year recurrence interval period, or a 1 in 2 chance of occurring in any one year. Daily streamflows in the 30Q2 range are general indicators of initial drought conditions which may cover large areas, and may be used by State regulators in determining water-use restrictions.

http://ga2.er.usgs.gov/lowflow/helplowflowstats.cfm

EPA has found that: "In 1986, the EPA determined that the hydrological-based 7Q10 design flow was similar to the biologically-based 4B3 design flow and recommended the use of either design flow for water quality standards and toxic wasteload allocation studies relating to chronic effects on aquatic life. Although the 7Q10 is used by about half the states in the nation, the 7Q10 is sometimes characterized as being either overprotective or under-protected of aquatic life in various areas of the country. States regularly propose alternative hydrologically-based design flow statistics for their water quality standards (in the form of xQy where x is the duration and y is the frequency). For example, one state currently uses the 3Q2 statistic for conventional pollutants and several other states use a 7Q2 statistic. States often justify the use of a design flow other than 7Q10 on the basis of different hydrogeology. States sometimes suggest the use of a percentile flow (e.g., the 4th percentile) on the basis of ease of calculation and communication with the public."
(http://www.epa.gov/waterscience/models/dflow/apps.htm)

In Massachussetts, both the 7Q10 and August Median flows for the sub-basin are used in their assessment of stressed streams.

In PA, Q7,10; Q7,2; Q30,10; Q30,2; and Q90,10 low-flow characteristics have been studied. http://pubs.usgs.gov/sir/2006/5130/pdf/sir2006-5130.pdf

**Seasonal Streamflow Conditions and Historic Droughts in Virginia**
(From http://va.water.usgs.gov/drought/histcond.htm)

In a typical year, highest streamflows occur during the winter months, decreasing through the spring and summer, with lowest streamflows occurring during the fall months. During the winter of 1998, above average precipitation recharged the ground-water system, which in turn, maintained streamflows in the above normal range of flows. Even though there was below average precipitation during the spring and summer of 1998, streamflows did not fall below normal until September of that year because of the high ground-water storage. With continued dry conditions in the fall, ground-water storage became depleted, and streamflows continued to decline to levels near those observed in past droughts. Streamflows remained in the below normal range during the winter of 1999 because precipitation was insufficient to fully recharge the ground-water system. During base-flow conditions (non-storm runoff), streams had about one-third of the flow during the winter of 1999 than they had during the winter of 1998. The already depleted ground-water storage conditions combined with less than normal precipitation during the past three months has resulted in continued low streamflows. June streamflows are

already at or near typical annual low flow values, and streamflows are expected to continue to decline through the summer.

There have been four major Statewide droughts since the early 1900's. The drought of 1930-32 was one of the most severe droughts recorded in the State. Recurrence intervals ranged from 30 years to greater than 80 years. The droughts of 1938-42 and 1962-71 were less severe; however, the cumulative streamflow deficit for the 1962-71 drought was the greatest of the four droughts because of the duration of this drought. The drought of 1980-82 was the least severe and had the shortest duration. Recurrence intervals in the 1980-82 drought ranged from 15 years across most of the State to greater than 80 years in the James River Basin.
Last modified: 03/12/02

**Base and Low flow in Loudoun County**

In Loudoun County, there are three stream gages with long periods of record (more than 20 years) and seven gages with only a few years of data. Because it is not possible to calculate 7Q10 on the newer stream gages, other statistics are be analyzed also.

**August Median Flows:**

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http://pubs.usgs.gov/wri/wri004135/pdf/report.pdf

**Importance of minimum base flow**

0.50 ft3/s/mi2, the ABF low-flow value recommended to "sustain and perpetuate indigenous aquatic fauna" (U.S. Fish and Wildlife Service, 1981). page 63
http://pubs.usgs.gov/wri/wri034330/pdf/wrir034330.pdf and
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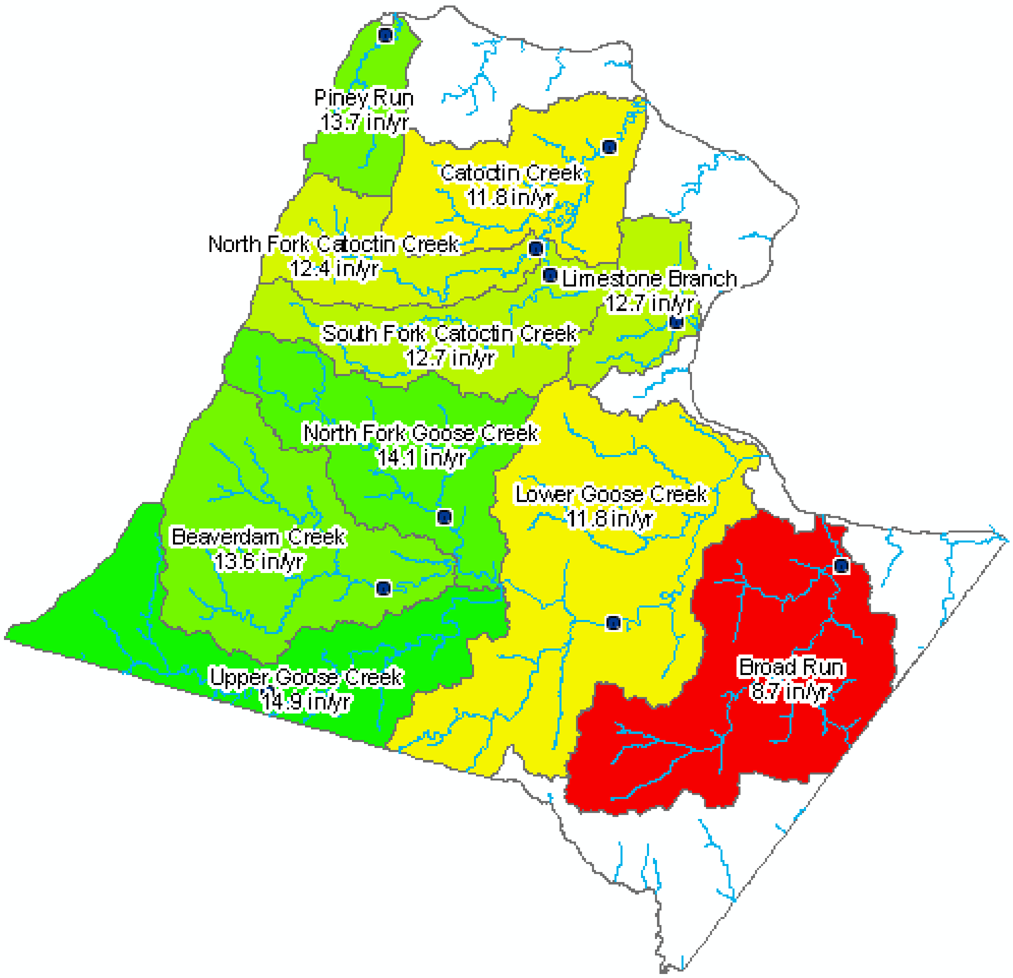
## References:

U.S. Fish and Wildlife Service, 1981, Interim regional policy for New England streamflow recommendations: Newton Corner, MA, U.S. Fish and Wildlife Service, 3 p.

**Spatial Distribution:**

What about the fact that 3 gages are long-term and others have only a few years? Let's go back and calculate recharge using similar recent data for those 3 gages thereby providing a more consistent basis for spatial comparison.

The spatial distribution of the recent (2002-2005) data may be mapped as:




O:\project\wrmp\Recharge\ Recharge_Analysis_Map06.mxd

**Temporal Changes:**

Have there been temporal changes in recharge? We can't examine all ten gages as seven have limited data. Using simple Excel trend fit shows that the three gages are trending downwards somewhat. We need to examine recharge concurrent with precipitation. How about cumulative recharge versus cumulative rainfall?

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http://pubs.usgs.gov/wri/wri004135/pdf/report.pdf

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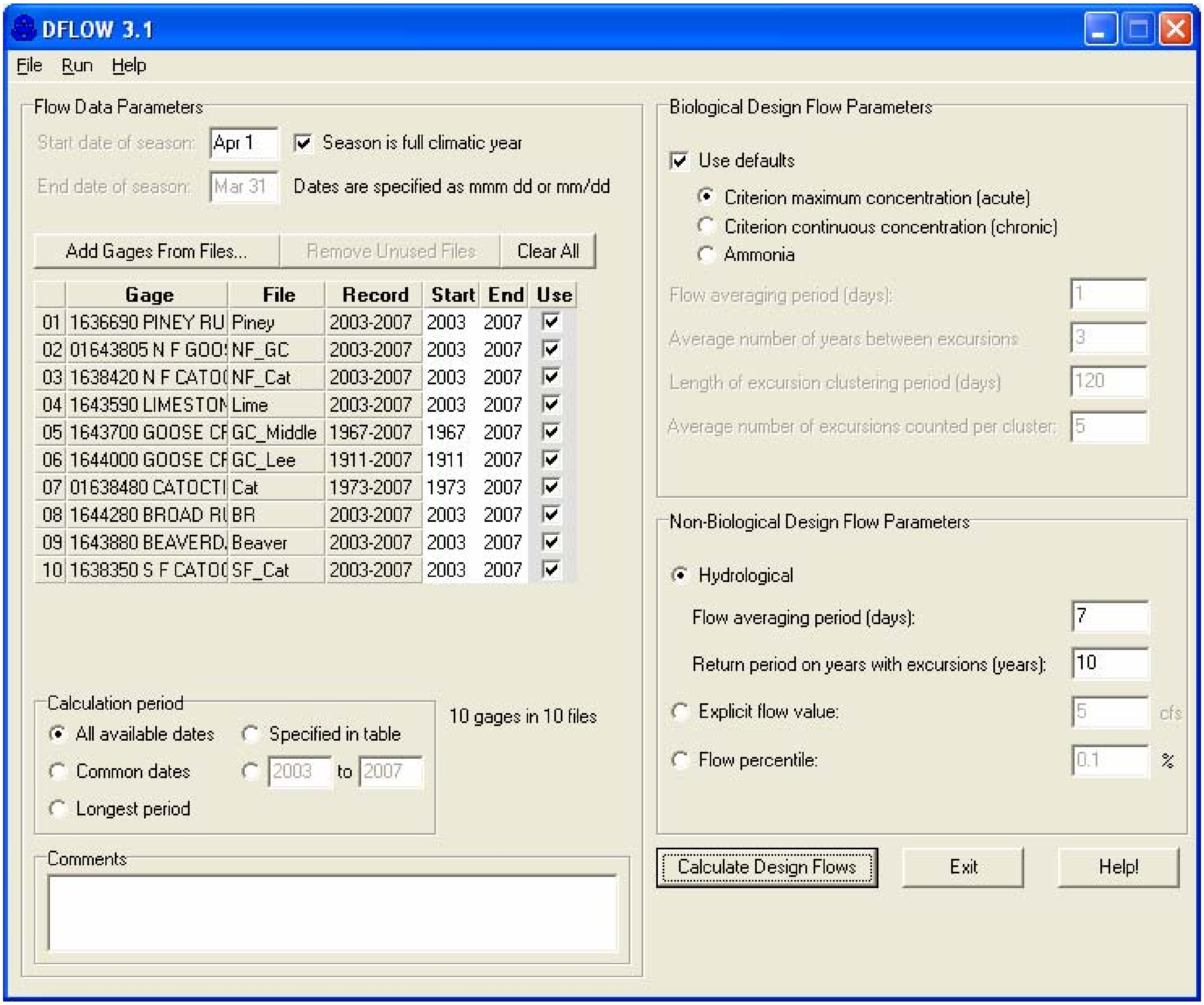
## References:

U.S. Fish and Wildlife Service, 1981, Interim regional policy for New England streamflow recommendations: Newton Corner, MA, U.S. Fish and Wildlife Service, 3 p.

# Calculating Baseflow Using DFLOW

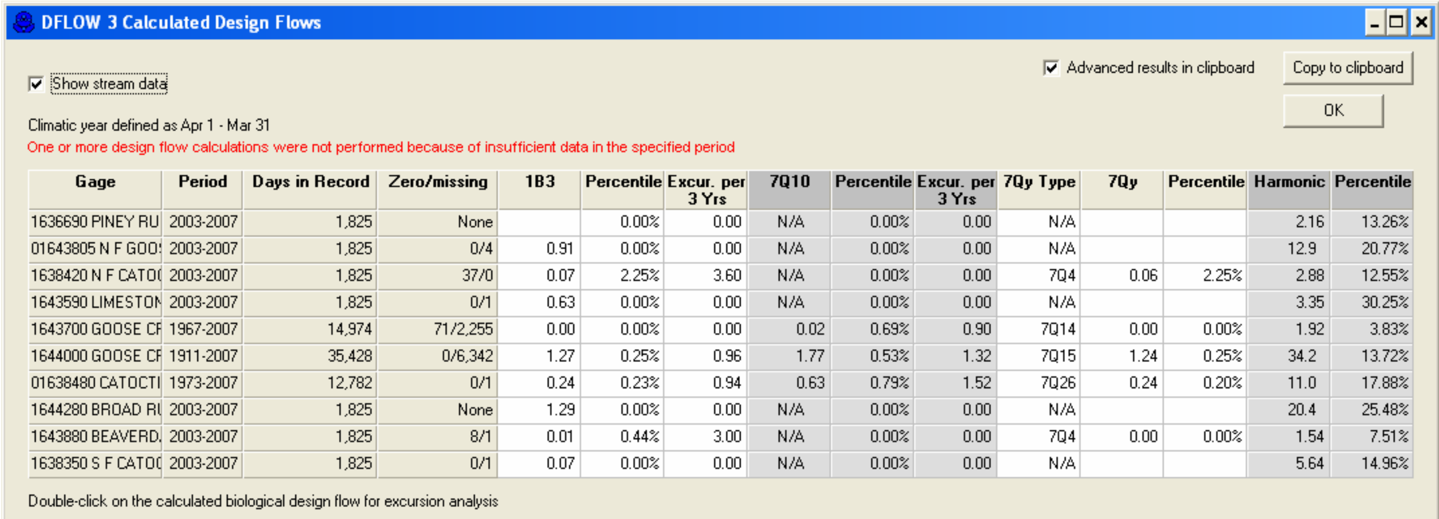
**Background:** DFLOW 3.1 is an update to the Windows-based revision of the DFLOW computer code developed by U.S. EPA in the early 1990s to estimate design stream flows for use in water quality studies. DFLOW 3.1 directly incorporates the USGS A193 calculation for Log Pearson Type III estimation, but otherwise uses the same algorithms as the original program. It also provides an easier-to-use interface and additional functionality.

**Application:** Edit and load data. This done starting with the USGS Streamflow web query. The DFLOW program cl.aims to use NWIS formatted data, but there are numerous manual edits required including, use of older header records, removal of blank readings, formatting date and adding leading zero to match station id.




Note that 7 of the 10 only began recording data in July 2001. It's not clear why DFLOW won't allow these early dates.

Now "Calculate Design Flows" for the 7Q10, 7Q5, 7Q2 and 1Q10.



DFLOW 3 Calculated Design Flows

Show stream data

Advanced results in clipboard

Copy to clipboard

OK

Climatic year defined as Apr 1 - Mar 31

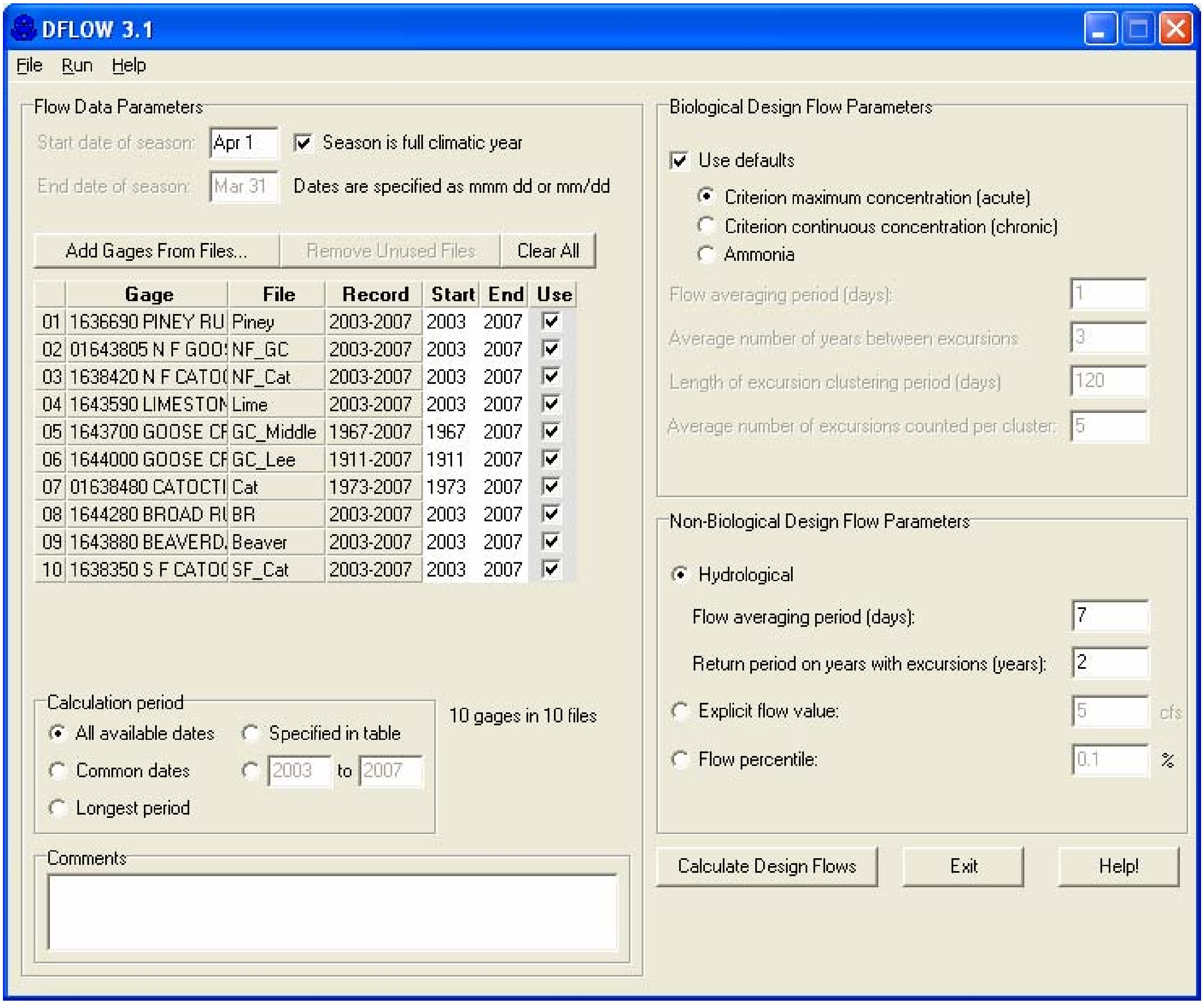
One or more design flow calculations were not performed because of insufficient data in the specified period

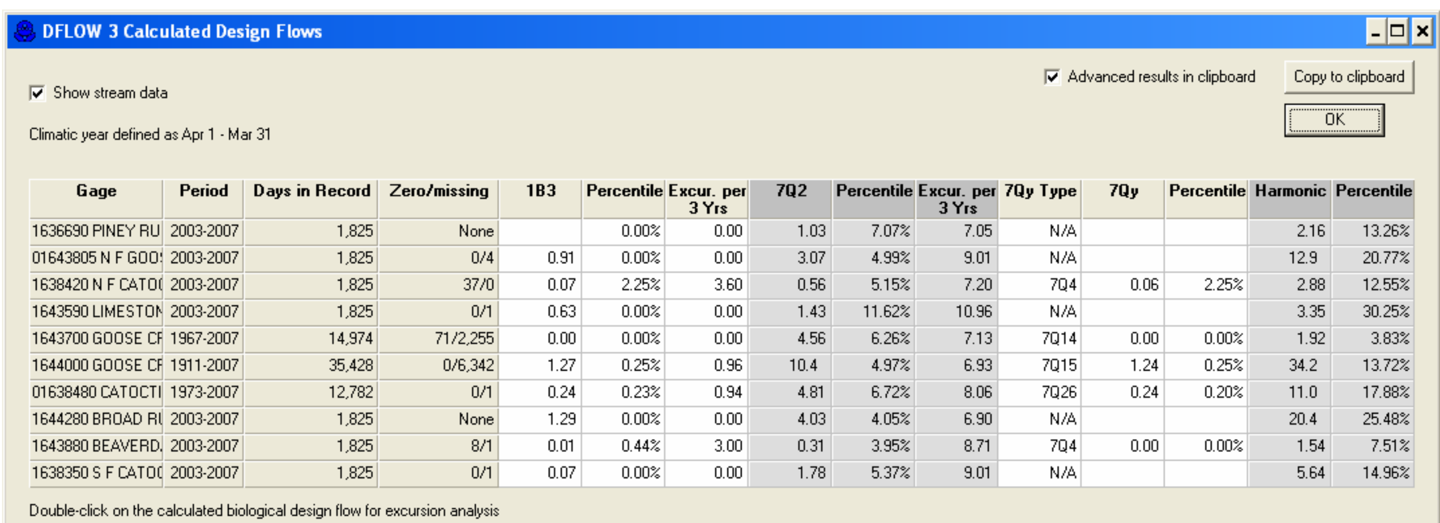
| Gage | Period | Days in Record | Zero/missing | 1B3 | Percentile | Excur. per 3 Yrs | 7Q10 | Percentile | Excur. per 3 Yrs | 7Qy Type | 7Qy | Percentile | Harmonic | Percentile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1636690 PINEY RU | 2003-2007 | 1,825 | None | | 0.00% | 0.00 | N/A | 0.00% | 0.00 | N/A | | | 2.16 | 13.26% |
| 01643805 N F GOO | 2003-2007 | 1,825 | 0/4 | 0.91 | 0.00% | 0.00 | N/A | 0.00% | 0.00 | N/A | | | 12.9 | 20.77% |
| 1638420 N F CATO | 2003-2007 | 1,825 | 37/0 | 0.07 | 2.25% | 3.60 | N/A | 0.00% | 0.00 | 7Q4 | 0.06 | 2.25% | 2.88 | 12.55% |
| 1643590 LIMESTON | 2003-2007 | 1,825 | 0/1 | 0.63 | 0.00% | 0.00 | N/A | 0.00% | 0.00 | N/A | | | 3.35 | 30.25% |
| 1643700 GOOSE CF | 1967-2007 | 14,974 | 71/2,255 | 0.00 | 0.00% | 0.00 | 0.02 | 0.69% | 0.90 | 7Q14 | 0.00 | 0.00% | 1.92 | 3.83% |
| 1644000 GOOSE CF | 1911-2007 | 35,428 | 0/6,342 | 1.27 | 0.25% | 0.96 | 1.77 | 0.53% | 1.32 | 7Q15 | 1.24 | 0.25% | 34.2 | 13.72% |
| 01638480 CATOCTI | 1973-2007 | 12,782 | 0/1 | 0.24 | 0.23% | 0.94 | 0.63 | 0.79% | 1.52 | 7Q26 | 0.24 | 0.20% | 11.0 | 17.88% |
| 1644280 BROAD RU | 2003-2007 | 1,825 | None | 1.29 | 0.00% | 0.00 | N/A | 0.00% | 0.00 | N/A | | | 20.4 | 25.48% |
| 1643880 BEAVERD. | 2003-2007 | 1,825 | 8/1 | 0.01 | 0.44% | 3.00 | N/A | 0.00% | 0.00 | 7Q4 | 0.00 | 0.00% | 1.54 | 7.51% |
| 1638350 S F CATO | 2003-2007 | 1,825 | 0/1 | 0.07 | 0.00% | 0.00 | N/A | 0.00% | 0.00 | N/A | | | 5.64 | 14.96% |

Double-click on the calculated biological design flow for excursion analysis

Copy this to clipboard and baste into new Excel sheet.

Now return and change from 7Q10 to 7Q2 to include short records




| Gage | Period | Days in Record | Zero/missing | 1B3 | Percentile | Excur. per 3 Yrs | 7Q2 | Percentile | Excur. per 3 Yrs | 7Qy Type | 7Qy | Percentile | Harmonic | Percentile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1636690 PINEY RU | 2003-2007 | 1,825 | None | | 0.00% | 0.00 | 1.03 | 7.07% | 7.05 | N/A | | | 2.16 | 13.26% |
| 01643805 N F GOO! | 2003-2007 | 1,825 | 0/4 | 0.91 | 0.00% | 0.00 | 3.07 | 4.99% | 9.01 | N/A | | | 12.9 | 20.77% |
| 1638420 N F CATO( | 2003-2007 | 1,825 | 37/0 | 0.07 | 2.25% | 3.60 | 0.56 | 5.15% | 7.20 | 7Q4 | 0.06 | 2.25% | 2.88 | 12.55% |
| 1643590 LIMESTON | 2003-2007 | 1,825 | 0/1 | 0.63 | 0.00% | 0.00 | 1.43 | 11.62% | 10.96 | N/A | | | 3.35 | 30.25% |
| 1643700 GOOSE CF | 1967-2007 | 14,974 | 71/2,255 | 0.00 | 0.00% | 0.00 | 4.56 | 6.26% | 7.13 | 7Q14 | 0.00 | 0.00% | 1.92 | 3.83% |
| 1644000 GOOSE CF | 1911-2007 | 35,428 | 0/6,342 | 1.27 | 0.25% | 0.96 | 10.4 | 4.97% | 6.93 | 7Q15 | 1.24 | 0.25% | 34.2 | 13.72% |
| 01638480 CATOCTI | 1973-2007 | 12,782 | 0/1 | 0.24 | 0.23% | 0.94 | 4.81 | 6.72% | 8.06 | 7Q26 | 0.24 | 0.20% | 11.0 | 17.88% |
| 1644280 BROAD RI | 2003-2007 | 1,825 | None | 1.29 | 0.00% | 0.00 | 4.03 | 4.05% | 6.90 | N/A | | | 20.4 | 25.48% |
| 1643880 BEAVERD. | 2003-2007 | 1,825 | 8/1 | 0.01 | 0.44% | 3.00 | 0.31 | 3.95% | 8.71 | 7Q4 | 0.00 | 0.00% | 1.54 | 7.51% |
| 1638350 S F CATO( | 2003-2007 | 1,825 | 0/1 | 0.07 | 0.00% | 0.00 | 1.78 | 5.37% | 9.01 | N/A | | | 5.64 | 14.96% |

Double-click on the calculated biological design flow for excursion analysis

To verify this work, Catoctin data was truncated to 1984. A 7Q10 was calculated as 3.01 cfs. This compares well with USGS reported value of 2.99.

WR Analysis: Stream base flow

Program: BFLOW by Arnold, et al, 1995

Finding: The SWAT program provides a quick determination of the baseflow component for the ten stream gages.

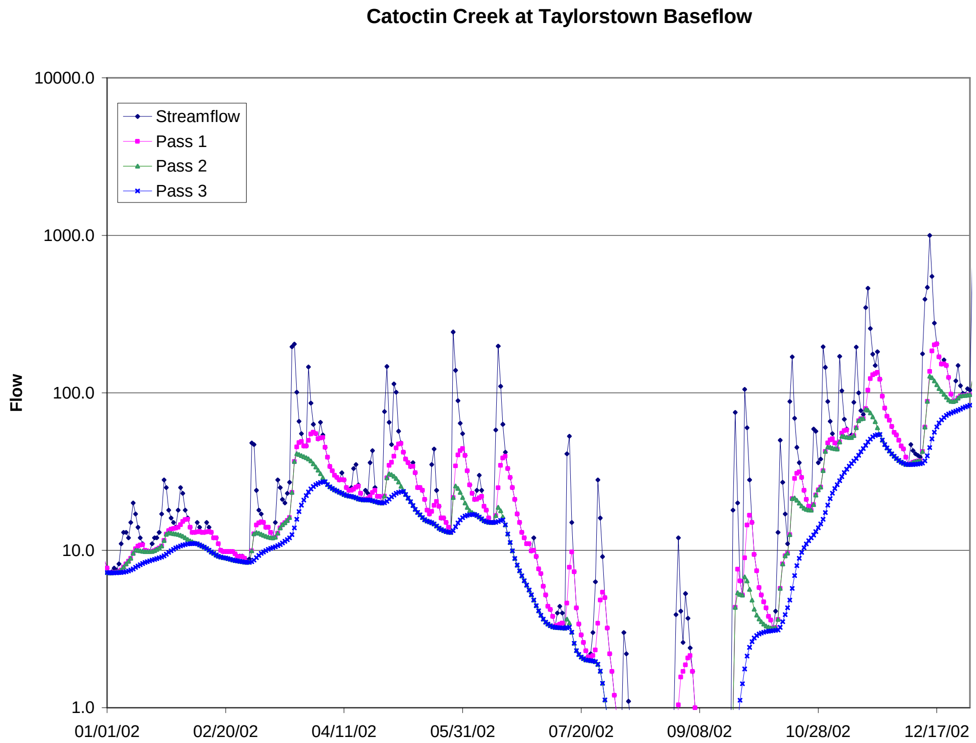
As an example, the period of record at Catoctin Creek at Taylorstown 1971-2006, was analyzed. There are about 13,000 daily measurements of stream flow. Data is currently maintained through a web query. Data must be manually reformatted to conform to BFLOW program specifications.

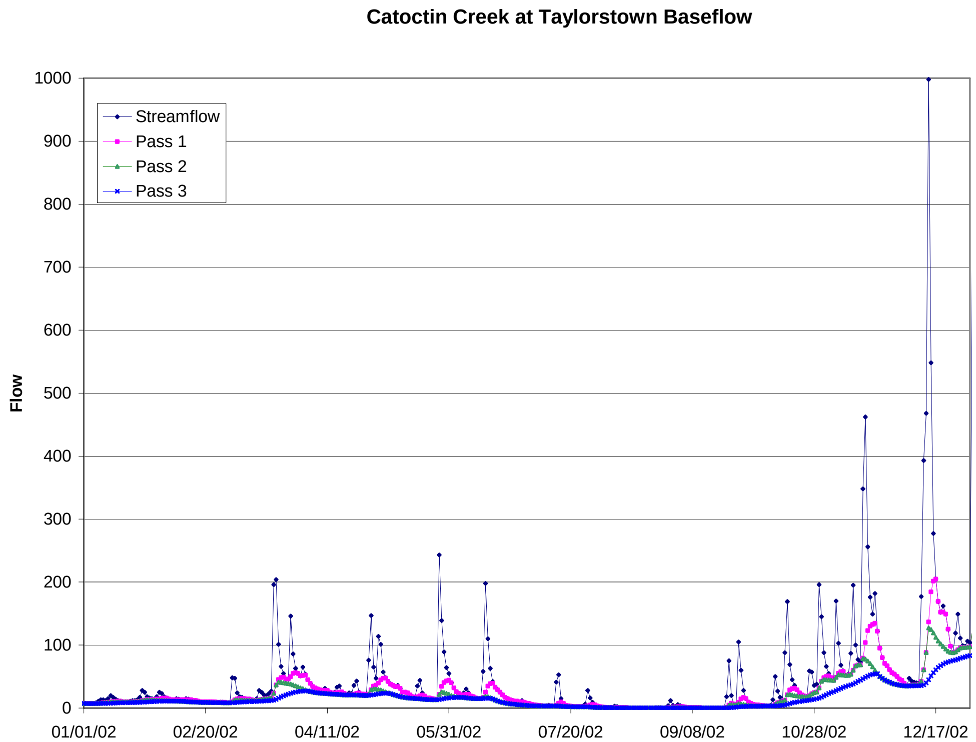
Arnold, et al, 1995

| Baseflow Fr1 | Baseflow Fr2 | Baseflow Fr3 |
|---|---|---|
| 0.61 | 0.46 | 0.39 |

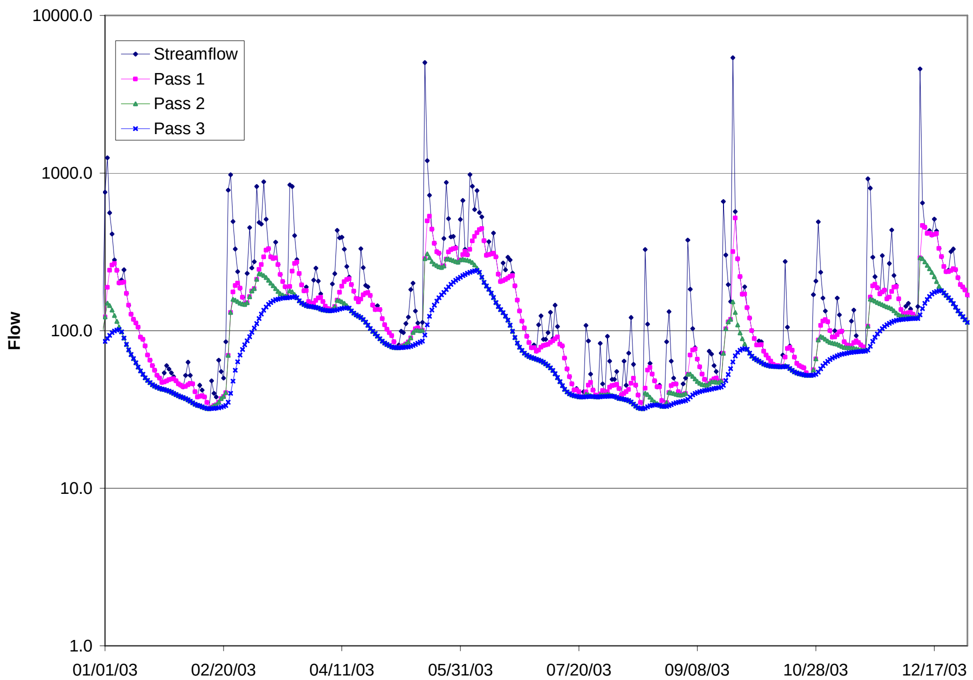
This indicates that 61 percent of the flow in Catoctin is baseflow and 39 percent is storm events.

Example outputs display in log flow and linear flow for the years 2002 to 2006 are presented.

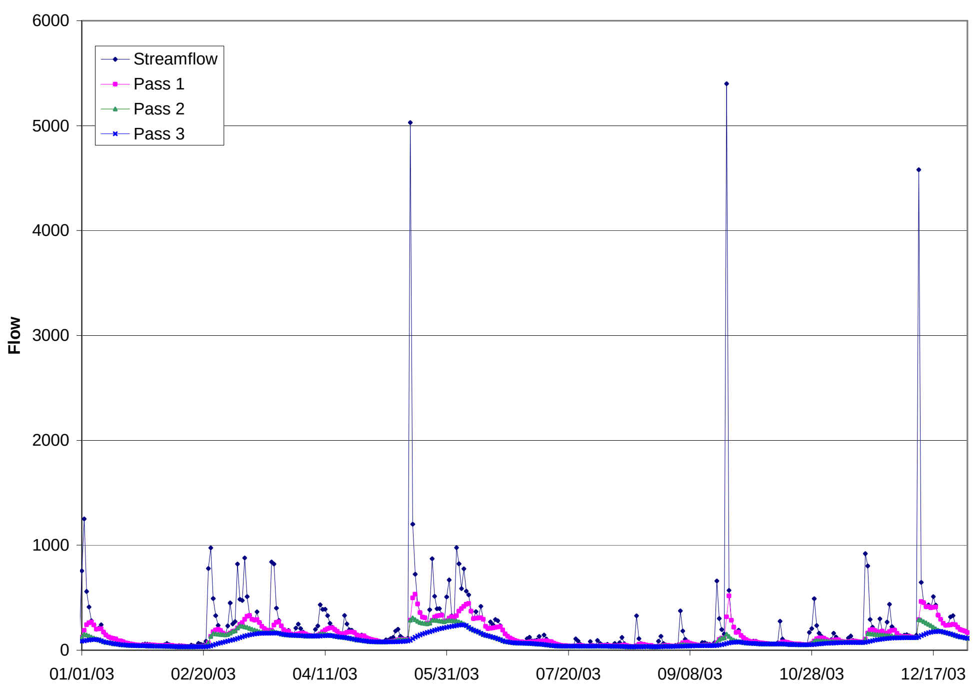


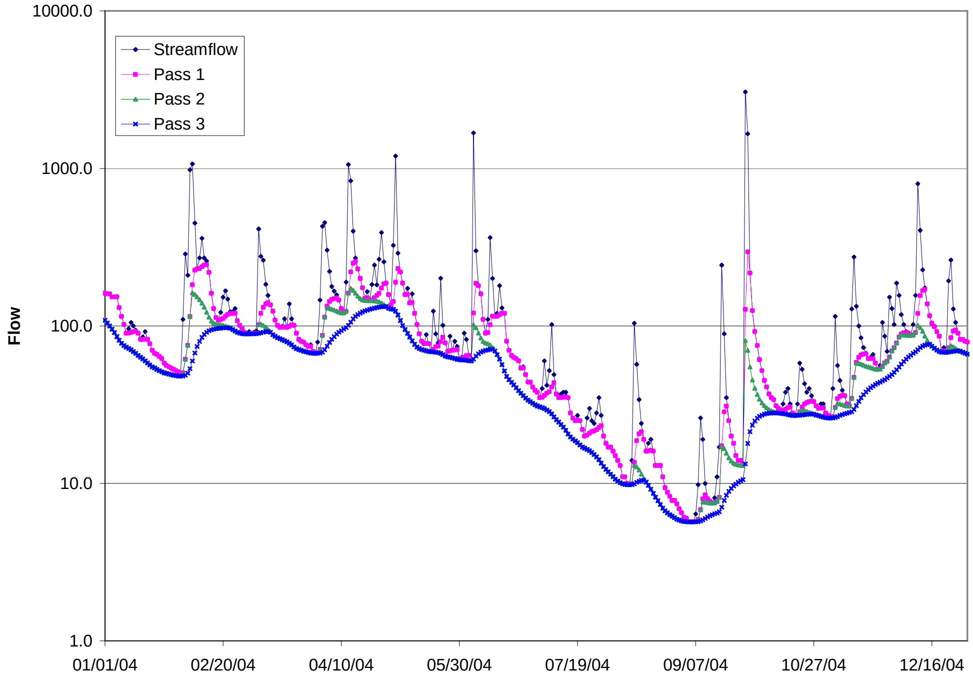
## Catoctin Creek at Taylorstown Baseflow



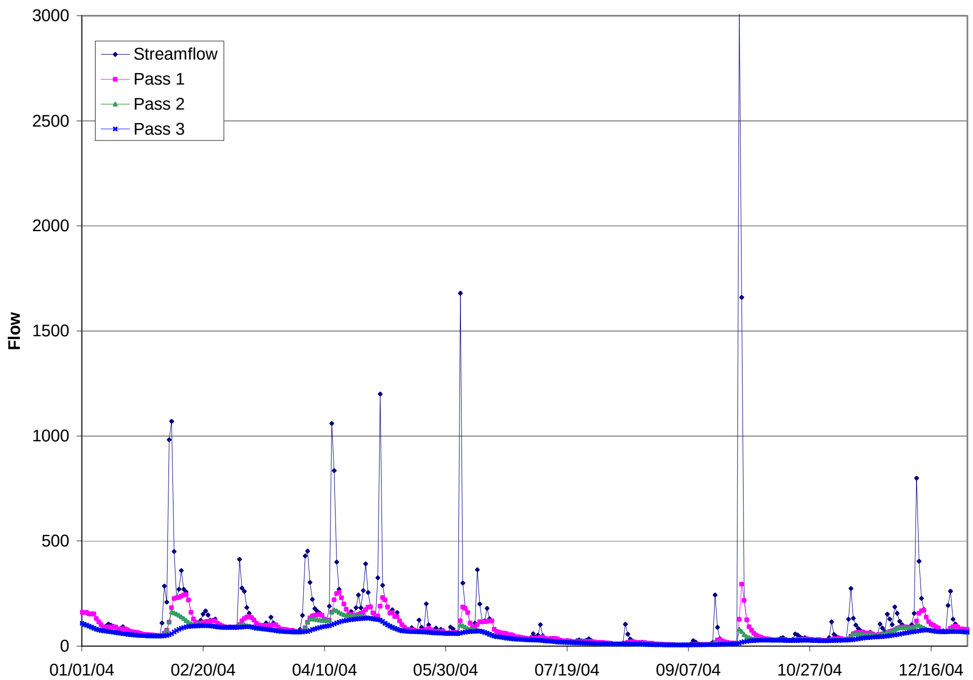

## Catoctin Creek at Taylorstown Baseflow



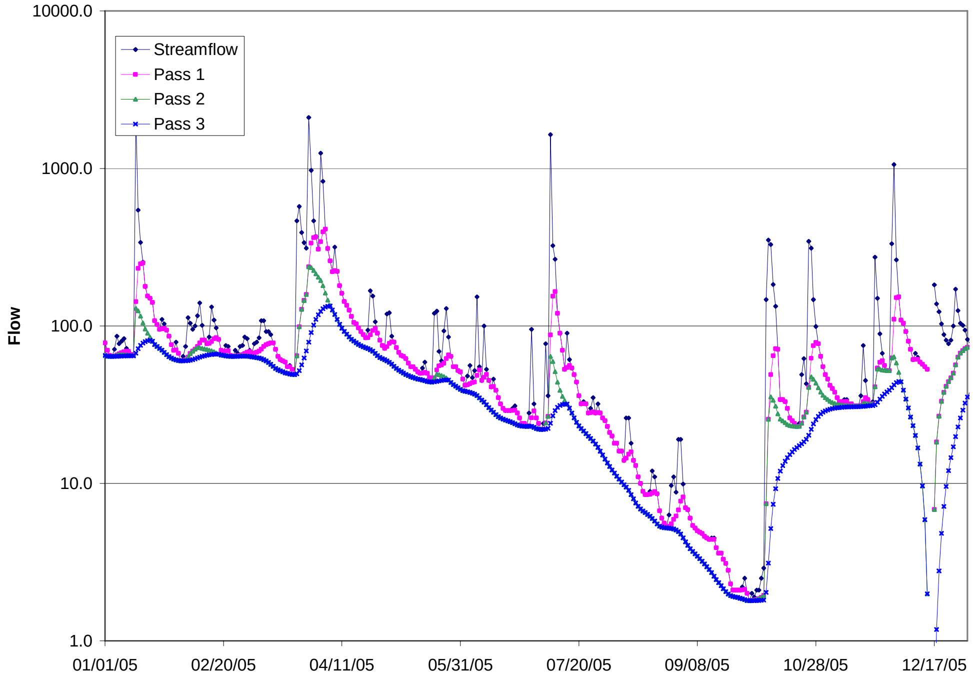
**Catoctin Creek at Taylorstown Baseflow**



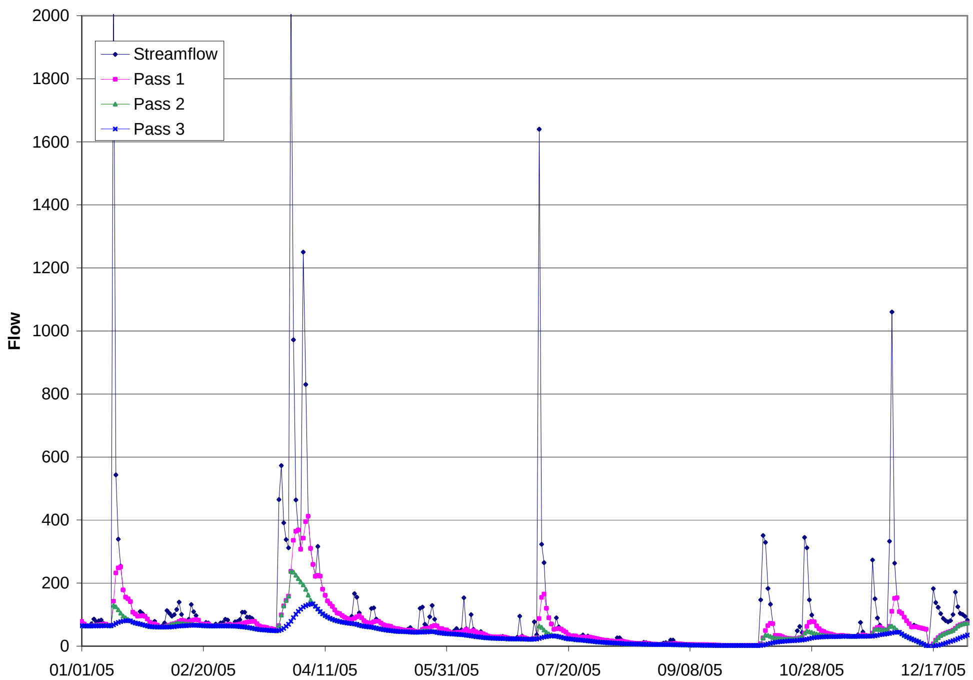

**Catoctin Creek at Taylorstown Baseflow**



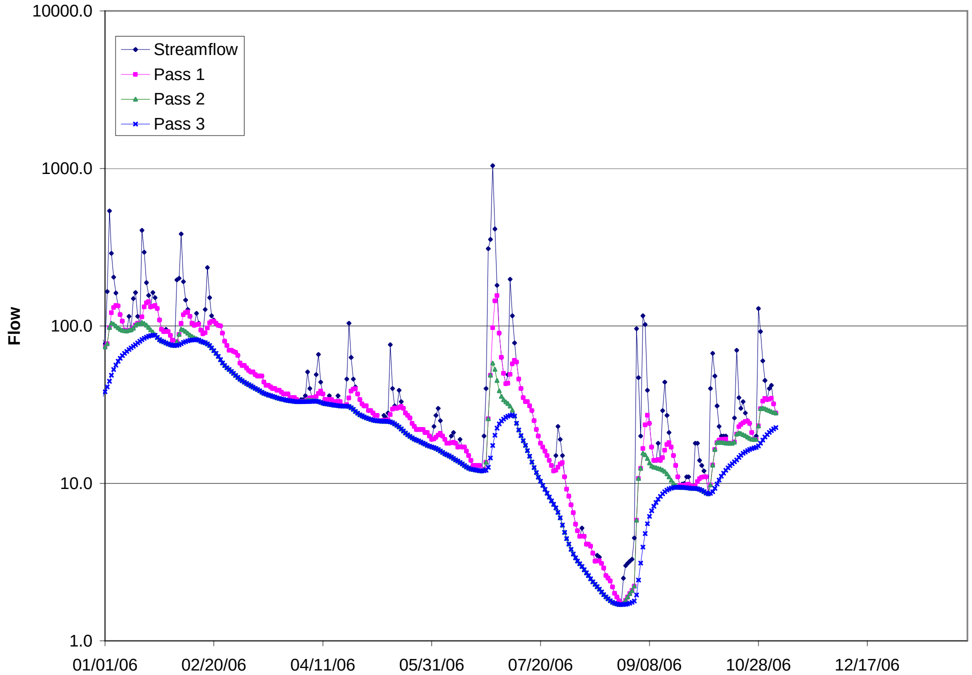
**Catoctin Creek at Taylorstown Baseflow**



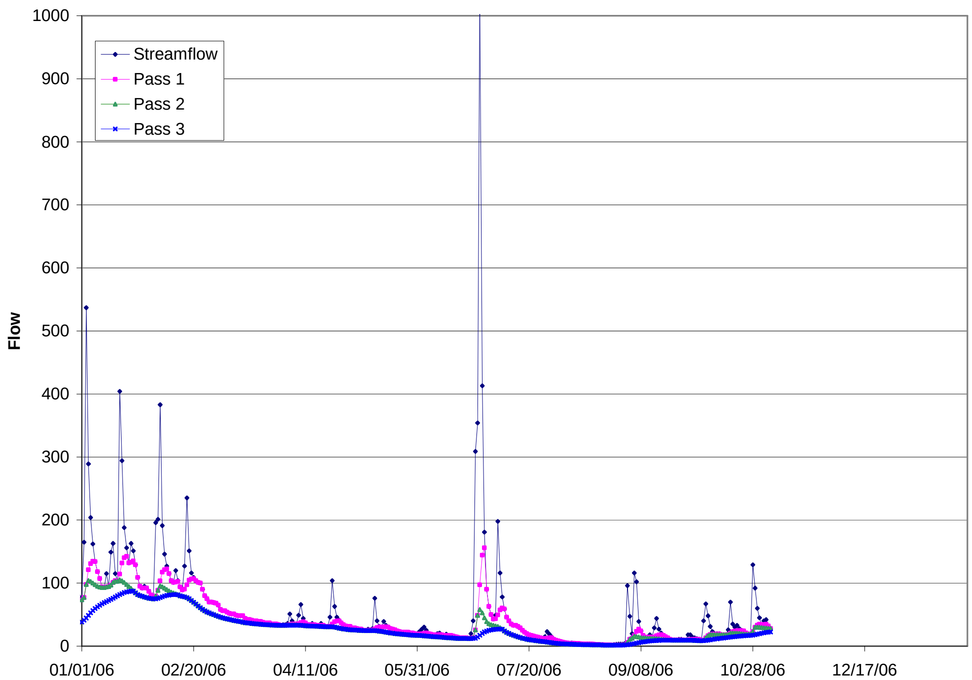

**Catoctin Creek at Taylorstown Baseflow**



## Catoctin Creek at Taylorstown Baseflow




## Catoctin Creek at Taylorstown Baseflow



Because a procedure had not been developed for calculating design flow based on the durations and frequencies specified in aquatic life criteria, the U.S. EPA recommended interim use of the 1Q5 and 1Q1Q low flows as the CMC design flow and the 7Q5 and 7Q1Q low flows as the CCC design flow for unstressed and stressed systems, respectively.

Recommendations:

If steady-state modeling is used, the hydrologically-based or the biologically-based stream design flow method should be used. If the hydrologically-based method is used, the 1Q10 and 7Q10 low flows should be used as the CMC and CCC design flow, except that the 30Q10 low flow should be used as the CCC design flow for ammonia is situations involving POTWs designed to remove ammonia where limited variability of effluent pollutant concentrations and resulting concentrations the receiving water can be demonstrated.

Q5
n

e

Climatic year defined as Apr 1 - Mar 31

| Gage | Period | Days in Record | Zero/missing | 1B3 | Percentile | Excur. per 3 Yrs | 7Q10 | Percentile | Excur. per 3 Yrs | 7Qy Type | 7Qy | Percentile | Harmonic | Percentile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1636690 PINEY RUN NEAR LOVETTSVILLE, VA | 2003-2007 | 1,825 | None | 0 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 2.16 | 13.26% |
| 01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, | 2003-2007 | 1,825 | 0/4 | 0.91 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 12.9 | 20.77% |
| 1638420 N F CATOCTIN CREEK AT RT 681 NEAR WATER | 2003-2007 | 1,825 | 37/0 | 0.07 | 2.25% | 3.6 | N/A | 0.00% | 0 | 7Q4 | 0.06 | 2.25% | 2.88 | 12.55% |
| 1643590 LIMESTONE BRANCH NEAR LEESBURG, VA | 2003-2007 | 1,825 | 0/1 | 0.63 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 3.35 | 30.25% |
| 1643700 GOOSE CREEK NEAR MIDDLEBURG, VA | 1967-2007 | 14,974 | 71/2,255 | 0 | 0.00% | 0 | 0.02 | 0.69% | 0.9 | 7Q14 | 0 | 0.00% | 1.92 | 3.83% |
| 1644000 GOOSE CREEK NEAR LEESBURG, VA | 1911-2007 | 35,428 | 0/6,342 | 1.27 | 0.25% | 0.96 | 1.77 | 0.53% | 1.32 | 7Q15 | 1.24 | 0.25% | 34.2 | 13.72% |
| 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA | 1973-2007 | 12,782 | 0/1 | 0.24 | 0.23% | 0.94 | 0.63 | 0.79% | 1.52 | 7Q26 | 0.24 | 0.20% | 11 | 17.88% |
| 1644280 BROAD RUN NEAR LEESBURG, VA | 2003-2007 | 1,825 | None | 1.29 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 20.4 | 25.48% |
| 1643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTV | 2003-2007 | 1,825 | 8/1 | 0.01 | 0.44% | 3 | N/A | 0.00% | 0 | 7Q4 | 0 | 0.00% | 1.54 | 7.51% |
| 1638350 S F CATOCTIN CREEK AT RT 698 NEAR WATER | 2003-2007 | 1,825 | 0/1 | 0.07 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 5.64 | 14.96% |

Advanced information

1636690 PINEY RUN NEAR LOVETTSVILLE, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 1.03 | 0.48 | 0.29 | 0.2 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 0.04 | 0.53 | 0.99 | 2.36 | 3.59 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 3.07 | 1.92 | 1.5 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 1.31 | 1.49 | 5.06 | 16.71 |
| | 2005 | 2002 | 2004 | 2003 |

1638420 N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 0.56 | 0.18 | 0.06 | 0 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 0 | 0.12 | 0.51 | 1.9 | 6.54 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

1643590 LIMESTONE BRANCH NEAR LEESBURG, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 1.43 | 1.06 | 0.9 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0.72 | 0.97 | 2 | 3.57 |
| | 2002 | 2005 | 2004 | 2003 |

1643700 GOOSE CREEK NEAR MIDDLEBURG, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 4.56 | 1.14 | 0.41 | 0.2 | 0.09 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0 |
| Recurrence Period | 31 | 15.5 | 10.333 | 7.75 | 6.2 | 5.167 | 4.429 | 3.875 | 3.444 | 3.1 | 2.818 | 2.583 | 2.385 | 2.214 |
| Observed | 0 | 0 | 0 | 0.05 | 0.11 | 0.13 | 0.41 | 0.83 | 0.86 | 0.87 | 1.69 | 1.9 | 2.13 | 2.97 |
| | 1991 | 1985 | 1986 | 1993 | 2002 | 1966 | 1987 | 1988 | 1980 | 1995 | 2005 | 1977 | 1983 | 1981 |

1644000 GOOSE CREEK NEAR LEESBURG, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 10.36 | 5.8 | 4.12 | 3.31 | 2.69 | 2.31 | 2.07 | 1.9 | 1.77 | 1.6 | 1.48 | 1.38 | 1.3 |
| Recurrence Period | 77 | 38.5 | 25.667 | 19.25 | 15.4 | 12.833 | 11 | 9.625 | 8.556 | 7.7 | 7 | 6.417 | 5.923 | 5.5 |
| Observed | 0.45 | 0.51 | 0.68 | 1.03 | 1.2 | 1.34 | 1.43 | 1.7 | 1.71 | 1.99 | 2.03 | 2.27 | 2.84 | 3.03 |
| | 1985 | 1941 | 1999 | 1991 | 1986 | 1966 | 1987 | 1932 | 1930 | 1995 | 1910 | 1931 | 2002 | 1993 |

01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 4.81 | 2.6 | 1.77 | 1.37 | 1.06 | 0.88 | 0.77 | 0.69 | 0.63 | 0.55 | 0.5 | 0.45 | 0.42 |
| Recurrence Period | 34 | 17 | 11.333 | 8.5 | 6.8 | 5.667 | 4.857 | 4.25 | 3.778 | 3.4 | 3.091 | 2.833 | 2.615 | 2.429 |
| Observed | 0.1 | 0.27 | 0.29 | 0.31 | 1.09 | 1.47 | 1.71 | 2.06 | 2.17 | 2.27 | 2.5 | 2.99 | 3.96 | 4.11 |
| | 1999 | 1986 | 2002 | 1991 | 1998 | 1997 | 1993 | 2005 | 1977 | 1995 | 1985 | 1981 | 2001 | 1983 |

1644280 BROAD RUN NEAR LEESBURG, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 4.03 | 2.9 | 2.44 | 2.19 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 1.64 | 3.16 | 3.97 | 5.36 | 15.14 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

1643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 0.31 | 0.01 | 0 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0 | 0.03 | 1.56 | 16.86 |
| | 2005 | 2002 | 2004 | 2003 |

1638350 S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 1.78 | 0.79 | 0.5 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0.18 | 0.95 | 3.41 | 13 |
| | 2002 | 2005 | 2004 | 2003 |

Climatic year defined as Apr 1 - Mar 31

| Gage | Period | Days in Record | Zero/missing | 1B3 | Percentile | Excur. per 3 Yrs | 7Q5 | Percentile | Excur. per 3 Yrs | 7Qy Type | 7Qy | Percentile | Harmonic | Percentile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1636690 PINEY RUN NEAR LOVETTSVILLE, VA | 2003-2007 | 1,825 | None | 0 | 0.00% | 0 | 0.2 | 1.70% | 3 | N/A | | | 2.16 | 13.26% |
| 01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, | 2003-2007 | 1,825 | 0/4 | 0.91 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 12.9 | 20.77% |
| 1638420 N F CATOCTIN CREEK AT RT 681 NEAR WATER | 2003-2007 | 1,825 | 37/0 | 0.07 | 2.25% | 3.6 | 0 | 0.00% | 0 | 7Q4 | 0.06 | 2.25% | 2.88 | 12.55% |
| 1643590 LIMESTONE BRANCH NEAR LEESBURG, VA | 2003-2007 | 1,825 | 0/1 | 0.63 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 3.35 | 30.25% |
| 1643700 GOOSE CREEK NEAR MIDDLEBURG, VA | 1967-2007 | 14,974 | 71/2,255 | 0 | 0.00% | 0 | 0.2 | 1.48% | 1.9 | 7Q14 | 0 | 0.00% | 1.92 | 3.83% |
| 1644000 GOOSE CREEK NEAR LEESBURG, VA | 1911-2007 | 35,428 | 0/6,342 | 1.27 | 0.25% | 0.96 | 3.31 | 1.50% | 2.29 | 7Q15 | 1.24 | 0.25% | 34.2 | 13.72% |
| 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA | 1973-2007 | 12,782 | 0/1 | 0.24 | 0.23% | 0.94 | 1.37 | 1.51% | 2.06 | 7Q26 | 0.24 | 0.20% | 11 | 17.88% |
| 1644280 BROAD RUN NEAR LEESBURG, VA | 2003-2007 | 1,825 | None | 1.29 | 0.00% | 0 | 2.19 | 0.77% | 2.4 | N/A | | | 20.4 | 25.48% |
| 1643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTV | 2003-2007 | 1,825 | 8/1 | 0.01 | 0.44% | 3 | N/A | 0.00% | 0 | 7Q4 | 0 | 0.00% | 1.54 | 7.51% |
| 1638350 S F CATOCTIN CREEK AT RT 698 NEAR WATER | 2003-2007 | 1,825 | 0/1 | 0.07 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 5.64 | 14.96% |

Advanced information

1636690 PINEY RUN NEAR LOVETTSVILLE, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 1.03 | 0.48 | 0.29 | 0.2 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 0.04 | 0.53 | 0.99 | 2.36 | 3.59 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 3.07 | 1.92 | 1.5 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 1.31 | 1.49 | 5.06 | 16.71 |
| | 2005 | 2002 | 2004 | 2003 |

1638420 N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 0.56 | 0.18 | 0.06 | 0 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 0 | 0.12 | 0.51 | 1.9 | 6.54 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

1643590 LIMESTONE BRANCH NEAR LEESBURG, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 1.43 | 1.06 | 0.9 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0.72 | 0.97 | 2 | 3.57 |
| | 2002 | 2005 | 2004 | 2003 |

1643700 GOOSE CREEK NEAR MIDDLEBURG, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 4.56 | 1.14 | 0.41 | 0.2 | 0.09 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0 |
| Recurrence Period | 31 | 15.5 | 10.333 | 7.75 | 6.2 | 5.167 | 4.429 | 3.875 | 3.444 | 3.1 | 2.818 | 2.583 | 2.385 | 2.214 |
| Observed | 0 | 0 | 0 | 0.05 | 0.11 | 0.13 | 0.41 | 0.83 | 0.86 | 0.87 | 1.69 | 1.9 | 2.13 | 2.97 |
| | 1991 | 1985 | 1986 | 1993 | 2002 | 1966 | 1987 | 1988 | 1980 | 1995 | 2005 | 1977 | 1983 | 1981 |

1644000 GOOSE CREEK NEAR LEESBURG, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 10.36 | 5.8 | 4.12 | 3.31 | 2.69 | 2.31 | 2.07 | 1.9 | 1.77 | 1.6 | 1.48 | 1.38 | 1.3 |
| Recurrence Period | 77 | 38.5 | 25.667 | 19.25 | 15.4 | 12.833 | 11 | 9.625 | 8.556 | 7.7 | 7 | 6.417 | 5.923 | 5.5 |
| Observed | 0.45 | 0.51 | 0.68 | 1.03 | 1.2 | 1.34 | 1.43 | 1.7 | 1.71 | 1.99 | 2.03 | 2.27 | 2.84 | 3.03 |
| | 1985 | 1941 | 1999 | 1991 | 1986 | 1966 | 1987 | 1932 | 1930 | 1995 | 1910 | 1931 | 2002 | 1993 |

01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 4.81 | 2.6 | 1.77 | 1.37 | 1.06 | 0.88 | 0.77 | 0.69 | 0.63 | 0.55 | 0.5 | 0.45 | 0.42 |
| Recurrence Period | 34 | 17 | 11.333 | 8.5 | 6.8 | 5.667 | 4.857 | 4.25 | 3.778 | 3.4 | 3.091 | 2.833 | 2.615 | 2.429 |
| Observed | 0.1 | 0.27 | 0.29 | 0.31 | 1.09 | 1.47 | 1.71 | 2.06 | 2.17 | 2.27 | 2.5 | 2.99 | 3.96 | 4.11 |
| | 1999 | 1986 | 2002 | 1991 | 1998 | 1997 | 1993 | 2005 | 1977 | 1995 | 1985 | 1981 | 2001 | 1983 |

1644280 BROAD RUN NEAR LEESBURG, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 4.03 | 2.9 | 2.44 | 2.19 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 1.64 | 3.16 | 3.97 | 5.36 | 15.14 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

1643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 0.31 | 0.01 | 0 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0 | 0.03 | 1.56 | 16.86 |
| | 2005 | 2002 | 2004 | 2003 |

1638350 S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 1.78 | 0.79 | 0.5 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0.18 | 0.95 | 3.41 | 13 |
| | 2002 | 2005 | 2004 | 2003 |

Climatic year defined as Apr 1 - Mar 31

| Gage | Period | Days in Record | Zero/missing | 1B3 | Percentile | Excur. per 3 Yrs | 7Q2 | Percentile | Excur. per 3 Yrs | 7Qy Type | 7Qy | Percentile | Harmonic | Percentile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1636690 PINEY RUN NEAR LOVETTSVILLE, VA | 2003-2007 | 1,825 | None | 0 | 0.00% | 0 | 1.03 | 7.07% | 7.05 | N/A | | | 2.16 | 13.26% |
| 01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, | 2003-2007 | 1,825 | 0/4 | 0.91 | 0.00% | 0 | 3.07 | 4.99% | 9.01 | N/A | | | 12.9 | 20.77% |
| 1638420 N F CATOCTIN CREEK AT RT 681 NEAR WATER | 2003-2007 | 1,825 | 37/0 | 0.07 | 2.25% | 3.6 | 0.56 | 5.15% | 7.2 | 7Q4 | 0.06 | 2.25% | 2.88 | 12.55% |
| 1643590 LIMESTONE BRANCH NEAR LEESBURG, VA | 2003-2007 | 1,825 | 0/1 | 0.63 | 0.00% | 0 | 1.43 | 11.62% | 10.96 | N/A | | | 3.35 | 30.25% |
| 1643700 GOOSE CREEK NEAR MIDDLEBURG, VA | 1967-2007 | 14,974 | 71/2,255 | 0 | 0.00% | 0 | 4.56 | 6.26% | 7.13 | 7Q14 | 0 | 0.00% | 1.92 | 3.83% |
| 1644000 GOOSE CREEK NEAR LEESBURG, VA | 1911-2007 | 35,428 | 0/6,342 | 1.27 | 0.25% | 0.96 | 10.4 | 4.97% | 6.93 | 7Q15 | 1.24 | 0.25% | 34.2 | 13.72% |
| 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA | 1973-2007 | 12,782 | 0/1 | 0.24 | 0.23% | 0.94 | 4.81 | 6.72% | 8.06 | 7Q26 | 0.24 | 0.20% | 11 | 17.88% |
| 1644280 BROAD RUN NEAR LEESBURG, VA | 2003-2007 | 1,825 | None | 1.29 | 0.00% | 0 | 4.03 | 4.05% | 6.9 | N/A | | | 20.4 | 25.48% |
| 1643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTV | 2003-2007 | 1,825 | 8/1 | 0.01 | 0.44% | 3 | 0.31 | 3.95% | 8.71 | 7Q4 | 0 | 0.00% | 1.54 | 7.51% |
| 1638350 S F CATOCTIN CREEK AT RT 698 NEAR WATER | 2003-2007 | 1,825 | 0/1 | 0.07 | 0.00% | 0 | 1.78 | 5.37% | 9.01 | N/A | | | 5.64 | 14.96% |

Advanced information

1636690 PINEY RUN NEAR LOVETTSVILLE, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 1.03 | 0.48 | 0.29 | 0.2 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 0.04 | 0.53 | 0.99 | 2.36 | 3.59 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 3.07 | 1.92 | 1.5 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 1.31 | 1.49 | 5.06 | 16.71 |
| | 2005 | 2002 | 2004 | 2003 |

1638420 N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 0.56 | 0.18 | 0.06 | 0 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 0 | 0.12 | 0.51 | 1.9 | 6.54 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

1643590 LIMESTONE BRANCH NEAR LEESBURG, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 1.43 | 1.06 | 0.9 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0.72 | 0.97 | 2 | 3.57 |
| | 2002 | 2005 | 2004 | 2003 |

1643700 GOOSE CREEK NEAR MIDDLEBURG, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 4.56 | 1.14 | 0.41 | 0.2 | 0.09 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0 |
| Recurrence Period | 31 | 15.5 | 10.333 | 7.75 | 6.2 | 5.167 | 4.429 | 3.875 | 3.444 | 3.1 | 2.818 | 2.583 | 2.385 | 2.214 |
| Observed | 0 | 0 | 0 | 0.05 | 0.11 | 0.13 | 0.41 | 0.83 | 0.86 | 0.87 | 1.69 | 1.9 | 2.13 | 2.97 |
| | 1991 | 1985 | 1986 | 1993 | 2002 | 1966 | 1987 | 1988 | 1980 | 1995 | 2005 | 1977 | 1983 | 1981 |

1644000 GOOSE CREEK NEAR LEESBURG, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 10.36 | 5.8 | 4.12 | 3.31 | 2.69 | 2.31 | 2.07 | 1.9 | 1.77 | 1.6 | 1.48 | 1.38 | 1.3 |
| Recurrence Period | 77 | 38.5 | 25.667 | 19.25 | 15.4 | 12.833 | 11 | 9.625 | 8.556 | 7.7 | 7 | 6.417 | 5.923 | 5.5 |
| Observed | 0.45 | 0.51 | 0.68 | 1.03 | 1.2 | 1.34 | 1.43 | 1.7 | 1.71 | 1.99 | 2.03 | 2.27 | 2.84 | 3.03 |
| | 1985 | 1941 | 1999 | 1991 | 1986 | 1966 | 1987 | 1932 | 1930 | 1995 | 1910 | 1931 | 2002 | 1993 |

01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 4.81 | 2.6 | 1.77 | 1.37 | 1.06 | 0.88 | 0.77 | 0.69 | 0.63 | 0.55 | 0.5 | 0.45 | 0.42 |
| Recurrence Period | 34 | 17 | 11.333 | 8.5 | 6.8 | 5.667 | 4.857 | 4.25 | 3.778 | 3.4 | 3.091 | 2.833 | 2.615 | 2.429 |
| Observed | 0.1 | 0.27 | 0.29 | 0.31 | 1.09 | 1.47 | 1.71 | 2.06 | 2.17 | 2.27 | 2.5 | 2.99 | 3.96 | 4.11 |
| | 1999 | 1986 | 2002 | 1991 | 1998 | 1997 | 1993 | 2005 | 1977 | 1995 | 1985 | 1981 | 2001 | 1983 |

1644280 BROAD RUN NEAR LEESBURG, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 4.03 | 2.9 | 2.44 | 2.19 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 1.64 | 3.16 | 3.97 | 5.36 | 15.14 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

1643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 0.31 | 0.01 | 0 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0 | 0.03 | 1.56 | 16.86 |
| | 2005 | 2002 | 2004 | 2003 |

1638350 S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 1.78 | 0.79 | 0.5 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0.18 | 0.95 | 3.41 | 13 |
| | 2002 | 2005 | 2004 | 2003 |

Climatic year defined as Apr 1 - Mar 31

| Gage | Period | Days in Record | Zero/missing | 1B3 | Percentile | Excur. per 3 Yrs | 1Q10 | Percentile | Excur. per 3 Yrs | 1Qy Type | 1Qy | Percentile | Harmonic | Percentile |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1636690 PINEY RUN NEAR LOVETTSVILLE, VA | 2003-2007 | 1,825 | None | 0 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 2.16 | 13.26% |
| 01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, | 2003-2007 | 1,825 | 0/4 | 0.91 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 12.9 | 20.77% |
| 1638420 N F CATOCTIN CREEK AT RT 681 NEAR WATER | 2003-2007 | 1,825 | 37/0 | 0.07 | 2.25% | 3.6 | N/A | 0.00% | 0 | 1Q3 | 0.07 | 2.25% | 2.88 | 12.55% |
| 1643590 LIMESTONE BRANCH NEAR LEESBURG, VA | 2003-2007 | 1,825 | 0/1 | 0.63 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 3.35 | 30.25% |
| 1643700 GOOSE CREEK NEAR MIDDLEBURG, VA | 1967-2007 | 14,974 | 71/2,255 | 0 | 0.00% | 0 | 0.01 | 0.47% | 0.6 | 1Q11 | 0 | 0.00% | 1.92 | 3.83% |
| 1644000 GOOSE CREEK NEAR LEESBURG, VA | 1911-2007 | 35,428 | 0/6,342 | 1.27 | 0.25% | 0.96 | 1.43 | 0.36% | 0.93 | 1Q12 | 1.19 | 0.19% | 34.2 | 13.72% |
| 01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA | 1973-2007 | 12,782 | 0/1 | 0.24 | 0.23% | 0.94 | 0.5 | 0.65% | 1.52 | 1Q21 | 0.23 | 0.20% | 11 | 17.88% |
| 1644280 BROAD RUN NEAR LEESBURG, VA | 2003-2007 | 1,825 | None | 1.29 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 20.4 | 25.48% |
| 1643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTV | 2003-2007 | 1,825 | 8/1 | 0.01 | 0.44% | 3 | N/A | 0.00% | 0 | 1Q4 | 0 | 0.00% | 1.54 | 7.51% |
| 1638350 S F CATOCTIN CREEK AT RT 698 NEAR WATER | 2003-2007 | 1,825 | 0/1 | 0.07 | 0.00% | 0 | N/A | 0.00% | 0 | N/A | | | 5.64 | 14.96% |

Advanced information

1636690 PINEY RUN NEAR LOVETTSVILLE, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 0.91 | 0.41 | 0.24 | 0.17 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 0.03 | 0.45 | 0.95 | 2.2 | 2.7 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

01643805 N F GOOSE CREEK AT RT 729 NEAR LINCOLN, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 2.63 | 1.62 | 1.25 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 1.1 | 1.2 | 4.5 | 14 |
| | 2005 | 2002 | 2004 | 2003 |

1638420 N F CATOCTIN CREEK AT RT 681 NEAR WATERFORD, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 0.31 | 0.07 | 0.02 | 0 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 0 | 0.04 | 0.26 | 1.7 | 4.2 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

1643590 LIMESTONE BRANCH NEAR LEESBURG, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 1.28 | 0.96 | 0.82 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0.68 | 0.86 | 1.8 | 2.9 |
| | 2002 | 2005 | 2004 | 2003 |

1643700 GOOSE CREEK NEAR MIDDLEBURG, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 2.86 | 0.56 | 0.17 | 0.08 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0 | 0 |
| Recurrence Period | 31 | 15.5 | 10.333 | 7.75 | 6.2 | 5.167 | 4.429 | 3.875 | 3.444 | 3.1 | 2.818 | 2.583 | 2.385 | 2.214 |
| Observed | 0 | 0 | 0 | 0.04 | 0.1 | 0.11 | 0.31 | 0.5 | 0.55 | 0.58 | 0.9 | 1 | 1.6 | 2.2 |
| | 1991 | 1986 | 1985 | 1993 | 1966 | 2002 | 1987 | 1995 | 1980 | 1988 | 2005 | 1977 | 1983 | 1981 |

1644000 GOOSE CREEK NEAR LEESBURG, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 8.45 | 4.73 | 3.35 | 2.69 | 2.18 | 1.87 | 1.67 | 1.53 | 1.43 | 1.29 | 1.19 | 1.11 | 1.05 |
| Recurrence Period | 77 | 38.5 | 25.667 | 19.25 | 15.4 | 12.833 | 11 | 9.625 | 8.556 | 7.7 | 7 | 6.417 | 5.923 | 5.5 |
| Observed | 0.4 | 0.42 | 0.55 | 0.8 | 0.86 | 1.2 | 1.2 | 1.2 | 1.2 | 1.5 | 1.6 | 1.8 | 2.1 | 2.3 |
| | 1941 | 1985 | 1999 | 1986 | 1991 | 1932 | 1987 | 1966 | 1995 | 1930 | 1910 | 1931 | 1936 | 1993 |

01638480 CATOCTIN CREEK AT TAYLORSTOWN, VA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Calculated | | 3.96 | 2.13 | 1.44 | 1.11 | 0.85 | 0.71 | 0.61 | 0.55 | 0.5 | 0.44 | 0.4 | 0.36 | 0.33 |
| Recurrence Period | 34 | 17 | 11.333 | 8.5 | 6.8 | 5.667 | 4.857 | 4.25 | 3.778 | 3.4 | 3.091 | 2.833 | 2.615 | 2.429 |
| Observed | 0.09 | 0.18 | 0.2 | 0.24 | 0.87 | 1.3 | 1.3 | 1.4 | 1.8 | 1.9 | 2 | 2.5 | 2.9 | 3.3 |
| | 1999 | 1991 | 1986 | 2002 | 1998 | 1985 | 1993 | 1997 | 2005 | 1977 | 1995 | 1981 | 2000 | 2001 |

1644280 BROAD RUN NEAR LEESBURG, VA

| | | | | | |
|---|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 | 5 |
| Calculated | | 3.62 | 2.6 | 2.16 | 1.92 |
| Recurrence Period | 5 | 2.5 | 1.667 | 1.25 | 1 |
| Observed | 1.3 | 3 | 3.4 | 4.7 | 11 |
| | 2002 | 2005 | 2006 | 2004 | 2003 |

1643880 BEAVERDAM CREEK AT RT 734 NEAR MOUNTVILLE, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 0.2 | 0.01 | 0 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0 | 0.02 | 0.95 | 11 |
| | 2005 | 2002 | 2004 | 2003 |

1638350 S F CATOCTIN CREEK AT RT 698 NEAR WATERFORD, VA

| | | | | |
|---|---|---|---|---|
| Recurrence Period | 1 | 2 | 3 | 4 |
| Calculated | | 1.51 | 0.59 | 0.33 |
| Recurrence Period | 4 | 2 | 1.333 | 1 |
| Observed | 0.07 | 0.85 | 3 | 9.1 |
| | 2002 | 2005 | 2004 | 2003 |