Computer Programs for Obtaining and Analyzing Daily Mean Streamflow Data from the U.S. Geological Survey National Water Information System Web Site

Appendix 5. Make U.S. Environmental Protection Agency DFLOW3 batch-input files MkDF (Version 1.0)—A program for creating batch-input files for DFLOW3

By Gregory E. Granato

Prepared in cooperation with the
U.S. Department of Transportation
Federal Highway Administration
Office of Natural and Human Environment

Open-File Report 2008–1362

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2009

Suggested citation:
Granato, G.E., 2009, Computer programs for obtaining and analyzing daily mean streamflow data from the U.S. Geological Survey National Water Information System Web Site: U.S. Geological Survey Open-File Report 2008–1362, 123 p. on CD-ROM, appendix 5 of 5.

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Conversion Factors and Abbreviations

Multiply	By	To obtain
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]

Abbreviations

1B3	1-day 3-year biological low flow
4B3	4-day 3-year biological low flow
7Q10	7-day 10-year low flow
ADAPS	USGS Automated Data Processing System
BCF	bias correction factor
BMP(s)	best management practice(s)
CD-ROM	computer disk-read only memory
dv	daily value
dd	data descriptor
EMC	event mean concentration
FHWA	Federal Highway Administration
GNWISQ	Get National Water Information System Streamflow (Q)
KTRLine	Kendall-Theil robust line
log10	common logarithm
MkDF	Make U.S. Environmental Protection Agency DFLOW3 batch input Files
MkPP	Make plotting position file
MOVE	maintenance of variance
NWIS	National Water Information System
NWISWeb	National Water Information System Web
PC	Personal Computer
Q	Streamflow
QSTATS	Streamflow (Q) Statistics
RDB	relational database
ROS	regression-on-order statistics
SELDM	stochastic empirical loading and dilution model
SQL	structured query language
SREF	Streamflow Record Extension Facilitator
TMDL(s)	Total Maximum Daily Load(s)
USGS	U.S. Geological Survey

Appendix 5. Make U.S. Environmental Protection Agency DFLOW3 batch-input files MkDF (Version 1.0)—A program for creating batch-input files for DFLOW3

By Gregory E. Granato

Abstract

The Make U.S. Environmental Protection Agency (USEPA) DFLOW3 batch-input files MkDF (Version 1.0) program was developed by the U.S. Geological Survey in cooperation with the Federal Highway Administration to facilitate creation of batch-input files for the USEPA's DFLOW3 program. The MkDF program provides an automatic method for creating DFLOW input files from a list of U.S. Geological Survey streamflow-gaging station numbers. A preprocessor was needed for batch-processing efforts because streamflow stations must be manually specified one-by-one in the DFLOW3 interface. The USEPA DFLOW3 program was developed to calculate water-quality design streamflows that are used for setting water-quality criteria, total maximum daily load (TMDL) waste-load allocations, and in-stream flow standards. The DFLOW program reads the entire drive, directory, and filename path from the DFLOW input file created with MkDF; thus, MkDF must be run each time the input files are moved or copied to a new location. The MkDF program and the USEPA DFLOW3 program have a graphical user interface that follows standard Microsoft Windows interface conventions.

Introduction

Streamflow information is important for many planning and design activities including water-supply analysis, habitat protection, bridge and culvert design, calibration of surface- and ground-water models, and water-quality assessments. Streamflow information is especially critical for water-quality assessments (Warn and Brew, 1980; Di Toro, 1984; Driscoll and others, 1989; Driscoll and others, 1990a, b). Calculation of streamflow statistics for receiving waters is necessary to estimate the potential effects of point sources such as wastewater-treatment plants and nonpoint sources such as highway and urban-runoff discharges on receiving water. Streamflow statistics indicate the amount of flow that may be available for dilution and transport of contaminants (U.S. Environmental Protection Agency, 1986; Driscoll and others 1990a, b). Streamflow statistics also may be used to indicate receiving-water quality because concentrations of water-quality constituents commonly vary naturally with streamflow. For example, concentrations of suspended sediment and sediment-associated constituents (such as nutrients, trace elements, and many organic compounds) commonly increase with increasing flows, and concentrations of many dissolved constituents commonly decrease with increasing flows in streams and rivers (O'Connor, 1976; Glysson, 1987; Vogel and others, 2003, 2005).

Reliable, efficient and repeatable methods are needed to access and process streamflow information and data. For example, the Nation's highway infrastructure includes an innumerable number of stream crossings and stormwater-outfall points for which estimates of stream-discharge statistics may be needed. The U.S. Geological Survey (USGS) streamflow data-collection program is designed to provide streamflow data at gaged sites and to provide information that can be used to estimate streamflows at almost any point along any stream in the United States (Benson and Carter, 1973; Wahl and others, 1995; National Research Council, 2004). The USGS maintains the National Water Information System (NWIS), a distributed network of computers and file servers used to store and retrieve hydrologic data (Mathey, 1998; U.S. Geological Survey, 2008). NWISWeb is an on line version of this database that includes water data from more than 24,000 streamflow-gaging stations throughout the United States (U.S. Geological Survey, 2002, 2008). Information from NWISWeb is commonly used to characterize streamflows at gaged sites and to help predict streamflows at ungaged sites.

Low-flow Analysis with DFLOW

Low-flow streamflow statistics that characterize conditions, which may occur during prolonged dry-weather periods, commonly are used as the basis for regulating potential effects of point sources. Low-flow streamflow statistics are used

because low flows provide minimal dilution, and low flows are commonly associated with other ecological stressors such as reduced habitat, increased temperatures, and an associated decrease in dissolved oxygen (U.S. Environmental Protection Agency, 1986). Low-flow estimates may also be used with estimates of runoff from a watershed to estimate the potential for water-quality exceedances from stormwater runoff during storms that occur during low-flow periods. Conditional-probability methods are needed to estimate the probability of an exceedence from such an event (Haan, 1977; Chow and others, 1988). In this case, the probability of occurrence of the stormwater load causing the water-quality exceedance at this low flow is multiplied by the probability of occurrence of the low flow to determine the probability of exceedance in the receiving water. For example, assuming that

- the 1-day 3-year biological low flow (1B3) has a probability of occurrence of 0.001 (0.1 percent) in any given year, and
- the probability of a water-quality exceedance is 0.1 (10 percent) if the dilution factor for stormwater-runoff loads discharged to a stream with a prestorm streamflow that equals the 1B3;

then the conditional probability of having such a water-quality exceedance on any given day is the product of the two probabilities, which is about 0.0001 (0.01 percent). This probability, if expressed as a return period, is about one day in 27 years (Haan, 1977; Chow and others, 1988).

The U.S. Environmental Protection Agency (USEPA) program DFLOW3 is used for estimating various design streamflows for use in setting water-quality criteria and TMDL waste-load allocations (U.S. Environmental Protection Agency, 1986, 2004; Rossman, 1990a, b). DFLOW3 uses the same algorithms as the original FORTRAN DFLOW program designed for mainframe computers, but DFLOW3 has an improved graphical user interface and additional functionality. In the current (2008) project to develop streamflow statistics for ungaged sites, DFLOW3 was used to calculate the 1-day 3-year biological low flow (1B3), the 4-day 3-year biological low flow (4B3), and the 7-day 10-year (7Q10) hydrologic low flow at 2,783 USGS streamflow-gaging stations in the conterminous United States. These low-flow statistics were calculated to provide planning-level low-flow estimates for the evaluating potential effects of highway runoff in receiving waters. The DFLOW3 program calculates results and displays them in tab-delimited format on a form designed to facilitate cut-and-paste into other applications (U.S. Environmental Protection Agency, 2004).

A method for batch selection of data files for multiple stations in DFLOW was needed because the existing interface is not designed for processing large sets of input files. DFLOW3 prompts the user with a dialog box to select the input file for each streamflow-gaging station from any location on the computer or network. The manual process for the selection and processing of individual data sets in DFLOW3 is slow and potentially error prone. An input-file option is available under the File menu in the upper left corner of the input form, but this feature was designed to allow the user to repeat an analysis saved from DFLOW3, rather than to facilitate the batch selection of data files for multiple stations. Also, the existing DFLOW input-file option is designed for a fixed period of record. As such, the DFLOW3 input files would need to be regenerated manually each time the user needs to analyze a group of streamflow data sets with additional years of data. Finally, the existing DFLOW3 input-file option is designed to read the entire drive letter and directory path name for all input files. As such, existing DFLOW3 input files cannot be used if there is a change in drive or directory structure. As a result, the MkDF computer program was written for generating DFLOW3 input files from a list of station numbers. MkDF was written to facilitate analysis of streamflow data from many stations and to recreate these input files when additional data becomes available or when files are moved.

Purpose and Scope

This manual describes the implementation, use, and interpretation of results from MkDF (Version 1.0) program. The MkDF program was developed by the USGS in cooperation with the Federal Highway Administration for use in the analysis of regional and national hydrologic data sets. The program was developed as part of a suite of tools to download and process streamflow information from the conterminous United States in support of a stochastic empirical loading and dilution model for planning-level estimates of the effects of highway runoff on receiving waters. The process for creating batch-input files for DFLOW3 is described. The formats of input and output data are described. Step-by-step use of the program's graphical user interface is illustrated. The program code was written in Microsoft Visual Basic 6.0 and is documented as individual files in a Visual Basic project directory on the computer disk containing this manual. Information on the theory, implementation, and use of DFLOW3 is available with current versions of the installation files and source code in the DFLOW directory on the CD-ROM containing this manual.

Use of the MkDF Program

MkDF is a Visual Basic program that uses a filename containing USGS streamflow-gaging-station identification numbers to search for the associated data files and, if successful, to make one or more input specification files for DFLOW3. The user interface consists of one interactive form identifying the program and providing the graphical user interface controls necessary to specify user input and provide feedback on the input-file contents. MkDF runs in batch mode to specify DFLOW3 options for multiple station files. The DFLOW program reads the entire drive, directory, and filename path from the DFLOW input file created with MkDF;

thus MkDF must be run each time the input files are moved or copied to a new location. The MkDF program, if installed properly, should be compatible with commonly used Microsoft Windows operating systems.

Installation and Removal

The MkDF program depends on a number of software drivers and dynamic-link libraries that may not be installed and available on the user's computer. This program must be installed by someone who has administrative rights on the program user's computer. The administrator must test the installation with the user's profile to ensure that all permissions are set properly. A readme.txt file with installation instructions and three installation files are in the folder MkDFInstall on the CD-ROM containing this manual. Three files—setup.exe, setup.LST, and MkDFv1.CAB—are needed to install the program. The file setup.exe is the installation program. The setup.LST file is a text file that provides the necessary installation specifications. The file MkDFv1.CAB is the file containing the program and support files. The setup program is a standard Microsoft installation wizard that should be familiar to the user or system administrator. These three files must be located in the same directory on the CD-ROM or in a directory on the user's computer. The person installing the program should follow all the standard choices for installation. The installation program creates the directory C:\Program Files\FHWA\HEP\MkDF\ and includes the MkDF program in the computer's registry. If desired, a shortcut to the program can be added to the desktop manually after installation. Sample files are saved on the CD-ROM containing this manual and should be copied to a directory in which the user has read, write, and execute rights. The user may uninstall the MkDF program and its support files by use of the standard Microsoft Windows Add or Remove Programs wizard on the control panel of the user's computer.

Input- and Output-File Formats

MkDF program reads one station-list file, creates one or more DFLOW-input files and, if necessary, creates an error file. The station-list filename is specified by the user. As the MkDF program runs, it ensures that the streamflow-data files created by the GNWISQ program (appendix 1) are in the specified directory. The GNWISQ streamflow files are not read by MkDF, but they must exist in the target directory or MkDF will generate an error file. MkDF also checks the file size of each streamflow file to ensure that each file contains at least 3 years of data. The DFLOW-input files are formatted for 1 to 100 streamflow-gaging-stations. The error file documents problems in the input data set. Examples of each type of file are provided in the example data directory for the MkDF program on the CD-ROM containing this manual.

Station-List Input-File Format

The MkDF program is designed to facilitate DFLOW3 analysis of data in batch mode. The program reads a station-list input file to obtain the station numbers necessary to build the DFLOW input file. This list file does not contain any header lines. The list file consists of 8- to 12-character streamflow-gaging-station numbers on separate lines without leading or following spaces. The station-list file should not include any text except the station numbers of interest and should not end in a blank line. The station-list input file may contain thousands of station numbers. MkDF will parse these station numbers into multiple DFLOW3 input files.

DFLOW3 Input-File Format (Output from MkDF)

The DFLOW3 input files produced as output from MkDF are formatted for use by version 3 of the USEPA DFLOW3 program. These files are named LowFlowXofY.dfl where "X" is the sequence number of each file and "Y" is the total number of files produced in one run of the MkDF program. Details about the file format are described in the DFLOW documentation on the CD-ROM containing this program. In general, the input file includes information about the calculation period, the seasons used for biological-flow calculations, three comment lines, the biological-flow analysis specifications, the hydrological-flow specifications, and the streamflow-gaging-station filenames. These filenames are specified based on the assumption that the station-list file, the DFLOW input files, and the NWISWeb streamflow-data files will be used in the same directory.

Error Output File Format

The error file, MkDFErr.txt, is created only if an error occurs while the station name is being tested, the presence of the NWISWeb streamflow-data files in the target directory is being verified, and the length of each data file is being checked. If an error occurs, the station number or the name of the associated data file is written to the error file with a message that indicates a problem. The file checks are done sequentially so each problem station in the station-list file is listed only once. Because the error file MkDFErr.txt will be overwritten or deleted with each run, the user may wish to rename this file manually to keep a record of any download errors.

Graphical User Interface

The graphical user interface consists of one interactive form and a file-specification dialog form. This interactive user interface form requires a screen resolution of at least 1024 by 768 pixels to display properly. The program is initiated by double clicking on the program file or a Microsoft Windows

shortcut to the executable-program file location. Initially, the user is presented with two choices, the 1B3 or the 4B3 flow (fig. 5-1). This choice, however, is not critical because it is easy to respecify the desired flow options in DFLOW3 (U.S. Environmental Protection Agency, 2004). The user also may specify the beginning and end year of the period of record of interest. The USEPA (2004) recommends a period of at least 20 years. The period of record must correspond with the period of record in files obtained from NWISWeb, but DFLOW3 allows the user to choose among several period-of-record options.

To proceed, the user must click on the "Select Batch File" command button. After the command button is pushed, a file-specification dialog box appears so that the user may select the name of a file containing one valid station number per line (fig. 5-2). The default name is "StationFile.txt," but almost any filename may be used. MkDF includes only a batch-file option because single or a few files are easier to read directly in the DFLOW3 interface. Because DFLOW3 is designed to read the entire filename and path from the input file, MkDF is designed so that the station file, the streamflow-data files, and the DFLOW3 input files are included in the same subdirectory.

Once the station file is selected, MkDF will read the file, check the input, and if an error occurs, inform the user by use of a message box and an error file (fig. 5-3). It checks station numbers for the proper format. It confirms that each file is in the specified directory, and it checks the file length as an indication that there are at least 3 years of data in the file. The message box also indicates the number of files that have passed these tests and thus will be included in the DFLOW3 input files. If there are no errors, the message box will not appear. If no files pass these tests, the program will automatically terminate after the user confirms the errors on the message box. If there are errors, the user should read the error file MkDFErr.txt in the target directory before restarting the program. If the message box appears, the user may click the OK button to proceed to the next step.

The next steps are to edit the information on the comment lines and process the data (fig. 5-4). The user may edit the contents of the first two 44-character comment lines in the input data files by entering information in the text boxes on the form before clicking the "Process Data" command button. A third comment line is written by the MkDF program to indicate the sequence number of each DFLOW3 input file and the total number of these files created during each use of the MkDF program. When the user clicks the "Process Data" button, the comment text boxes are disabled, the output files are created and written, and an output-file text box appears to confirm the name and location of the DFLOW3 input files that are created (fig. 5-5). At any time in the data-specification process, the user may click the "Close" button to terminate the program, but this button will not be active while the program is creating DFLOW3 input files.

Summary

The Make DFLOW3 batch-input files MkDF (Version 1.0) program was developed by the U.S. Geological Survey in cooperation with the Federal Highway Administration to facilitate analysis of daily mean streamflow data from many stations with the U.S. Environmental Protection Agency's DFLOW3 program. Streamflow statistics are important for many planning and design activities including water-supply, habitat protection, bridge and culvert design, and water-quality assessments. Low-flow streamflow statistics that characterize conditions, which may occur during prolonged dry-weather periods, commonly are used as the basis for regulating potential effects of point sources. Low-flow estimates may also be used with estimates of runoff from a watershed to estimate the potential for water-quality exceedances from stormwater runoff during storms that occur during low-flow periods. DFLOW3 is a U.S. Environmental Protection Agency computer program for estimating these low-flow statistics for use in setting water-quality criteria and TMDL waste-load allocations. MkDF uses a filename containing identification numbers for USGS streamflow-gaging station to search for the associated daily mean streamflow-data files and, if the data file is found, to add it to a DFLOW3 input file. The DFLOW program reads the entire drive, directory, and filename path from the DFLOW input file created with MkDF; thus MkDF must be run each time the input files are moved or copied to a new location. MkDF was written to facilitate analysis of data from more than 2,783 stations at which at least 24 years of daily mean streamflow data had been collected during the period 1961–2004 within the conterminous United States.

This manual describes the implementation, use, and interpretation of results from MkDF (Version 1.0) program. MkDF was written in Microsoft Visual Basic 6.0 and has a graphical user interface that follows standard Microsoft Windows interface conventions. The user interface consists of one interactive form and a file-specification dialog form that follows standard Microsoft Windows installation and interface conventions. The program uses an input file of USGS streamflow-gaging station numbers. The program outputs a text file that is in the proper format for a DFLOW3 input file. An executable version of the program, example files, and the Visual Basic source code are documented in the MkDF directory on the computer disk containing this manual.

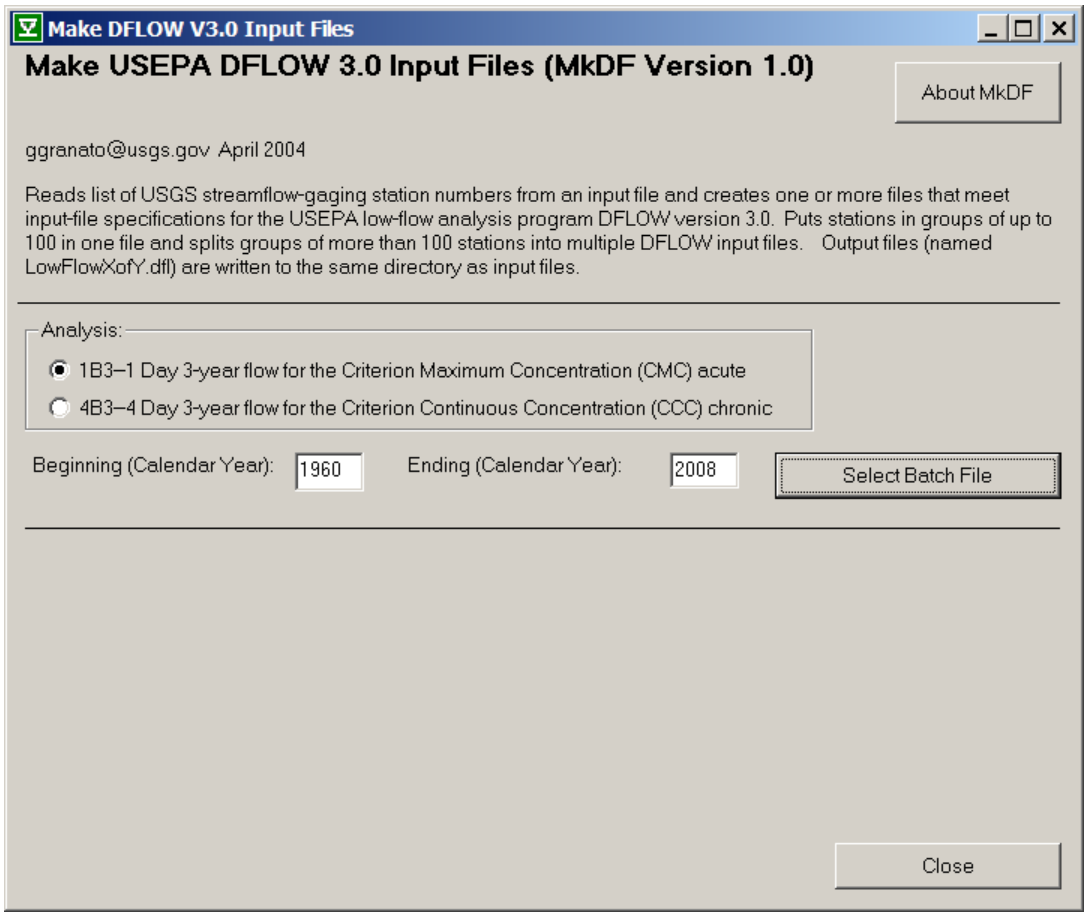

Figure 5-1. Initial appearance of the MkDF program input form when the program opens.

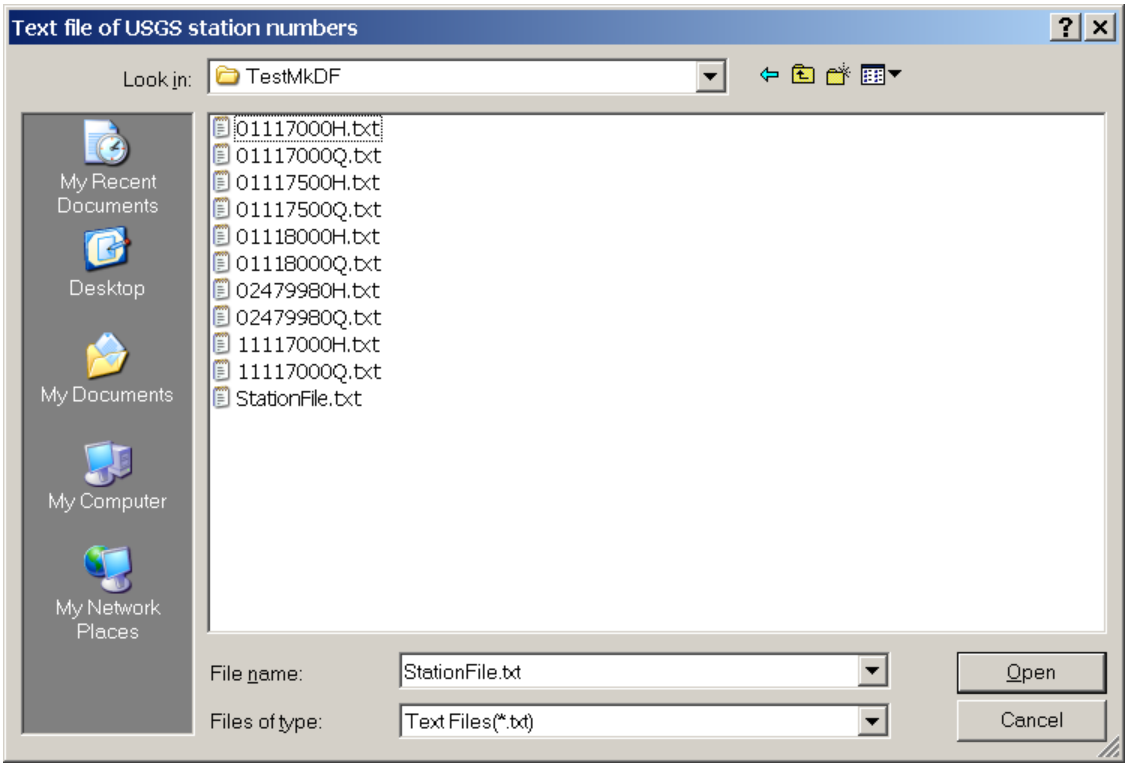

Figure 5-2. Example of the MkDF program file-specification dialog box.

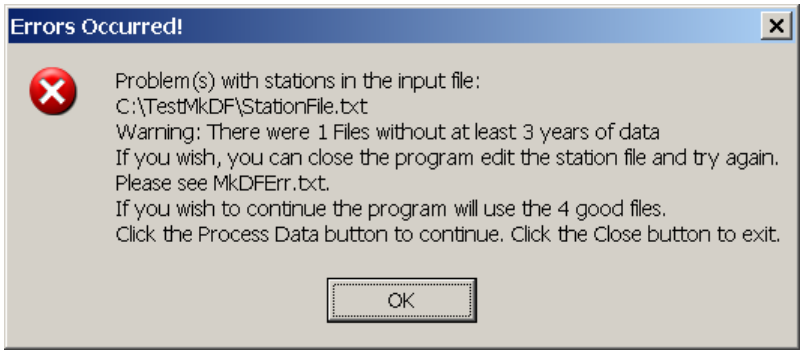

Figure 5-3. Example of the MkDF program input-file error message.

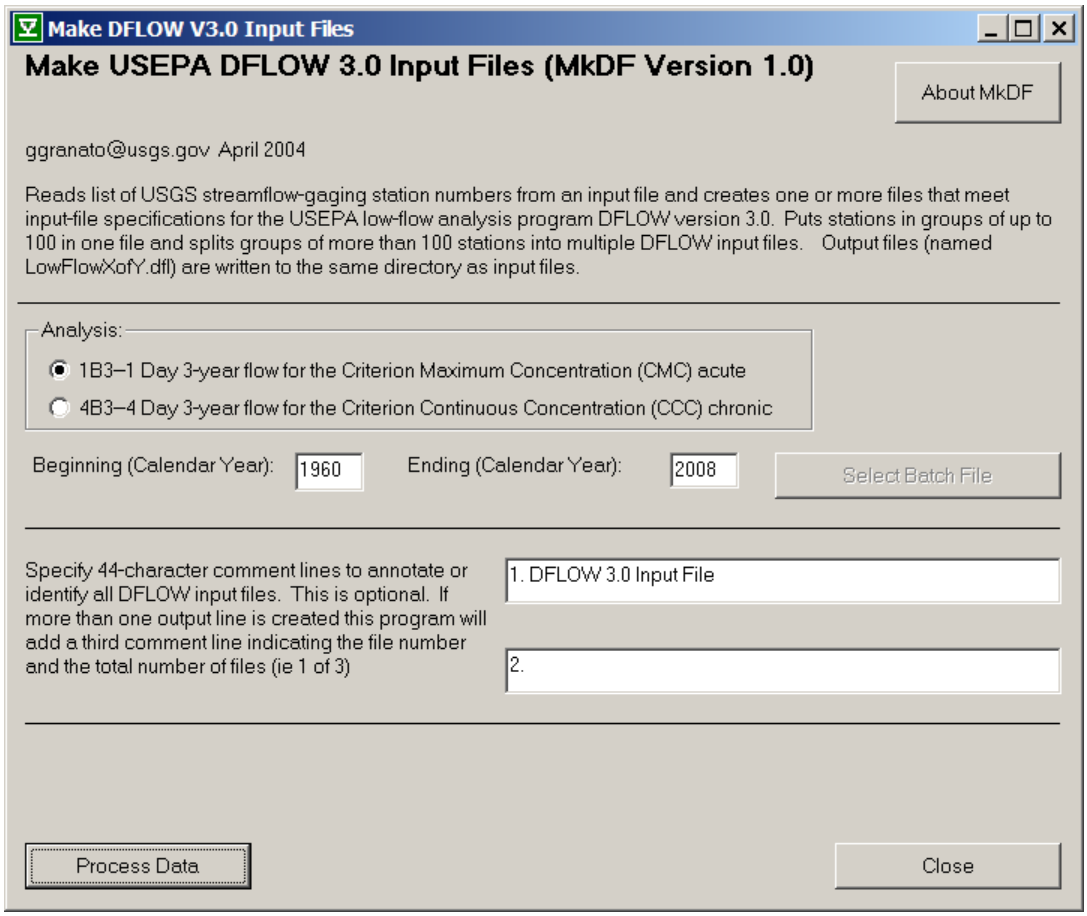

Figure 5-4. Example of the MkDF program input form as configured for processing a batch of streamflow-gaging-station files specified in the station-input file.

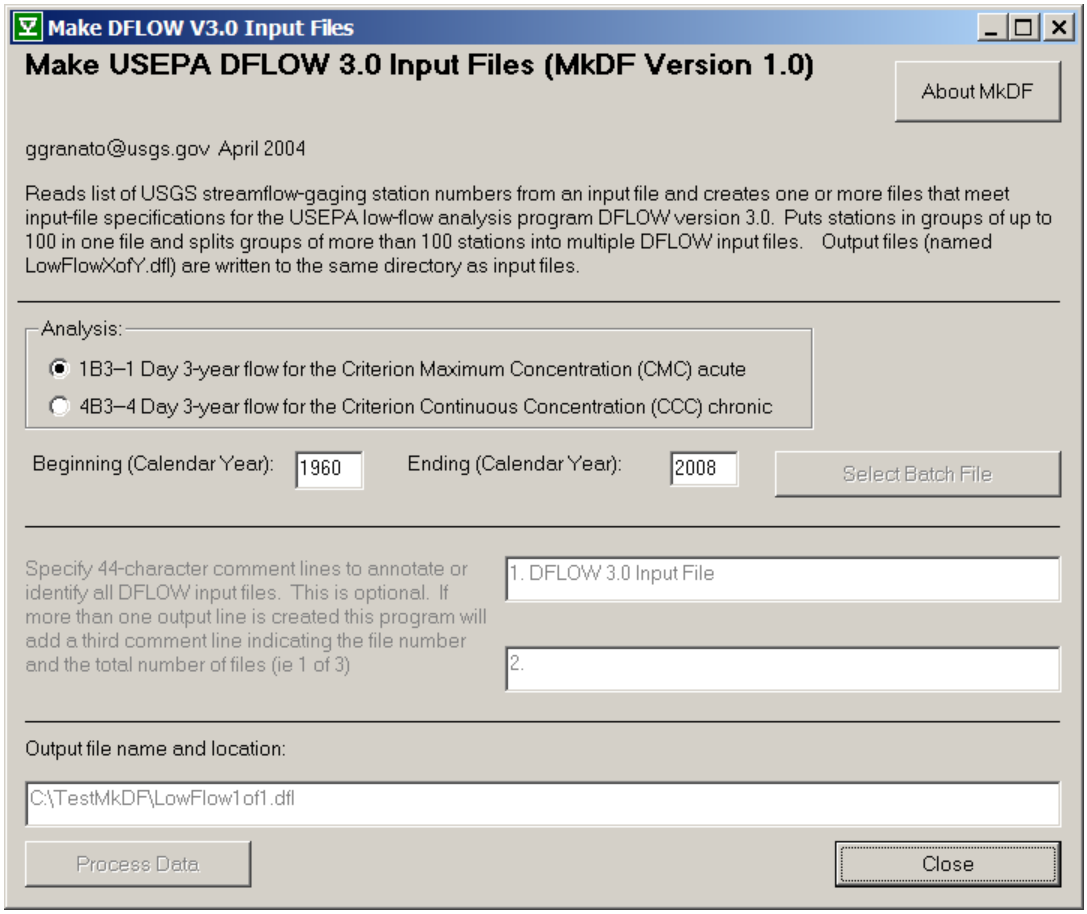

Figure 5-5. Example of the MkDF program input form once it completes batch processing and indicating the name and location of the U.S. Environmental Protection Agency DFLOW3 input files it created.

Acknowledgments

The author thanks Lewis Rossman of the U.S. Environmental Protection Agency for information about batch processing in DFLOW3; this information was helpful for designing MkDF as a DFLOW3 preprocessor. Gene Parker and Marla Stuckey of the U.S. Geological Survey provided thoughtful and thorough technical reviews of the companion software products that helped improve this program and the associated documentation.

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