

# **PROGRAM USER GUIDE FOR RORA**

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## **INTRODUCTION**

This manual describes the use of the computer program RORA 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 an earlier report (Rutledge, 1998, pages 17-32).

The program estimates ground-water recharge 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. Results of the program were compared with results of the manual application of the Rorabaugh Method (Rutledge and Daniel, 1994).

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. Regulation and diversion of streamflow should be negligible. More information about application of the method is included in the earlier report (Rutledge, 1998, pages 2-3) and another report about the method (Rutledge, 2000, pages 10-11)

```

#
# U.S. Geological Survey
# National Water Information System
# Retrieved: 2001-08-29 13:12:17 EDT
#
# -----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.
#
# This file contains published daily mean streamflow data.
#
# This information includes the following fields:
#
# agency_cd   Agency Code
# site_no    USGS station number
# dv_dt      date of daily mean streamflow
# dv_va      daily mean streamflow value, in cubic-feet per-second
# dv_cd      daily mean streamflow value qualification code
#
# Sites in this file include:
# USGS 02038850 HOLIDAY CREEK NEAR ANDERSONVILLE, VA
#
#
agency_cd   site_no      dv_dt dv_va dv_cd
5s      15s      10d      12n      3s
USGS 02038850 1970-01-01 17
USGS 02038850 1970-01-02 8.4
USGS 02038850 1970-01-03 6.8
USGS 02038850 1970-01-04 6.2
USGS 02038850 1970-01-05 7.3
USGS 02038850 1970-01-06 4.9
USGS 02038850 1970-01-07 5.1
USGS 02038850 1970-01-08 6.5
USGS 02038850 1970-01-09 4.0
USGS 02038850 1970-01-10 3.2
USGS 02038850 1970-01-11 3.3
USGS 02038850 1970-01-12 3.7
USGS 02038850 1970-01-13 3.4
USGS 02038850 1970-01-14 3.5
USGS 02038850 1970-01-15 3.7
USGS 02038850 1970-01-16 3.8
USGS 02038850 1970-01-17 4.0
USGS 02038850 1970-01-18 13
USGS 02038850 1970-01-19 18
USGS 02038850 1970-01-20 11

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**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 things the program user may need to do before using the program. The first-time user who is experimenting with the data files included with this report can skip this section and proceed to the instructions for running the program. The section about the SCREEN program 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://water.usgs.gov/nwis/discharge>. From this site, the user will need to select site selection criteria. For example, if the site of interest is Holiday Creek in Virginia, yet the site identification number is not known, the selection criteria might be *State* and *Site Name*. After proceeding to the option to select a site, the user would then enter *Holiday* under site name, then the state of Virginia. After these options, the user selects the particular station of interest. Under *Choose Output Format* a range of dates is selected and the user should select *Tab-separated data*. Then the user should select to save as a file, designate the directory where the data are to be written on the user's computer, and specify a file name. 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.) Under *save as file type* the user should specify *plain text*. An example streamflow data file, obtained as described above, is illustrated in figure 1.

### THE "SCREEN" PROGRAM

Before analyzing a streamflow data file the user might execute the SCREEN program to display the period of record. To demonstrate, execute the program by clicking on 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.

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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 (a number for each day in the month) and periods of incomplete record. (This display is generated onto a file by the program SCREEN, and on the monitor by RORA. Streamflow data file is *Indian.txt*.)**

## **DRAINAGE AREA**

The RORA program allows the user to derive estimates of ground-water recharge 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. Each line must include the name of the streamflow data file and the drainage area. This variable may be obtained from USGS databases, web sites, or data books, or the program user may determine it from topographic maps or other sources. The file *station.txt* includes entries for the streamflow data files that are included with this report. These can be used as a guide for the format of additional entries.

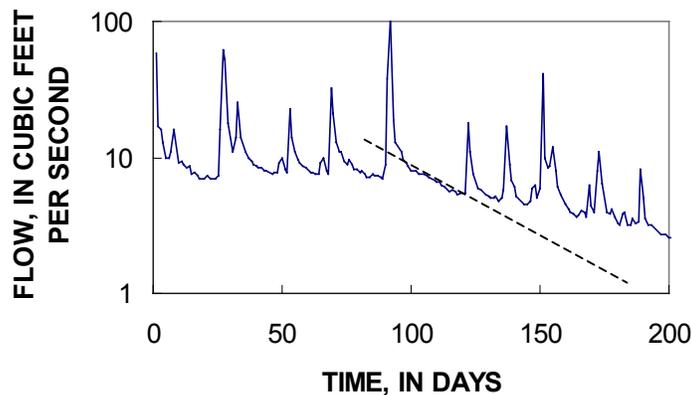
Typically, this variable will be the same as the surface drainage area of the streamflow gaging station. In some applications the hydrologist may have information to indicate the ground-water contributing area is significantly different from the surface drainage area. In this case the former might be designated in file *station.txt*.

## THE RECESSION INDEX

The program requires an estimate of the recession index. There are many methods for obtaining this variable; the basic procedure is to draw a straight line through data that represent linear recession on the semilog hydrograph (figure 3) then designate the recession index as the slope in days per log cycle. According to the Rorabaugh model of ground-water discharge to a stream, the recession will appear linear on such a graph when the ground-water-head profile has become stable (Rorabaugh, 1964). More discussion of the recession index is given by Rutledge (2000, pages 14-18).

The matching strip method has been used in a number of studies (Snyder, 1939; Toebes and Strang, 1964; Nathan and McMahon, 1990). The method is described by Bevans (1986). A method employed by Knisel (1963) involves plotting the streamflow on one day during a period of recession against the flow on a day later in that same period, and repetition of this process for numerous data pairs throughout the period of record. This method could be used, followed by unit conversions to obtain the recession index.

The program user can designate the recession index in the file *index.txt*. The file is included with entries for five streamflow data files. The format of these entries should be used as a guide for additional entries. The RORA program gives the user the option of reading the recession index from *index.txt*, or manual entry of the value during program execution.



**Figure 3. The basic procedure for determining the recession index is to draw a straight line through streamflow data during periods that show linear recession on the semilog hydrograph. (In this example, data are considered from day 100 to 118, julian dates of 1976. Streamflow record is Holiday Creek near Andersonville, Virginia.)**

## RUNNING THE PROGRAM

This section gives specific instructions for running RORA for the five streamflow data files that are included with this report. The station information files *station.txt* and *index.txt*, which are provided with this report, have entries for these stations. The file *rorasum.txt* has header information for summary results of the RORA 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 clicking on the RORA application in Windows Explorer, or by opening the MS-DOS window and entering the command "rora". In the first trial run, enter *Indian.txt* as the streamflow data file, then designate the starting year as 1971 and the ending year as 1980. When asked for the recession index, answer with the letter *y* indicating the program is to obtain it from file *index.txt*. Answer again with the letter *y* that the requirement of antecedent recession should be its default value. As a test of the program the user should repeat the process for the other four stations *Holiday.txt*, *Sewee.txt*, *LitAndro.txt*, and *BigHill.txt*. The program will ask an additional question for *BigHill.txt* because it includes days of zero flow. Answer *y* that flow on these days is to be designated 0.01 cubic foot per second.

After the program is executed five times as described above, the output file *rorasum.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 *roraqrt.txt*, *roramom.txt*, *roraWY.txt*, and *rorapek.txt* are created the first time the program is executed, then over-written each time the program is executed again. To save results on these files the user will need to copy or rename to a separate file with each program run. As noted in the documentation report (Rutledge, 1998), results of the RORA program should be reported at the time scale of the quarter year (or season) or a larger time scale. Results on the basis of the month might be useful in some applications although the program user should be aware of potential problems (Rutledge, 2000, pages 29-31). Seasonal results might be obtained by calculating monthly totals from file *roramom.txt*.

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. In this case, long-term results will not be written to *rorasum.txt*. To demonstrate, the program user can execute RORA, specifying *Indian.txt* as the streamflow file, and specifying the time period 1970 to 1980. In this case, a line is written to *rorasum.txt* indicating incomplete record, but partial results are written to other files (*roraqrt.txt*, *roramom.txt*, *rorapek.txt*, and *roraWY.txt*). The number "-99.99" indicates no result.

File "rorasum.txt"

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Each time the RORA program is run, a new line is written to the end of this file.

File name	Drainage area (Sq. miles	Period	Requirement of antecedent recession (days)	Number of peaks detected	Recession index (Days/ LogQ)	Recharge (in/yr)
Indian.txt	8.88	1971-1980	2	507	100.0	17.097
Holiday.txt	8.53	1971-1980	2	521	80.0	12.210
Sewee.txt	117.00	1971-1980	3	380	65.0	16.676
LitAndro.txt	73.50	1971-1980	3	342	60.0	20.751
BigHill.txt	37.00	1971-1980	3	293	32.0	2.455

**Figure 4. Example results of the RORA program (written to file *rorasum.txt*) from test runs described in this report. (Other results are written to other files described in the report.)**

Because calculations for each recharge event require streamflow data before and after the event, there can be errors near the beginning and the end of the period of interest. These errors can include nondetection of a recharge event. In some applications the program might be executed for a period that begins prior to the period of interest and ends after the period of interest, then results for the period can be extracted from output files such as *roraqrt.txt*.

Specific instructions above are for verifying that the program is executing correctly on the user's computer. When the program is applied using streamflow data from other basins, the user will need to obtain the recession index (see earlier section and references). Experiments might be conducted to show the sensitivity of the estimate of recharge to variation in the recession index (Example: Rutledge, 2000, page 18). If the hydrologist is concerned about errors caused by direct surface runoff, the requirement of antecedent might be increased above the default value. This can affect the program's ability to detect recharge events, thus inducing other errors (Rutledge, 2000, pages 26-28).

## REFERENCES

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