PROGRAM USER GUIDE FOR PART

By A.T. Rutledge

INTRODUCTION

This manual describes the use of the computer program PART for analysis of streamflow records using data in a particular format (example: Figure 1). This format was not available at the time the program was developed but is now available from USGS web sites. This manual does not include complete explanation of the computer program; the reader is referred to Rutledge (1998, pages 33-38).

The program uses streamflow partitioning to estimate a daily record of base flow (ground-water discharge) under the streamflow record. The program scans the period of record for days that fit a requirement of antecedent recession, designates ground-water discharge to be equal to streamflow on these days, then linearly interpolates the ground-water discharge on days that do not fit the requirement of antecedent recession. Although calculations are made on the daily time scale, the author recommends results should be reported at a larger time scale (at least a month but preferably a larger time scale).

The PART 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. Regulation and diversion of streamflow should be negligible. More information about application of the method is included in the report (Rutledge, 1998, pages 2-3).

Note –
The PART program was first adapted for reading web data in 2002. In 2007, adaptations were made in the code to accommodate changes in the way USGS web data handle gaps in streamflow record. This newer version of the program was posted on the PART web site in January 2007. The newer version can read data in the new or old format.

```
# -------------------------------- WARNING ----------------------------------------
# The data you have 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 use.
# Additional info: http://waterdata.usgs.gov/nwis/help/?provisional
#
# File-format description:  http://waterdata.usgs.gov/nwis/?tab_delimited_format_info
# Automated-retrieval info: http://waterdata.usgs.gov/nwis/?automated_retrieval_info
#
# Contact:   gs-w_support_nwisweb@usgs.gov
# retrieved: 2007-01-08 12:44:58 EST
#
# Data for the following site(s) are contained in this file
#    USGS 02038850 HOLIDAY CREEK NEAR ANDERSONVILLE, VA
# -----------------------------------------------------------------------------------
#
# Data provided for site 02038850
#    DD parameter statistic   Description
#    02   00060     00003     Discharge, cubic feet per second (Mean)
#
# Data-value qualification codes included in this output:
#     A  Approved for publication -- Processing and review completed.
#
agency_cd site_no   datetime  02_00060_00003      02_00060_00003_cd
5s        15s       16s        14s        14s
USGS      02038850  1966-04-27       5.6        A
USGS      02038850  1966-04-28       7.0        A
USGS      02038850  1966-04-29       4.8        A
USGS      02038850  1966-04-30       4.2        A
USGS      02038850  1966-05-01       4.2        A
USGS      02038850  1966-05-02       23         A
USGS      02038850  1966-05-03       11         A
USGS      02038850  1966-05-04       6.1        A
USGS      02038850  1966-05-05       4.9        A
USGS      02038850  1966-05-06       4.3        A
USGS      02038850  1966-05-07       3.7        A
USGS      02038850  1966-05-08       3.5        A
USGS      02038850  1966-05-09       3.2        A
USGS      02038850  1966-05-10       2.9        A
USGS      02038850  1966-05-11       2.9        A
USGS      02038850  1966-05-12       2.9        A
USGS      02038850  1966-05-13       2.9        A
USGS      02038850  1966-05-14       3.8        A
USGS      02038850  1966-05-15       3.2        A
USGS      02038850  1966-05-16       2.8        A
USGS      02038850  1966-05-17       2.6        A
USGS      02038850  1966-05-18       2.5        A
USGS      02038850  1966-05-19       5.8        A
USGS      02038850  1966-05-20       3.6        A
USGS      02038850  1966-05-21       2.8        A
USGS      02038850  1966-05-22       2.5        A
USGS      02038850  1966-05-23       2.3        A
USGS      02038850  1966-05-24       2.3        A
USGS      02038850  1966-05-25       4.5        A
USGS      02038850  1966-05-26       3.6        A
USGS      02038850  1966-05-27       2.9        A
USGS      02038850  1966-05-28       4.2        A
USGS      02038850  1966-05-29       2.9        A
USGS      02038850  1966-05-30       2.4        A
USGS      02038850  1966-05-31       3.6        A
USGS      02038850  1966-06-01       2.8        A
USGS      02038850  1966-06-02       2.4        A
USGS      02038850  1966-06-03       2.2        A
USGS      02038850  1966-06-04       2.0        A
USGS      02038850  1966-06-05       1.8        A
USGS      02038850  1966-06-06       1.7        A
USGS      02038850  1966-06-07       1.7        A
USGS      02038850  1966-06-08       1.7        A
USGS      02038850  1966-06-09       1.5        A
USGS      02038850  1966-06-10       1.5        A
USGS      02038850  1966-06-11       2.1        A
USGS      02038850  1966-06-12       1.5        A
USGS      02038850  1966-06-13       1.4        A
USGS      02038850  1966-06-14       1.4        A
USGS      02038850  1966-06-15       1.3        A
USGS      02038850  1966-06-16       1.2        A
```

Figure 1. Example streamflow data file obtained from a USGS web site. (This is truncated from the data file Holiday.txt, which is available with this manual.)

PREPARING TO USE THE PROGRAM

This section describes data files the program user may need to obtain or prepare prior to executing the program. The first-time user experimenting with the data files included with this report may skip this section and proceed to the instructions for running the program (page 6). The section about the SCREEN program (page 4) may be helpful to the first-time user.

OBTAINING STREAMFLOW DATA FILES

A streamflow data file can be obtained from the following USGS web site: http://waterdata.usgs.gov/nwis/dv/?referred_module=sw. From this site, the user is first asked to "Choose Site Selection Criteria". For example, if the site of interest is Holiday Creek near Andersonville, Virginia, yet the site identification number is not known, the user might check the boxes for *State* and *Site Name* and then hit the "Submit" button. At the subsequent "Select sites that meet all of the following criteria" page, the user would then enter *Holiday* under site name, select the state of Virginia from the state list, check the "Streamflow, ft^3/s" box in the "Water Level/Flow Parameters" group of the Available parameters list, and then issue the request using the "Submit" button near the very bottom of the page. The subsequent page will be a list of all sites found that meet the specified criteria. Clicking on the site number will display a page including graph(s) of the previous 365 days of data. The final step to obtain a file of streamflow data is to check the "00060 Discharge (Mean)" item under the Available parameters heading, choose "Tab-separated" from the Output format list, enter the Begin and End dates of interest, and then hit GO. Once the data are displayed in your browser select "Save as" from the file pull-down menu of your browser and designate the directory where the data are to be written on the user's computer, and specify a file name. On some systems this might require copying and pasting into Notepad. File names should be in the format *xxxxx.txt*, where *xxxxx* is an abbreviated station name. In this case the file name might be designated as *Holiday.txt*. (Note: the length of the file name, including *.txt,* should be 12 characters or less.) Designate file type should be "Text File (.txt)". An example streamflow data file, obtained as described above, is illustrated in figure 1.

A few comments about data files obtained from a USGS web site. Beginning in 2006, some files may include text qualifiers about streamflow data. These qualifiers, which may be evident in recent data (2006+), can appear immediately after a streamflow quantity and in some cases the qualifier may be located in the place of the streamflow quantity. The program may not execute properly due to these text qualifiers. For this reason the program user may need to edit streamflow data files, scanning for these qualifiers, and removing them if they exist.

In some applications, the program user may choose to generate a data file from a source other than a USGS web site. In this case, a few items about file format may be helpful: (1) Most of the header information (fig. 1) is not read by the program, and may not be necessary in a user-generated file. (2) The program starts reading data, two lines after it

detects the string "agency" in the first five spaces of a line. (3) The columns of information in each data line are tab-separated in a data file from a USGS web site (these could be substituted with single blank spaces in a user-generated data file).

As noted on the first page, efforts have taken place to maintain the functionality of the program using data in a particular format. Nonetheless, there may be some cases in which the program user will need to modify format statements in the code and re-compile the program. The fortran source code is available on the program web site.

THE "SCREEN" PROGRAM

Before analyzing a streamflow data file the user may execute the SCREEN program to display the period of record. To demonstrate, execute the program by double-clicking the application in windows or by entering the command "screen" in the MS-DOS command window. Designate the streamflow data file Indian.txt. The output file screenout.txt should look like figure 2. This illustrates data are available from October 1958 to September 1968 and from October 1970 to September 1986.

```
THIS IS OUTPUT OF THE SCREEN PROGRAM,
VERSION OF JANUARY 2007

READING FILE NAMED Indian.txt
FIRST YEAR IN RECORD =  1958
 LAST YEAR IN RECORD =  1986
              MONTH
 YEAR   J F M A M J J A S O N D
 1958   X X X X X X X X X . . .
 1959   . . . . . . . . . . . .
 1960   . . . . . . . . . . . .
 1961   . . . . . . . . . . . .
 1962   . . . . . . . . . . . .
 1963   . . . . . . . . . . . .
 1964   . . . . . . . . . . . .
 1965   . . . . . . . . . . . .
 1966   . . . . . . . . . . . .
 1967   . . . . . . . . . . . .
 1968   . . . . . . . . . X X X
 1969   X X X X X X X X X X X X
 1970   X X X X X X X X X . . .
 1971   . . . . . . . . . . . .
 1972   . . . . . . . . . . . .
 1973   . . . . . . . . . . . .
 1974   . . . . . . . . . . . .
 1975   . . . . . . . . . . . .
 1976   . . . . . . . . . . . .
 1977   . . . . . . . . . . . .
 1978   . . . . . . . . . . . .
 1979   . . . . . . . . . . . .
 1980   . . . . . . . . . . . .
 1981   . . . . . . . . . . . .
 1982   . . . . . . . . . . . .
 1983   . . . . . . . . . . . .
 1984   . . . . . . . . . . . .
 1985   . . . . . . . . . . . .
 1986   . . . . . . . . . X X X

  COMPLETE RECORD = .      INCOMPLETE = X
```

Figure 2. Example graphical display of a streamflow record, showing periods of complete record and periods of incomplete record. (This display is generated onto a file by the program SCREEN, and on the monitor by PART. Streamflow data file is _Indian.txt_.)

DRAINAGE AREA

The PART program derives estimates of ground-water discharge that are expressed in units of length (inches) and in units of specific discharge (inches per year). In order to make such calculations the program needs the drainage area of the streamflow station. There should be one line written to the file *station.txt* for each streamflow data file (figure 3). Each line must include the name of the streamflow data file and the drainage area. The file *station.txt* includes entries for the streamflow data files that are included with this report, and may be used as a guide for the format of additional entries.

A few items about the format of *station.txt*. The file should have 10 header lines which are not read by the program. Beginning with line 11, each line should include streamflow file name (such as *Indian.txt*) and the drainage area of that station. The program is formatted to read these two fields as A12, 1F8.0. All drainage areas below are given with two decimal spaces after the decimal point, in which case the programmed format is ignored, and the two decimal places are read. When new lines are added to *station.txt*, no tabbing should be used. The program is sensitive to the case of the letters in the name of the streamflow file. For example one of the example data files included is "Indian.txt". The case of letters in file *station.txt* (figure 3) is the same, including the capital I. The program user should be aware of this when executing the program (next page).

```
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.
----------------------------------------------------------------
             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.
--------------------- ------------------------------------------
Indian.txt       8.88   02371200   Indian Creek near Troy Alabama
Holiday.txt      8.53   02038850   Holiday Cr near Andersonville, VA
Sewee.txt      117.00              Sewee Creek near Decatur, TN
LitAndro.txt    73.50   01057000   Lt Androscoggin R nr S.Paris, ME
BigHill.txt     37.00              Big Hill Cr near Cherryvale KS
```

Figure 3. Example file "station.txt", including the drainage area for each of the data files that are included with the program.

The drainage area might be obtained from USGS databases, web sites, or data books, or the program user may determine it from topographic maps or other sources. Typically, it is the surface drainage area of the streamflow gaging station. In some applications, the hydrologist may have information to indicate the ground-water contributing area is significantly different from the surface drainage area. In this case the former might be designated in file *station.txt*. If the value placed in station.txt differs from the surface drainage area the program user should exercise caution because program output files express streamflow in units of length and units of specific discharge.

RUNNING THE PROGRAM

This section gives specific instructions for running PART for the five streamflow data files that are included with this report. The station information file *station.txt* has entries for these stations. The file *partsum.txt* has header information for summary results of the PART program. As provided with this report, the file does not include results, but each time the program is executed a new line will be written to the end of this file.

The program can be executed by double-clicking the PART application in Windows Explorer, or by opening the MS-DOS window and entering the command "part". In the first trial run, enter *Indian.txt* as the streamflow data file (note case sensitivity), then designate the starting year as 1971 and the ending year as 1980. As a test of the program the first-time user should repeat the process for the other four stations *Holiday.txt*, *Sewee.txt*, *LitAndro.txt*, and *BigHill.txt*. (Remember -- the case of all letters in file names must agree with case in file *station.txt* (figure 3).)

After the program is executed five times as described above, the output file *partsum.txt* should be identical to figure 4. Each time the program was run, a new line was written to the end of this file. The other output files *partqrt.txt*, *partmon.txt*, *partWY.txt*, and *partday.txt* are created the first time the program is executed, then over-written each time the program is executed again. To save the results in these files the user will need to copy or rename each to a separate file after each program run. As noted in the documentation report (Rutledge, 1998), results at the small time scale (*partday.txt*) are provided for generating graphics but should not be used quantitatively. The meaningful results of the program are those that correspond to the quarter year, season, year, or greater time scale. Monthly results may be useful in some applications. Seasonal results might be obtained by summation of monthly totals from file *partmon.txt*.

```
File "partsum.txt"                            Program version – Jan 2007
------------------------------------------------------------------
Each time the PART program is run, a new line is written to the end
of this file.

          Drainage                                              Base-
          area                  Mean            Mean            flow
File name  (Sq.    Time      streamflow       baseflow          index
          miles)  period    (cfs) (in/yr)   (cfs) (in/yr)       (%)
------------------------------------------------------------------

Indian.txt    8.88  1971-1980   16.06   24.56   10.46   16.00  65.2
Holiday.txt   8.53  1971-1980   11.66   18.57    6.96   11.09  59.7
Sewee.txt   117.00  1971-1980  227.35   26.39  129.77   15.07  57.1
LitAndro.txt 73.50  1971-1980  154.52   28.56  105.32   19.46  68.2
BigHill.txt  37.00  1971-1980   32.98   12.11    4.84    1.78  14.7
```

Figure 4. Example results of the PART program (written to file partsum.txt) from test runs described above. (Other results are written to other files described in the report.)

The program generates a graphical display of the completeness of the record (figure 2). Results of the program will be most useful if the time period is one in which the record is complete for all calendar years. In the case of the record illustrated in figure 2, this would be 1959 to 1967 (or a subset of these years) or 1971 to 1985 (or a subset of these years). If there is a gap within the period specified, the program will not make calculations. (For example if the period specified was 1961 to 1980.) The program will make calculations in some cases of missing record if the days missing are only at the beginning or the ending of the period specified. Although some output is generated, in this case long-term results will not be written to *partsum.txt*. To demonstrate, the program user can execute PART, specifying *Indian.txt* as the streamflow file, and specifying the time period 1970 to 1980. In this case, a line is written to *partsum.txt* indicating incomplete record, but partial results are written to other files, such as *partqrt.txt* (below) and *partmon.txt, partday.txt*, and *partWY.txt*. The number "-99.99" indicates no result.

```
THIS IS FILE PARTQRT.TXT FOR INPUT FILE: Indian.txt

PROGRAM VERSION DATE = JANUARY 2007


      QUARTER-YEAR STREAMFLOW IN INCHES
      --------------------------------
        JAN-    APR-   JULY-   OCT-    YEAR
        MAR     JUNE   SEPT    DEC     TOTAL
1970   -99.99  -99.99 -99.99  3.83   -99.99
1971    13.25   7.46   3.61   3.67    27.99
1972     9.87   3.41   1.22   7.44    21.94
1973    12.94  12.35   2.77   2.94    30.99
1974     8.50   6.42   1.70   3.69    20.31
1975    16.94   6.29   7.62   7.14    37.98
1976     8.80  10.94   3.41   5.09    28.25
1977     8.79   2.76   2.02   3.06    16.64
1978     8.49   5.16   2.06   1.54    17.25
1979     8.42   7.43   3.57   3.94    23.37
1980     7.49   9.90   1.35   2.18    20.92


      QUARTER-YEAR BASE FLOW IN INCHES
      -------------------------------
        JAN-    APR-   JULY-   OCT-    YEAR
        MAR     JUNE   SEPT    DEC     TOTAL
1970   -99.99  -99.99 -99.99  2.29   -99.99
1971     8.99   5.93   2.38   2.70    20.01
1972     6.72   2.34   0.78   2.30    12.14
1973     7.89   8.77   2.18   1.84    20.67
1974     5.75   3.97   1.16   2.41    13.28
1975     6.86   4.20   3.86   5.47    20.39
1976     6.66   8.18   2.67   3.40    20.91
1977     6.32   2.53   1.33   1.96    12.14
1978     4.61   3.27   1.24   1.07    10.18
1979     5.36   4.89   2.27   3.01    15.54
1980     4.69   7.12   1.12   1.58    14.51
```

REFERENCE

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.