

COMPUTER SOFTWARE FOR CONVERTING GROUND-WATER AND WATER-QUALITY DATA FROM THE NATIONAL WATER INFORMATION SYSTEM FOR USE IN A GEOGRAPHIC INFORMATION SYSTEM

by Jonathon C. Scott

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ABSTRACT

A geographic information system (GIS) is computer software that provides the capabilities to rapidly display and analyze spatially referenced data. To use a GIS efficiently, software is needed that provides a link between existing spatially referenced data-base systems and the GIS.

The U.S. Geological Survey (USGS) stores large amounts of spatially referenced hydrologic data in computerized data-base systems. Currently, these data-base systems are physically located on computers that are installed in many USGS offices nationwide. This report describes software that can be used quickly and easily to convert site-description and water-quality data from these data-base systems to the GIS that is used by the USGS. The software described in this report is designed to be used with the same hardware and software that is available to most USGS personnel.

CHAPTER 1. INTRODUCTION

Since 1982, the U.S. Geological Survey (USGS) has been installing and maintaining a nationwide network of computers. The primary uses of these computers are the storage, retrieval, and analysis of hydrologic data. USGS personnel use a computerized data-base system called the National Water Information System (NWIS) for many of these tasks. The NWIS contains computer software and data files for processing large amounts of hydrologic data (Dempster, 1990). On many of these computers the USGS is using a geographic information system (GIS) licensed from the Environmental Systems Research Institute (ESRI) named ARC/INFO¹ (Rennick, 1986). The GIS is used for the display, analysis, and interpretation of data (Guptill and Nystrom, 1986). This report describes computer software for converting site-description and water-quality data that have been retrieved from the NWIS for use with the ARC/INFO GIS.

Hydrologic data stored in the NWIS are stored with the location of the site where the data were collected. The site location is identified by latitude and longitude. Some sites are visited more than once and data are collected and stored in the NWIS for multiple site visits. This results in multiple records in the NWIS for the same site. These records may contain values for the same hydrologic measurement. For example, water temperature might be measured at the same site on different dates.

¹The use of firm and trade names in this report is for identification purposes only and does not constitute endorsement by the USGS.

Sometimes users of the software will convert hydrologic data literally so there is a one-to-one correspondence between the records from the NWIS with the records in the GIS. At other times, users will aggregate data statistically while converting it from the NWIS data-base system to the GIS. The software described in this report can convert data using either of these methods.

Purpose and Scope

This report describes software for the conversion of hydrologic data retrieved from the NWIS to a GIS. This conversion provides the linkage that integrates the NWIS with the GIS for the display and interpretation of hydrologic data using spatial-data analysis. The report also describes the procedures to be used for retrieving data from the NWIS, and the options available for converting the data for use in the ARC/INFO GIS. The report briefly describes the internal operation of the computer programs that are used in the conversion process.

The conversion software is not intended to be used for converting an entire NWIS data base to a GIS data base. The NWIS provides many specialized capabilities for entering, updating, retrieving, summarizing, graphing, and tabling of hydrologic data that are not readily available in the GIS used by the USGS. The NWIS is the primary repository of hydrologic data and is designed with all of these capabilities. When a GIS is needed to supplement the capabilities provided in the NWIS, the necessary data need to be retrieved from the NWIS and placed in the GIS.

Overview and Definitions

Because the software described in this report is designed to work with the ARC/INFO GIS, all references to "the GIS" in this report implicitly refer to the proprietary ARC/INFO software. The NWIS-to-ARC/INFO conversion software is comprised of a collection of programs that is referred to as the conversion software.

A GIS stores the geographic locations of map features. These map features include points, lines, and polygons, as well as explanatory map labels. A hydrologic example of a point map feature is the location of a ground-water well. Similarly, the path of a stream channel is represented on a map by a line. The land area drained by the stream is a polygon. In the GIS, each of these types of map features is stored in the computer system using a file format specifically designed to describe the topological characteristics of the map feature. The collection of files within the GIS that contain data for a particular map feature is referred to as a coverage.

Most maps are a two-dimensional representation of a portion of the curved surface of the earth. These maps are created using a mathematical procedure that translates the coordinates of map features on the curved surface of the earth to locations on a two-dimensional mapping plane. The procedure is called a map projection. There are many map projections that can be used (Snyder, 1987). The GIS stores the locations of map features using two-dimensional coordinates computed with a map projection.

Information describing map features also can be stored in the GIS. This information may be any type of ancillary data that pertains to the map feature. These ancillary data

are called attributes. For example, some attributes of a water well are well depth, depth to water, water temperature, date of well construction, and the name of the well owner. Attribute data are stored in the GIS using an INFO file. An INFO file is a file that is accessible with the relational INFO file-management system (Henco, Inc., 1983).

The user of the conversion software has the option of storing the attribute data in one of the INFO files that is part of the coverage called the point attribute table (PAT) (ESRI, Inc., 1987a, p. 5-3). Alternatively, the user has the option of storing the attribute data in a separate INFO file, referred to as a related file. When the GIS is used for analysis and display of the attribute data, a link can be established between the PAT and the related file to associate the attribute data with the point features. Either of these INFO files used for storing attribute data is referred to as an attribute file.

The locations of data converted by the software are stored in the GIS as point features. The hydrologic data associated with the points are stored as point attributes. When more than one data record for the same location is converted by the software, and statistical aggregation is not used, the software stores multiple records in the GIS for the point and its attributes (fig. 1). Thus there is a one-to-one relationship between records retrieved from the NWIS and attribute data stored in the coverage. This one-to-one conversion of hydrologic data is referred to as literal conversion. Alternatively, there is a many-to-one relationship when statistical aggregation is used, referred to as *statistical conversion* (fig. 2).

Often the same hydrologic measurements are not made at every site visit. Therefore, tables of hydrologic-data retrievals show that some data are missing in certain lines and columns. The conversion software handles missing data differently, depending upon the type of the data. When character-type data are missing, the conversion software leaves blank the corresponding attribute field of the INFO file. When numeric-type data are missing, the conversion software places a missing-value indicator in the corresponding attribute field. A missing-value indicator is a number that is unlikely to occur in the data, and is used to denote that a measurement was not stored in the NWIS. When data are aggregated statistically, data are sometimes insufficient for computing statistical estimates. In these cases, a missing-value indicator is stored for the corresponding statistic.

Hardware and Software Requirements

The software was developed on a Prime minicomputer running revision 21 of the Primos operating system. Most of the computer programs that comprise the software are written in Fortran 77 (Johnson, 1983). The software is designed to work specifically with the NWIS and the ARC/INFO GIS. The software is integrated with other software used by USGS personnel and is not designed to minimize dependencies on other software products. Consequently, the software cannot be converted easily for use on other computer systems. The specific dependencies are identified in the following paragraphs.

The NWIS contains two data dictionaries that describe the data elements stored within the system. The software uses subroutines from the NWIS program library to access the data dictionaries and retrieve information about data elements that have been retrieved from the NWIS.

ATTRIBUTE DATA

Latitude	Longitude	Station name	Date	Water level
360004	0950004	SITE A	891215	23.15
360004	0950004	SITE A	900130	22.95
360010	0950015	SITE B	550818	15.75
360010	0950015	SITE B	700704	13.20
360015	0945954	SITE C	650130	18.93
360015	0945954	SITE C	720430	19.01

COVERAGE

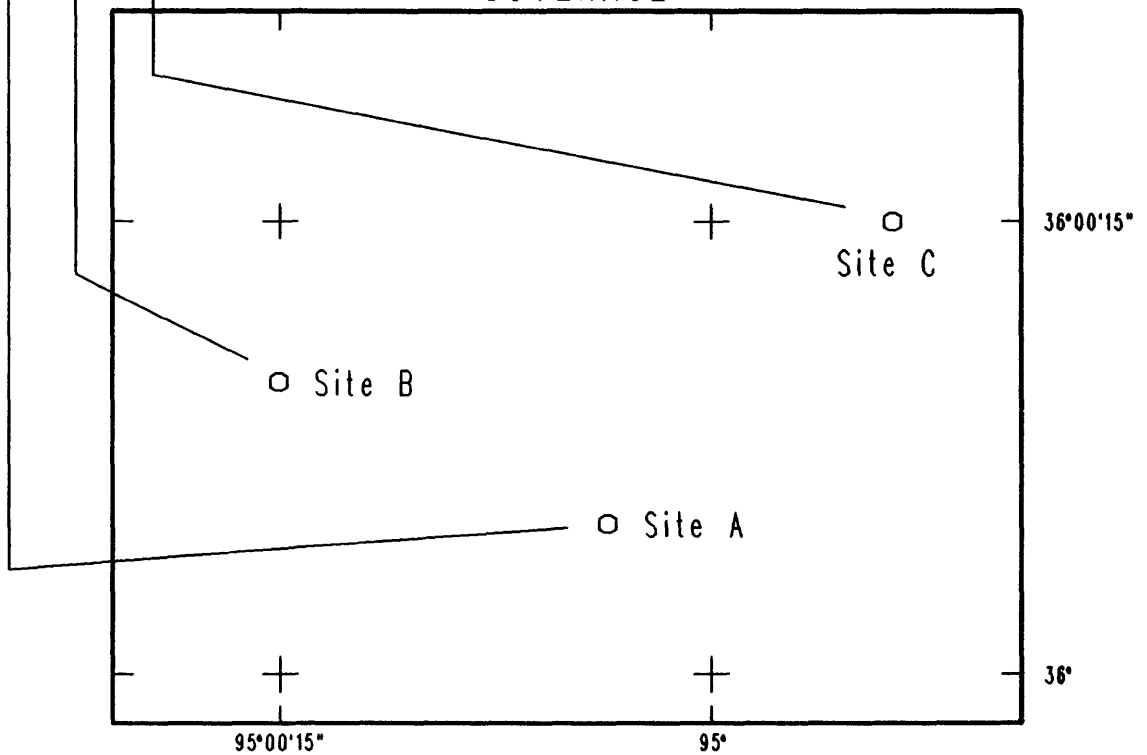


Figure 1.— An example of literal conversion of data.

ATTRIBUTE DATA

Latitude	Longitude	Station name	Minimum date	Maximum date	Average water level
360004	0950004	SITE A	891215	900130	23.05
360010	0950015	SITE B	550818	700704	14.48
360015	0945954	SITE C	650130	720430	18.97

COVERAGE

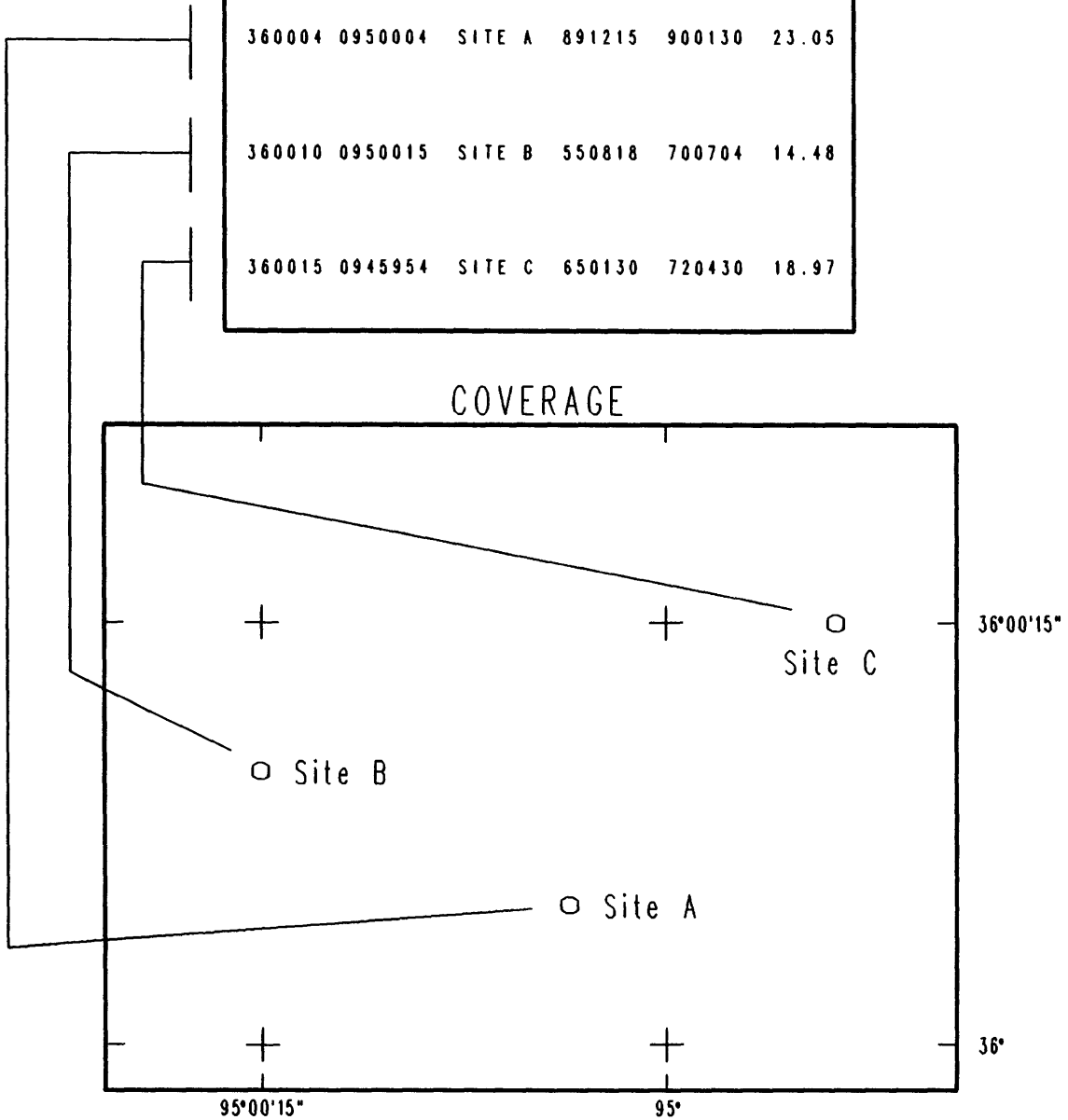


Figure 2.— An example of statistical conversion of data.

Some programs in the software utilize subroutines from the ARC/INFO subroutine library, revision 4.0.1 (Lupien, 1988). Some programs utilize subroutines in the Primos operating system (Spencer, 1986). Additionally, some subroutines from the proprietary IMSL library are used (IMSL, Inc., 1987).

The interaction between the user of the software and the various programs that comprise the software is handled by a computer program written in the Prime Command Procedure Language (CPL) (Landy, 1982). Partially converted data files are transferred between computer systems using the File Transfer Service, revision 5.1 (Venne and Fulchino, 1985). The ARC/INFO GIS consists of software from two vendors. Spatial coordinate data and topological relationships are managed by the ARC software (ESRI, Inc., 1987a). Attribute data are managed by the INFO file-management software, revision 9.42 (Henco, Inc., 1983). Finally, the software uses subroutines written for statistical computations for water-quality data with constituent measurements below one or more detection limits (Helsel and Cohn, 1988).

Acknowledgments

Several Fortran subroutines used in the conversion software were written by other scientists in the USGS. The author acknowledges the contributions of Timothy Cohn, Dennis Helsel, and William Kirby, who developed subroutines used in the conversion software for the statistical analysis of water-quality data. The author also acknowledges the work of Richard Luckey and Claud Baker who developed the subroutines used in the conversion software for retrieving data from the NWIS data dictionaries.

CHAPTER 2. PROGRAM USAGE

Before data can be converted for use in the GIS, the desired data must be retrieved from the NWIS. The NWIS provides many retrieval capabilities for grouping and formatting data. The design of the conversion software places some constraints on the options that may be selected when retrieving data from the NWIS for use with the conversion software. These constraints are presented in the first section of this chapter.

Retrieval of Data

This report does not describe all of the retrieval options available to a user of the NWIS. Only those specific options that need to be used when retrieving data from the NWIS for use with the conversion software are described.

The NWIS stores hydrologic data in different data-base systems depending on the data type. Different commands are used to retrieve different data types. Site-description data are stored in a data-base system called the ground-water site inventory (GWSI) and are accessed by entering the command: GWSI. Although the name of the data-base system implies storage of ground-water site data, data for other types of sites are accessible through GWSI. Water-quality data are stored in a separate data-base system and are accessed by entering the command: QWDATA. Each of these commands starts a different interactive computer program that the user controls by selecting options from lists of choices or menus.

Ground-Water Data

Data are retrieved from GWSI by specifying one of several optional gross site-selection methods. Additionally, the user may specify detailed tests to further limit the data that are retrieved. Next, one of several retrieval formats are selected. The conversion software uses data in a fixed-format file, referred to as a subfile (Rogers and Luckey, 1990, p. 8-14). Therefore, when the GWSI retrieval software displays the message:

Specify format (1=Std, 2=Dump 3=Subfile, 4=Special (<CR>=1):

a three (3) needs to be entered to create a subfile.

When a subfile is specified, the GWSI retrieval software displays a message prompting the user to enter a file name for the subfile, as shown below.

Enter file name for subfile (<CR>=GW.SUBF):

Any name may be entered that conforms to the restrictions imposed by the computer-operating system (Seybold, 1985, p. 1-6) and contains less than 27 characters. A carriage return can be typed without entering a subfile name to use the default file name, in this example "GW.SUBF".

When a subfile is written by the GWSI retrieval software, a second file describing the contents of the subfile optionally may be written. The conversion software needs this second file to determine the contents of the subfile, and the file name must be the same as the name of the subfile, with the characters ".LIST" appended to the end of the name. Thus, when the following messages are displayed by the GWSI retrieval software:

Do you wish a listing of the subfile fields and locations (Y/N,<CR>=Y)?

Enter name for file (<CR>=GW.SUBF.LIST):

a carriage return needs to be entered in response to each message.

After these responses have been entered, the GWSI retrieval software displays a series of messages prompting the user to enter field codes (Babcock and others, 1990, p. 2-1 through 2-126) for the data to be written to the subfile. Each field code corresponds to a specific attribute stored in GWSI.(Field codes also are referred to as "component codes" in the GWSI documentation.)

The messages displayed by the GWSI retrieval software, and a few sample responses are shown below.

Specify fields to be included in the subfile. Enter <CR> to end —

Enter field code: C009

Enter field code: C010

Enter field code: C900

Enter field code:

The conversion software needs the latitude (C009) and longitude (C010) of the data-collection site. These data must be stored as the first two fields in the subfile. The remaining fields may be any fields the user chooses to retrieve.

With some options of the conversion software the user specifies a key field used for grouping hydrologic data. The key field is used to determine which records belong in each group. Data may be grouped in order to discard records that contain the same value for the key field, to relate two attribute files by the key field, or to aggregate statistically hydrologic records with the same value of the key field. Often, the key field is the site-identification number (C001). The key field must be specified while entering field codes for the GWSI retrieval software, if grouping will be performed by the conversion software,

When the retrieval of GWSI data has been completed, two files will have been created that are needed for using the conversion software (fig. 3). The first file contains information about data-collection sites. The second file contains a description of the contents of the first file.

To summarize, the conversion software imposes three constraints on the way data are retrieved from GWSI, as follows.

- (1) The retrieved data must be stored in a subfile and the name of the subfile may not contain more than 27 characters.
- (2) A second file must be created containing a description of the subfile. The second file must have the same name as the subfile with the characters ".LIST" appended to the file name.
- (3) The latitude (field code C009) and the longitude (field code C010) of the data-collection site must be the first two fields in the subfile. Additionally, if a key field will be used, the field to be used for grouping the data must be retrieved.

Water-Quality Data

Water-quality data are retrieved from the NWIS using two separate menu options. During the first menu option, the user specifies information for determining which water-quality analyses are to be retrieved. During the second menu option, the user specifies the format and contents of the data file that is created during the retrieval. When retrieving water-quality data for use with the conversion software, three constraints are placed on the manner in which these two menu options are performed.

The first menu option used in the QWDATA software is named "LOCATE SITES AND/OR SAMPLES". When this menu option is selected, the user enters responses to a series of messages that determine which water-quality analyses are to be retrieved. After the data to be retrieved have been identified, the user enters the file name for storing the record-identification numbers of the desired water-quality analyses. Next, the following message is displayed:

DO YOU WANT TO SAVE A LIST OF SITES THAT HAVE QW DATA (YES OR NO) ?

In order to use the conversion software, this question must be answered with a "YES". The conversion software needs this list of sites to determine the latitude and longitude of the data-collection sites. After "YES" is entered, the QWDATA software displays the following message.

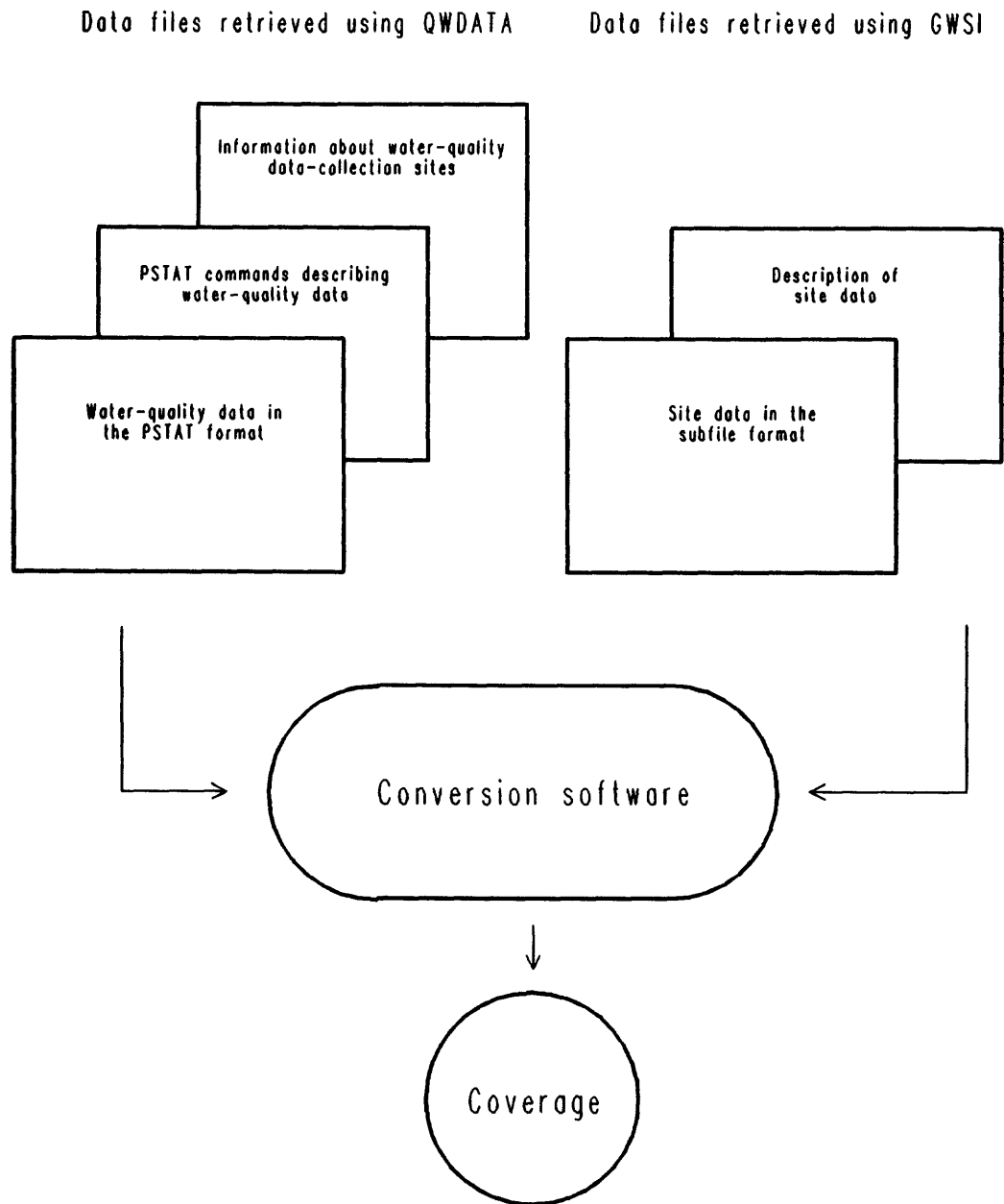


Figure 3.— Files needed to use the conversion software for each type of data.

PLEASE ENTER NAME OF FILE TO HOLD THE LIST:

Any file name that conforms to the restrictions imposed by the computer-operating system may be entered. The file name entered here will be used when running the conversion software.

The second menu option used in the QWDATA software is named "MAKE A PSTAT (FLAT FILE) DATA SET". (PSTAT is the name of proprietary software for statistical analysis.) When this menu option is selected, the QWDATA software displays messages prompting the user to enter two file names. The first file name identifies the file created during the first QWDATA-menu option, which contains the record-identification numbers. The second file name specifies the file that will be used to store the retrieved water-quality data. The second file name may be any name that conforms to the constraints of the computer-operating system and contains no more than 27 characters.

Next, the QWDATA software displays a set of messages describing optional methods for storing water-quality data that contain remark codes (Maddy and others, 1990, p. 2-32), as shown below.

QWPSTAT REMARK HANDLING OPTIONS :

- 1 — REMARK CODES (SUCH AS < OR ND) INCLUDED WITH THE DATA,
- 2 — REMARK CODES DELETED BUT VALUES ASSOCIATED WITH REMARK CODES RETAINED (A REMARK CODE OF "ND" WILL HAVE A VALUE OF "-" (MISSING VALUE OF THE FIRST KIND),
- 3 — VALUES WITH REMARK CODES SET TO "-" (MISSING VALUE OF THE SECOND KIND).

WITH EACH CHOICE, YOU WILL RECEIVE A SEPARATE FILE CONTAINING COUNTS OF THE REMARKED VALUES

PLEASE ENTER 1, 2, OR 3.

The conversion software can process water-quality data retrieved using any of these three methods for handling remark codes. However, the first method is preferred because it provides the most information and enables the conversion software to calculate representative estimates when a statistical conversion is performed.

When remark codes are included with the data and literal conversion is performed, the conversion software scans the data for each water-quality constituent. If any value for the constituent is remarked, the conversion software creates a field in the attribute file for storing remark codes for the constituent. Conversely, if none of the values for the constituent are remarked, the conversion software does not create a field for storing remark codes for the constituent.

When remark codes are included with the data and statistical conversion is performed, the conversion software uses a modeling procedure for calculating statistical estimates. When remarked values are deleted or retrieved without remark codes, statistical estimates for the constituent are biased (Gilliom and Helsel, 1984).

When the retrieval of water-quality data has been completed, three files have been created that are needed for using the conversion software (fig. 3). The first file, created during selection of water-quality analyses, contains information about data-collection sites. The second and third files are created during the retrieval of water-quality data in the PSTAT format. The second file contains the water-quality data, and the third file contains a description of the contents of the data file, using the PSTAT command language. The third file has the same name as the second water-quality-data file with the characters ".CMND" appended to the file name.

To summarize, the conversion software imposes three constraints on the way data are retrieved using QWDATA, as follows.

- (1) When the desired water-quality analyses are identified, a file must be created that contains information about the water-quality data-collection sites.
- (2) The retrieved data must be stored in another file using the PSTAT format, and the file name may not contain more than 27 characters.
- (3) Remark codes need to be included with the data (menu-option one).

Conversion of Data for Use with a Geographic Information System

The conversion software is started by typing a command for the Primos computer-operating system. The conversion software may be run in an interactive mode (using the RESUME command), in batch mode (using the JOB command), or in phantom mode (using the PH command). For simplicity, the examples in this report show usage of the RESUME command, which is abbreviated with the letter "R". Refer to the Prime User's Guide (Seybold, 1985, p. 13-14 through 14-13) for additional information about batch and phantom modes.

The software provides several options that may be selected when converting data to the GIS. Any of these options may be selected by appending phrases to the command that runs the software. These phrases are called command-line arguments. The command format for starting the conversion software is shown below.

R *pathname*>NWISARC *infile outcover arguments*

where:

pathname is the location of the directory containing the NWISARC.CPL program on the local computer system,
infile is the name of the file containing the data retrieved from the NWIS (either a GWSI subfile, or a QWDATA retrieval in the PSTAT format),
outcover is the name of the coverage to be created, and
arguments are optional specifications that describe how the conversion is to be performed.

The conversion software provides many options for creating a coverage of hydrologic data. The options used by the conversion software are determined by a combination of three different methods.

- (1) Options may be specified as arguments on the command line. An argument is specified with a hyphen, immediately followed by a key word. Some key words are followed by one space and data pertaining to the option. The key word is an acronym that identifies the option that user wants to select for converting the data. Key words can be abbreviated, so there are several different acronyms that correspond to each optional specification.
- (2) Most options may be specified by a value stored in a global-variable file. A global-variable file is a method used in the Primos operating system for storing the values of variables in a binary-format file (Seybold, 1985, p. 4-9 through 4-10). Global-variable files are manipulated with the Primos commands DEFGV, SET_VAR, LIST_VAR, and DELETE_VAR (Calvillo, 1985). Global variables have names that begin with a period. The names of global variables used by the conversion software are shown in this report in capital letters enclosed in double quotation marks.

Many options for the conversion software can be specified by setting the value of a global variable, and enabling the use of the global-variable file with a command-line argument. The *infile* can be specified by storing the name of the data file in the global variable named ".INFILE". Similarly, the *outcover* can be specified in the global variable named ".OUTCOVER". The conversion software is notified to use global-variable-file specifications with the key word -INPUT, followed by the name of the global-variable file. The -INPUT key word may be abbreviated with any of the acronyms -INP, -IN, or -I. The following command will start the conversion software, with all specifications being provided in the global-variable file named NWISARC.GVARS.

R *pathname*>NWISARC -I NWISARC.GVARS

If specifications are provided on the command line, as well as in a global-variable file, the specifications on the command line take precedence. For example, if the global variable ".OUTCOVER" has the value QWDATA, and the following command line is used:

R *pathname*>NWISARC QW.PSTAT QW.COVER -I NWISARC.GVARS

the coverage created by the software is named QW.COVER, not QWDATA.

- (3) If not specifically identified by the user, most options will be determined by the conversion software. When not specified, certain options are assumed, and thus are default options. Specification using the command line or a global variable takes precedence over default options.

The following seven sections of this report contain information about the optional specifications. Argument key words, abbreviated key-word acronyms, applicable global-variable names, and default options are described for each option. A brief description of optional specifications can be obtained by starting the conversion software with the `-HELP` argument. This argument is incompatible with other specifications, and causes the software to display information about options on the terminal screen, instead of converting data for use in the GIS. The `-HELP` key word may be abbreviated using any of the following acronyms: `-HEL`, `-HE`, or `-H`. Starting the conversion software without any specifications is equivalent to using the `-HELP` argument.

Messages about some problems that may occur during conversion are written in a file, called the *error file*. These messages are displayed by the software, when run in an interactive mode. The error file is not deleted when the conversion software finishes processing data. The error file is named by appending the characters ".ERRORS" to the end of *outcover*. This file may be reviewed and stored with the documentation for the coverage. Information about the messages written to the error file is included in a later section of this report, Description of Messages (p. 27).

Data-Type Options

Because data retrieved from GWSI and QWDATA are formatted differently, the user has the option of specifying the data type when starting the conversion software. The data type is either `GW` for data retrieved using GWSI, or `QW` for data retrieved using QWDATA. If no data type is specified, the default data type is `GW`. The data type is specified on the command line using the `-TYPE` key word, followed by either `GW` or `QW`. The `-TYPE` key word may be abbreviated using any of the following acronyms: `-TYP`, `-TY`, `-T`. The data type is specified in a global-variable file by setting the value of the global variable named ".TYPE" to either `GW` or `QW`.

When the data type is `GW`, the *infile* is expected to contain a GWSI subfile. Another file is assumed to exist with the same name as the subfile, with the characters ".LIST" appended to the file name.

When the data type is `QW`, the *infile* is expected to contain water-quality data in the PSTAT format. A second file is assumed to exist with the same name as *infile* with the characters ".CMND" appended to the file name. A third file is required that contains information about water-quality data-collection sites. The name of this third file can be specified using the key word `-SITEFILE`, followed by the file name. The `-SITEFILE` key word may be abbreviated by either of the acronyms `-SITE` or `-SI`. The name of the third file also

may be specified by storing the file name in the global variable named “.SITEFILE”. If the third file name is not specified, it is assumed to be QW.SITES.

Attribute-Naming and Formatting Options

When attribute data are stored in an INFO file, a name is assigned to each attribute. For example, the depth to water in a well is an attribute, and might be assigned the name WLEVEL. The attribute name is used to refer to the data when performing analyses with the GIS. The methods used by the conversion software for determining attribute names is described below.

Attribute data are assigned a field type, a field-storage width, and a field-display width. Real-numeric data also are assigned a value that controls the number of digits displayed to the right of the decimal point (number of decimal places).

The field type specifies how the attribute data are stored in the INFO file. The conversion software uses three field types: character, binary integer, and binary real. The storage width designates the number of bytes used to store the data in the INFO file. The conversion software always uses four bytes to store binary-integer and binary-real data. The conversion software uses the maximum number of characters that can be stored for a character field in the NWIS data-base system to determine the number of bytes used to store the corresponding data in an INFO file.

The value used for the display width determines the number of columns used when the data are displayed. The conversion software sets the display width equal to the storage width for character data. The display width for numeric data is determined by the following conditions. The display width of numeric QW data initially is set to ten. The display width of numeric GWSI data initially is set to the maximum number of columns allocated for displaying the field with the GWSI data-base software. If necessary, the display width for numeric data from either source is increased to accommodate a missing-value indicator and the number of decimal places.

The conversion software uses precision data associated with a real field in the NWIS data-base system to determine the number of decimal places associated with the corresponding field in an INFO file.

Water-quality remark codes stored in an INFO file by the conversion software are assigned the character field type, and the storage and display widths are set equal to one. The methods used by the conversion software to store statistical fields in an INFO file is explained in Statistical-Conversion Options (p. 20).

Attribute names must conform to the following three restrictions: (1) Attribute names may not begin with any of the following characters: The digits zero through nine, a hyphen, an asterisk, a slash, a plus, a single quote, or a left or right parenthesis; (2) attribute names may not contain a blank, an equal sign, or a comma; (3) attribute names may not contain more than 16 characters (Henco, Inc., 1983).

Any combination of three methods may be used by the conversion software for the assignment of attribute names. These attribute-naming methods provide default, site-specific, and user-specific conventions for assignment of attribute names.

- (1) The conversion software can prepare a default name for an attribute. The method for determining the default name is dependent on the data type. For the **GW** data type, default attribute names are the same as the corresponding GWSI component names. These names begin with a capital “C” or “T”, and are followed by the three-digit component number. For the **QW** data, default attribute names are composed by appending the corresponding five-digit parameter code after the letter “P”. For **QW** remark codes, default attribute names are composed by appending the corresponding parameter code after the letter “R”.
- (2) Site-specific attribute-naming conventions are established when the conversion software is installed on a computer system. Information about how these conventions are established can be found in Chapter 3, Site-Specific Naming Conventions (p. 26). If a site-specific naming convention exists for an attribute, the site-specific name has precedence over the default attribute name.
- (3) User-specific attribute-naming conventions may be specified when the conversion software is started. User-specific naming conventions have precedence over both site-specific and default naming conventions.

To create user-specific naming conventions, a file is prepared with an editor that contains definitions of the attribute names. Include the **-NAMEFILE** key word on the command line, followed by the file name, to cause the conversion software to process user-specific naming conventions. The **-NAMEFILE** key word may be abbreviated with the acronyms **-NA** or **-N**. User-specific naming conventions also may be enabled by storing the file name in the global variable named “.NAMEFILE”.

There is one record in a user-specific naming-convention file for each attribute with a user-specific attribute name. The format of a record in the file differs, depending on the type of data being processed.

When the data type is **GW**, a record is composed of four fields. The first field is the GWSI field code (for example C009). The second field is the corresponding attribute name. The first two fields need to be entered for every record in the file. The third and fourth fields are needed only for data that are calculated during a GWSI retrieval.

The GWSI software can compute data during the retrieval process by using “temporary fields” (Rogers and Luckey, 1990, p. 8-7). For example, an analyst might want to compute and store the elevation of the ground-water surface in feet above or below sea level. (Sea level refers to the National Geodetic Vertical Datum of 1929, NGVD of 1929,—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called “Mean Sea Level of 1929.”) Elevation of the ground-water surface is calculated by subtracting the depth to water (C030 or C237) from the elevation of the data-collection site (C016). When an attribute is calculated in this manner, the conversion software needs information about the field type, and if the field type is real, the number of decimal places. The display width for calculated attribute data is determined by the conversion software.

If a subfile contains temporary fields and a user-supplied naming-convention file is not supplied, or does not contain a record identifying a temporary field, then the conversion software places the data in the INFO file using the following conventions. The component name for a temporary field is formed by concatenating the letter "T" with a three-digit number. The character-field type is used for storing the data and the storage and display widths are equal to width of the field in the subfile.

The third field in a GW-type user-specific naming-convention file is a letter designating the field type. Use the letter "C" to denote a character field. Use either "B" or "I" to denote an integer field. Use either "F" or "N" to denote a real field. The fourth field is an integer specifying the number of decimal places for a real field. The Fortran format for a GW-type user-specific naming-convention file record is '(A5,1X,A16,1X,A1,1X,I1)'. An example file is shown below.

```
C001 SITE
C027 HOLE_DEPTH
T900 WLEVEL          N 2
```

When the data type is QW, a record is composed of three fields. The first field is the five-digit water-quality parameter code. The second field is the desired attribute name for data corresponding to the parameter code. The third field is the desired attribute name for remark codes associated with the parameter code. The first field is required, and one or both of the second and third fields need to be entered. The Fortran format of the record is '(A5,2(1X,A16))'. An example file is shown below.

```
00010 WTEMP
00020 ATEMP
01002 AS.TOT          AS.TOT.RMK
```

Map-Projection Options

When the software is installed on a computer system, a default map projection is defined. The default map projection is used by the conversion software to transform latitude-longitude coordinates into two-dimensional coordinates unless the user specifies a different map projection. (See Chapter 3, Map Projection, p. 24, for information about how the site-specific map projection is installed.) A different map projection can be described using an Arc Macro Language (AML) program (ESRI, Inc., 1987b). The AML program provides all the information needed by the ARC PROJECT command (ESRI, Inc., 1987a) to transform a file of latitude-longitude coordinates to the desired projection. Shown below is an example of such a program.

```
&ARGS INFILE FMT
PROJECT FILE %INFILE% PROJECTED.POINTS
INPUT
PROJECTION GEOGRAPHIC
QUADRANT NW
UNITS DMS
FLIP YES
FORMAT %FMT%
PARAMETERS
OUTPUT
/* Any desired modifications need to be made from here down
PROJECTION UTM
ZONE 14
UNITS METERS
YSHIFT -4000000
PARAMETERS
/* Any desired modifications need to be made from here up
END
&RETURN
```

The example program can be modified to describe many different map projections. Comments in the above program (lines beginning with “/*”) indicate where modifications may be made. The conversion software will use a user-supplied map-projection AML program when the -PROJ key word is included on the command line, followed by the file name of the AML program. The -PROJ key word may be abbreviated with the acronyms -PRJ or -PR. Also, the use of a customized map-projection program can be enabled by storing the file name of the program in the global variable named “.PROJ”.

Storage Options

The conversion software gives the user the option of storing attribute data in one of two INFO files. The data may be stored in the coverage PAT. The INFO-file name of the coverage PAT is formed by appending the characters “.PAT” to the end of *outcover*. If the user does not specify otherwise, attribute data are stored in the coverage PAT. Alternatively, the user may store attribute data in a separate INFO file.

Four different, mutually exclusive approaches may be used when processing hydrologic data with the conversion software. The approaches are mutually exclusive because only one of them may be specified for the conversion software at a time. Of course, the conversion software may be used more than once, with a different approach selected each time.

- (1) The first approach, which is the default, is to create a coverage of points and store attributes in the PAT.

- (2) The second approach, which is specified by including the `-POINTS` argument on the command line, is to create a coverage of points only and not store any attribute data. The `-POINTS` argument may be abbreviated with the acronyms `-PNTS`, `-PTS`, or `-PT`. This approach cannot be specified using a global variable.
- (3) The third approach, which is specified by including the `-ATTRIBUTES` key word on the command line, is to create only a separate INFO file containing the attribute data. No coverage is created. The `-ATTRIBUTES` key word may be abbreviated with the acronyms `-ATTR` or `-AT`. Optionally, the `-ATTRIBUTES` key word may be followed by the name of the INFO file to be created.

This approach cannot be specified using a global variable. However, the name of the INFO file can be stored in the global variable named `“.ATTRFILE”`. If the name of the INFO file is not specified either on the command line or in a global-variable file and the `-ATTRIBUTES` key word is used, then the conversion software stores the attribute data in an INFO file named by appending the characters `“.DAT”` to the end of *outcover*.

- (4) The fourth approach, which is specified by including the `-RELATE` key word on the command line, is to create a coverage of points and store the attributes in a separate INFO file. The `-RELATE` key word may be abbreviated with the acronyms `-REL` or `-R`. This approach cannot be specified with a global variable.

Similar to the `-ATTRIBUTES` argument, the name of the INFO file to be created can follow the `-RELATE` key word on the command line or be stored in the global variable named `“.ATTRFILE”`. If the name of the INFO file is not specified when `-RELATE` is used, then the file is named by appending the characters `“.DAT”` to the end of *outcover*.

When the `-RELATE` option is used, a key field is needed for establishing a relationship between records in the PAT and the attribute file. The key field is added to both the PAT and the attribute file. The key word `-KEY` can be included on the command line, followed by an identifier for the key field. For GW-type data, the `-KEY` key word is followed by the component code of the field to be used. For QW-type data, the `-KEY` key word is followed by one of the key-field acronyms listed in table 1. The `-KEY` key word may be abbreviated with the acronyms `-KE` or `-K`. Alternatively, the key-component code or key-field acronym may be stored in the global variable named `“.KEY”`.

If `-ATTRIBUTES` is specified, and no key field is identified, the default key field is station-identification number (`SITEID`). When `SITEID` is the key field and the data type is `QW`, both the site-identification number and the station-name attributes are added to the PAT.

The four approaches for storing converted data are summarized in table 2.

Literal-Conversion Options

One additional option may be used when literal conversion is performed. This option prevents storage of more than one spatial location in the coverage for a group of records

Table 1.— *Acronyms used for specifying key fields with the -KEY argument when converting water-quality data*

Key-field acronym	Corresponding GWSI-component code	Field description
SITEID	C001	Site-identification number
STATE	C007	State code
COUNTY	C008	County code
FIPS	—	Combined state and county codes
HUC	C020	Hydrologic-unit code
GUNIT	C714	Geologic-unit code

Table 2.— *Mutually exclusive storage options of the conversion software*

[An “X” in the table indicates that the command-line option listed on the row causes the action listed on the column. A “/” indicates that one or two attributes are stored in the point-attribute-table file.]

Command-line key-word acronym	Coverage of point stored	Attributes stored in point-attribute-table file	Attributes stored in separate INFO file
(none)	X	X	
-POINT	X		
-ATTRIBUTES			X
-RELATE	X	/	X

in the *INFILE* that contain the same data in the the key field. When this option is not specified, a location is stored in the coverage for every record in the *infile*. Normally, the key field is the site-identification number, but the key field can be changed using the **-KEY** argument or the “.KEY” global variable, as described in the previous section (p. 18).

The option to prevent the storage of locations that duplicate the key field is specified by including the **-NDUP** argument on the command line. The **-NDUP** key word may be abbreviated with the acronyms **-NDP** or **-ND**. There is no global variable associated with **-NDUP** argument, therefore this option may be specified only on the command line.

The **-NDUP** option may only be used with the second (**-POINTS**) or the fourth (**-RELATE**) storage approach described in the previous section (p. 18). When the **-NDUP** option and either the **-POINTS** or the **-RELATE** option are used, the conversion software creates a point coverage with no two points duplicating the same key field. Usage of the **-NDUP** argument has no effect on the attribute file created by the conversion software.

The **-NDUP** argument is redundant when specified with the **-STATS** argument discussed in the next section. If both are specified, the conversion software displays a warning message and ignores the **-NDUP** argument. If the **-NDUP** argument is specified with the default storage option or with the **-ATTRIBUTES** storage option, the conversion software displays an error message and stops.

When literal conversion is performed with **GW**-type data, the latitude and longitude of the data-collection site are always added to the attribute file. When literal conversion is performed with **QW**-type data, four attributes are always added to the attribute file. These four attributes are site-identification number, station name, sampling date, and sampling time, named **SITEID**, **SNAME**, **DATE**, and **TIME** respectively.

Statistical-Conversion Options

Instead of literally converting the data in the *infile*, statistical descriptions of the data can be stored in the attribute file. A variety of different statistics may be calculated and stored (table 3). Some statistics pertain only to water-quality data and are available only when the data type is **QW**.

The analysis methods used to measure water-quality constituents frequently are valid only for measuring concentration levels above some measurement threshold. A measurement for a sample that contains less than the threshold amount usually is reported and stored with a value equal to the analysis-method threshold, and a remark code indicating that the concentration is less than the reported value. Data that are subject to a measurement threshold are referred to as censored data. Methods for calculating descriptive statistics for censored data have been incorporated into the conversion software (Helsel and Cohn, 1988). These methods use a logarithmic-probability regression technique for estimating the mean and standard deviation, and an adjusted maximum-likelihood estimator (Cohn, 1988) for estimating percentiles below the highest detection limit.

Since data from **GWSI** are not stored with remark codes, statistical estimates pertaining to censored data are not available.

Table 3.— *Acronyms used for specifying statistical fields with the -STATS argument*

[The acronym of the desired statistic is placed after the -STATS key-word argument on the command line, or stored in the global variable named “.STATS”. If more than one statistic is desired, single quotes should surround the list of acronyms specified on the command line. Some statistics are only calculated for water-quality data, as designated by an “X” in the table.]

Acronym used after -STATS argument or in .STATS global variable	Valid only for water- quality data	Statistics calculated
ALL		All applicable statistics for data type
NONE		No statistics (used to override global variable)
#NM		Number of non-missing values
#M		Number of missing values
#0		Number of zero values
#<0		Number of values less than zero
AVG		Average value
MAX		Maximum value
MIN		Minimum value
IQR		Inner-quartile range (75th - 25th percentile)
P25		Lower quartile (25th percentile)
P50		Middle quartile (50th percentile) or median
P75		Upper quartile (75th percentile)
STD		Standard deviation
#<T	X	Number of censored values
#>T	X	Number of non-censored values
#T	X	Number of thresholds (detection limits)
<T	X	Minimum threshold
>T	X	Maximum threshold
R	X	Correlation coefficient of log-normal model

Statistical conversion is performed by including the `-STATS` argument on the command line, followed by statistical acronyms indicating which statistics are to be calculated and stored (table 3). If more than one statistical acronym is included on the command line, the list of statistical acronyms needs to be enclosed in single quotes. The `-STATS` key word may be abbreviated with the acronyms `-STAT`, `-STA`, or `-ST`. Alternatively, the statistical acronyms may be stored in the global variable named `".STATS"`. The list of statistical acronyms does not need to be enclosed in quotes when stored in the global variable.

When statistical conversion is performed, the data in the *infile* are aggregated using the key field to define groups of records. Thus, the number of records in the attribute file created by the conversion software is equal to the number of unique values of the key field in the *infile*. The methods for specifying the key field are discussed in a previous section, Storage Options (p. 18).

For each numeric field in the *infile*, all of the requested statistics are calculated. For each character field in the *infile* the value for the field in the first record of the group is stored. *Warning:* The character data stored for the record may not be valid for all records in the group. Also, the latitude and longitude of the first record in a group are used to compute the spatial location for the point in the coverage, and are stored in the attribute file. The key field used for aggregating data also is stored in the attribute file.

When statistical conversion is performed with *QW*-type data two more attributes, named `DATE.MIN` and `DATE.MAX`, are created for storing the earliest date and the latest date of water-quality analyses in the group.

Statistical attributes are named in a manner similar to the naming conventions used when literal conversion is performed. First, the name that would be used for the attribute during literal conversion is determined using the methods described previously in Attribute-Naming and Formatting Options (p. 14). This name is referred to as the root name. The name of each statistical attribute is formed by appending a period and the statistical acronym to the root name for the attribute. The suffixes contain no more than four characters. Because attribute names cannot be longer than 16 characters, root names are limited to 12 characters. If an attribute name is longer than 12 characters, it is truncated to form the root name.

The conversion software is designed to calculate statistical estimates for many kinds of hydrologic data. However, some groups of data have characteristics that cause problems when attempting to calculate statistical estimates. Most of these problems cause messages to be written to the error file, and actions are taken by the conversion software, as follows.

- (1) When more than 80 percent of the data are censored, very little information can be deduced about the distribution of values in the censored region. Statistical estimates for such a group are little better than a guess. When more than 80 percent of the data are censored the mean, standard deviation, and quartiles are set to the missing-value indicator.
- (2) Similarly, at least three values must not be censored, or the mean, standard deviation, and quartiles are set to the missing-value indicator.

- (3) It is possible that a negative censored value could be retrieved. The modeling procedure used in the conversion software cannot process data with negative detection limits. In this case, the mean, standard deviation, and quartiles are set to the missing-value indicator.
- (4) Some water-quality measurements, such as temperature or the concentration of radionuclides, can be reported as negative values. If other values for the measurement in a group are also censored, then the modeling procedure cannot be used to estimate the data distribution. In this case, the mean, standard deviation, and quartiles are not calculated and the values for these statistics are set to the missing-value indicator.
- (5) Remark codes other than "less than" are possible. When the remark codes "M" (presence verified, but not quantified), "N" (presumptive evidence of presence), or ">" (greater than) are present, the modeling procedure calculates statistics without using these data. The measurements stored with these remark codes are counted as missing.
- (6) In the past, some water-quality laboratories have reported a zero for the measurement of a constituent that was below the detection limits for the analysis. When zero values are found in a group of data that also contains censored values, the conversion software changes the zero values to the value of the highest detection limit found in the group of data for the constituent. The altered values are assigned the "less than" remark code.
- (7) When none of the data are censored and there is only one value in the group, the value is stored as the mean value, the standard deviation is set to zero, and the quartiles are set to the missing-value indicator. No message is written to the error file.
- (8) When none of the data are censored and there are more than one, but less than four records in the group, the quartiles are set to the missing-value indicator. No message is written to the error file.

Two-Part Conversion Options

Sometimes, the NWIS data-base system will be located on a different computer system than the one to be used for storing the coverage. The conversion software has been designed so that the conversion process may be performed in two parts. The first part is performed on the computer system where the NWIS data-base system is located and the NWIS retrievals are performed, and the second part is performed on the computer system where the coverage is stored. In order to process the data the conversion software needs to run on both computer systems. The NWIS needs to be installed on the first computer system, and the ARC/INFO software needs to be installed on the second computer system.

The first part of the processing reformats the data in the *infile*, and determines the attribute names. If requested, the first part computes statistics and removes records with duplicate values for the key field. At the end of the first part, the software displays messages

prompting the user to enter information describing the storage location for the coverage on the second computer system. The conversion software needs to be run interactively when the first part of a two-part conversion is performed. The second part of the processing transforms the spatial coordinates, creates a point coverage, and stores attribute data in an attribute file on the second computer system.

To convert data in a two-part process, include the **-PART** key word on the command line, followed by either of the integers: one (1) or two (2). The **-PART** key word may be abbreviated with the acronyms **-PAR** or **-PA**. Alternatively, the part number may be stored in the global variable named **".PART"**. If the **-PART** option is not specified, part number zero (0) is assumed, which indicates that both parts of the process are to be performed. With the exception of the value for the part number, the same options need to be specified when the conversion software is run for each part of the process.

CHAPTER 3. SOFTWARE DESIGN

Installation Procedure

Several steps are performed to install and customize the conversion software on a computer system. Four subdirectories are created during the installation (fig. 4). The following paragraphs describe the features of the software that can be customized. The actual installation process is described with documentation that accompanies the files containing the conversion software. This section of the report does not describe the installation process in detail, but describes the procedures for customizing the software for a particular site.

The **NWISARC.CPL** program contains a statement near the beginning that defines the variable named **SOURCE_DIR**.

```
&S SOURCE_DIR := PC
```

This variable stores the name of the directory that contains the four subdirectories: **DOC**, **SOURCE**, **INSTALL**, and **RUN**. As shown in figure 4, the directory is the uppermost circle, labelled "Software directory". In the statement the directory is named "PC". The installer needs to change "PC" in the statement to the name of the corresponding directory on the local computer system.

Map Projections

A site-specific map-projection program named **OUR.PROJECTION.AML** is stored in the directory named **RUN**. This program is written in the same manner as the user-specific map-projection program described previously, in the section **Map-Projection Options** (p. 16). The modified program needs to be stored in the **RUN** directory. If the name of the file containing the program is changed, the text "**OUR.PROJECTION.AML**" in following statement near the beginning of the **NWISARC.CPL** program needs to be changed to the name of the site-specific **AML** program.

```
PRFG: -PR, -PRJ, -PROJ PROJ=OUR.PROJECTION.AML;~
```

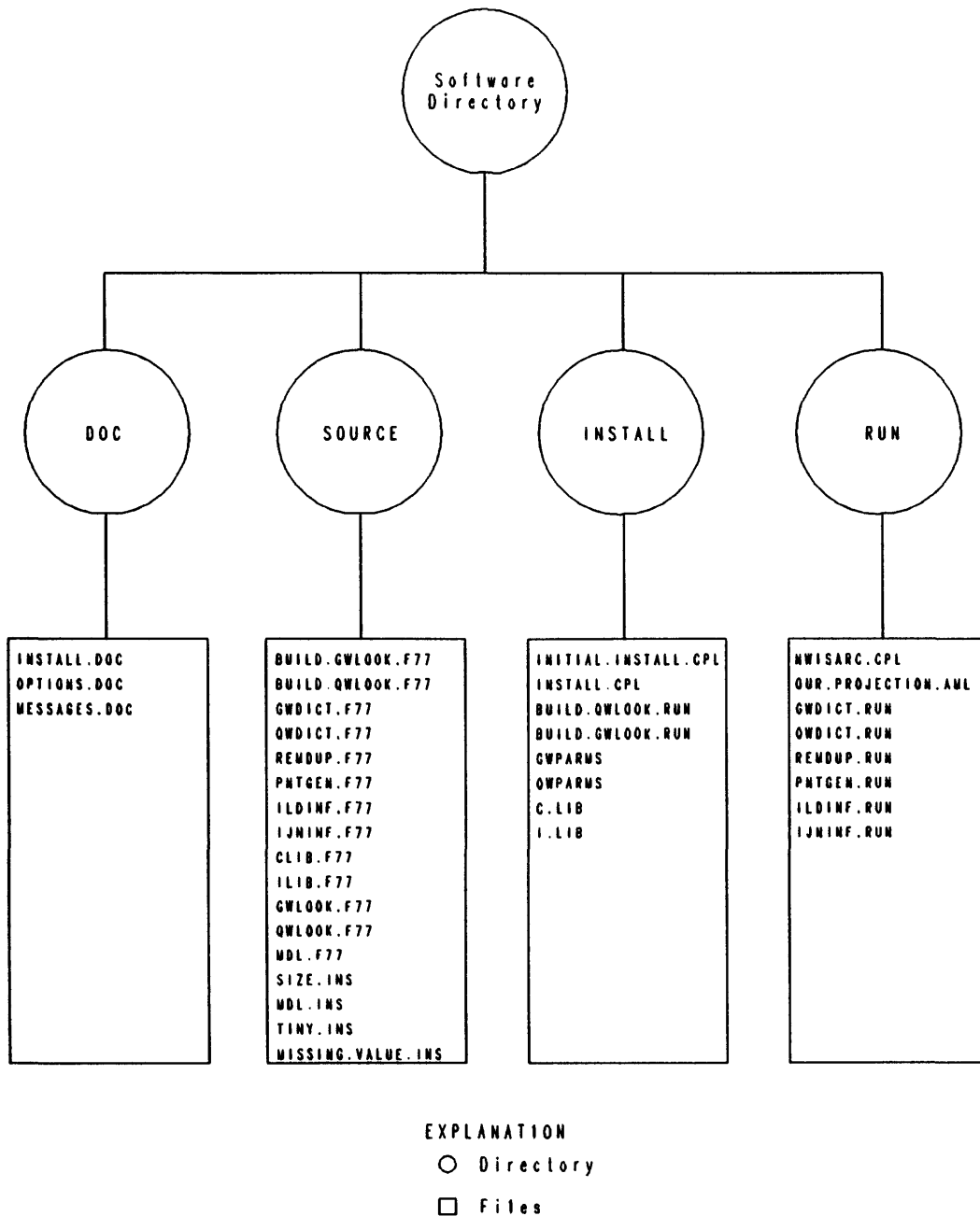


Figure 4.— Files and directories containing the conversion software.

Site-Specific Naming Conventions

Site-specific naming conventions are established by creating two Fortran subroutines when the conversion software is installed. Each of these subroutines defines the site-specific naming conventions for one of the two data types. The conversion software includes Fortran programs that are used to create the two subroutines from site-specific naming-convention files.

The formats of site-specific naming-convention files are identical to the formats of user-specific naming-convention files (see Attribute-Naming and Formatting Options, p. 14). Two example files are provided with the conversion software, named GWPARMS for GW-type data and QWPARMS for QW-type data. After a text-editing program has been used to create a site-specific naming-convention file for GW-type data, the program named BUILD.GWLOOK.RUN is run to create the subroutine named GWLOOK.F77. Similarly, the program named BUILD.QWLOOK.RUN is used to create the subroutine named QWLOOK.F77 from the QW-type site-specific naming-convention file. After the GWLOOK.F77 and QWLOOK.F77 have been created, they are compiled and installed with the rest of the conversion software.

Space Allocation

The conversion software contains the Prime \$INSERT compiler directive (Johnson, 1983), which causes the compiler to include the contents of a named file at the location of the directive. This allows repetition of a statement or a group of statements in several locations in the program. The \$INSERT directive is used in the conversion software for repeating declaration statements for variables.

The file named SIZE.INS contains specifications pertaining to the maximum size of arrays used in the conversion software as follows.

- (1) The variable named MAXSTA defines the maximum number of statistics that can be computed and stored.
- (2) The value of the variable named MAXOBS defines the maximum number of records in a statistical-aggregation group, and limits the number of water-quality data-collection sites.
- (3) The variable named LENOBS defines the number of characters in the value of the variable MAXOBS. If the value of MAXOBS is increased or decreased, the value of LENOBS may need to be changed.
- (4) The value of the variable named MAXCOD defines the maximum number of attributes that can be stored, and limits the number of user-specified attribute names.
- (5) The value of the variable named IRECLN describes the length of several character variables used in various subroutines and programs in the conversion software (table 4). The length of these character variables limits the number of attributes that can be processed by the conversion software. If the value of IRECLN is changed, all the corresponding character-variable lengths need to be changed.

Table 4.— *Locations of character variables in the conversion software subject to the limit defined by the variable IRECLN*

File name	Subroutine name	Variable name(s)
CLIB.F77	CWRTST	OUTLIN
GWDICT.F77	GWDICT	LINEO, BUFFER
	GWRTRC	LINEI, LINEO
	GWSTAT	LINE1, LINEH, BUFFER
QWDICT.F77	QWDICT	OUTLIN, BUFFER
	QWSTAT	LINE1, INLINE, OUTLIN
IJNINF.F77	IJNINF	LINE5K
ILDINF.F77	ILDINF	LINE5K
REMDUP.F77	REMDUP	RECORD, LREC

The file named MDL.INS contains specifications for arrays used in the subroutines for estimating statistics for censored data. Since these subroutines were not written by the author of this report, the source code was modified only to the extent necessary to make the code compatible with the conversion software. Placing array limits and constants in an inserted file was one of the changes made to the code.

Missing-Value Indicator

The missing-value indicator is stored in a variable named MISVAL, defined in the file named MISSING.VALUE.INS. The missing-value indicator is a real number, unlikely to occur in hydrologic data. The missing-value indicator is written to the attribute file when numeric data are missing from a record during literal conversion, and when insufficient data are available in a group during statistical conversion. MISVAL is equated to -99,998. in the conversion software.

The number of characters in the missing-value indicator is defined by the variable named MISLEN in the MISSING.VALUE.INS file. If the value for MISVAL is changed during installation of the conversion software, the value MISLEN may need to be changed.

Description of Messages

Many different informative messages may be displayed while the conversion software is running. These messages are not discussed in this report. Two other kinds of messages, warning messages and error messages, indicate that the conversion process may not be proceeding normally.

When a warning message is displayed, the software continues processing the conversion using an assumption about the proper resolution of a potential problem. The warning

message indicates the action that is being taken. When the software cannot resolve a problem, an error message is displayed and the conversion stops.

All of the warning messages, and most of the error messages that can be displayed by the software are listed in alphabetical order in the following two sections. The name of the program(s) or subroutine(s), called "SOURCE", that can produce the message is listed with each one. Next, a description of the problem and potential methods for problem resolution are listed.

Warning Messages

- TEXT: WARNING: Attribute name for ___ invalid. . . ignored
SOURCE: GUNFIN and QUNFIN
ACTION: The name for the attribute code listed does not conform to the constraints imposed by the INFO file-management software. The conversion software ignores the user-specified name. Correct the user-specific attribute naming-convention file.
- TEXT: WARNING: Error reading precision for component ___
SOURCE: GUNFIN
ACTION: The number of decimal places for the listed component code is not an integer. The software will determine the number of decimal places for the attribute. Correct the user-specific attribute naming-convention file.
- TEXT: WARNING: INFO-attribute-file name set to ___
SOURCE: NWISARC
ACTION: The name of attribute file was not specified after -RELATE or -ATTRIBUTES on the command line or stored in the ".ATTRFILE" global variable. The file will be named *outcover.DAT* .
- TEXT: WARNING: Insufficient uncensored data for parameter ___
SOURCE: IPRMDL
ACTION: Less than 20 percent of the data are uncensored, or there are less than 3 uncensored values for the listed parameter code. Estimates for the mean, standard deviation, and quartiles are set to the missing-value indicator.
- TEXT: WARNING: Invalid key field: ___ . . . ignored
SOURCE: REMDUP
ACTION: The listed key field is not present in the data retrieved from the NWIS. The software continues conversion without removing duplicates.

TEXT: WARNING: Maximum number of user-supplied names reached
SOURCE: GUNFIN and QUNFIN
ACTION: The user-specified attribute naming-convention file being used contains at least the maximum number of records (MAXCOD in SIZE.INS). The software ignores records beyond the maximum number. The value for MAXCOD can be increased and the software can be reinstalled.

TEXT: WARNING: -NDUP may be used only with -RELATE or -POINTS options. -NDUP option ignored...
SOURCE: NWISARC
ACTION: The -NDUP option cannot be specified with the -ATTRIBUTES or the default storage approach. If the option is desired, then one of the listed storage approaches must be specified.

TEXT: WARNING: Negative and censored values are present for parameter ___: log-normal model is inappropriate
SOURCE: IPRMDL
ACTION: Both negative and censored data are present for the listed parameter. The estimates for the mean, standard deviation, and quartiles are set to the missing-value indicator.

TEXT: WARNING: Negative detection limit found for parameter ___
SOURCE: IPRMDL
ACTION: A negative censored value was present in a group of data for the listed water-quality parameter code. The mean, standard deviation, and quartiles are set to the missing-value indicator.

TEXT: WARNING: ___ not allowed with GW data
SOURCE: CSTAFG
ACTION: The listed statistical acronym pertains only to censored water-quality data. The software ignores the acronym.

TEXT: WARNING: Parameter and remark names for ___ invalid... ignored
SOURCE: QUNFIN
ACTION: The attribute name and the remark-code name for the listed water-quality parameter code do not conform to the constraints imposed by the INFO file-management software. The conversion software ignores both user-specified names. Correct the user-specific attribute naming-convention file.

TEXT: WARNING: Remark name for ___ invalid... ignored
SOURCE: QUNFIN
ACTION: The remark-code attribute name for the listed water-quality parameter code does not conform to the constraints imposed by the INFO file-management software. The conversion software ignores the user-specified name. Correct the user-specific attribute naming-convention file.

TEXT: WARNING: Root name ___ shortened to ___
SOURCE: GWDICT and QWDICT
ACTION: The listed user-specific or site-specific attribute name is longer than 12 characters. The root name used for defining statistical attribute names is listed. This will cause a subsequent error if the root names for attributes are not unique.

TEXT: WARNING: The following message(s) are for key = ___
SOURCE: IPRMDL
ACTION: During statistical conversion, a series of messages may be issued for a single group of data. This message is issued before the first message of a group and lists the value of the key field for the group.

TEXT: WARNING: Unknown statistic: ___ ignored.
SOURCE: NWISARC
ACTION: The listed statistical acronym is not valid and is ignored. See table 3 for valid statistical acronyms.

TEXT: WARNING: ___ values set to missing for parameter ___ because remark code: >, M, or N was present
SOURCE: IPRMDL
ACTION: The listed number of values with one of the three remark codes was changed to the missing-value indicator before statistical estimates were calculated.

TEXT: WARNING: ___ zero values for parameter ___ set to upper detection limit: ___
SOURCE: IPRMDL
ACTION: The listed number of zero values for the listed water-quality parameter code were changed to the highest detection limit in the group of data. These values were remarked as less than the listed censoring threshold before statistical estimates were calculated.

Error Messages

TEXT: ERROR: ___ does not exist or is inaccessible
SOURCE: NWISARC
ACTION: The listed *infile* was not found. Correct the file name specification.

TEXT: ERROR: Duplicate field name ___
SOURCE: ILDINF and IJNINF
ACTION: At least two attributes were assigned the same name listed. Correct the user-specific or site-specific naming conventions, or use the default naming conventions.

TEXT: ERROR: Illegal value for -PART: ___
 0 = create definitions, reformat data, create coverage (default)
 1 = create definitions, reformat data, send to remote site
 2 = process definitions and reformatted data into coverage
SOURCE: NWISARC
ACTION: The listed value for the part of the process to perform was not
 0, 1, or 2. Correct the part number.

TEXT: ERROR: Invalid key: ___
SOURCE: QPXDEF
ACTION: The listed key field was specified and is not valid (see table 1).
 Correct the specifications for the key field.

TEXT: ERROR: Key field ___ not in data
SOURCE: GWDICT
ACTION: The listed key field was specified and is not present in the
 subfile. Retrieve the data again, or correct the specifications
 for the key field.

TEXT: ERROR: No GWSI data present in file
SOURCE: GWDICT
ACTION: Correct the retrieval specifications, and retrieve the data again.

TEXT: ERROR: Number of items > Maximum number (___)
SOURCE: QWDICT and CWRTST
ACTION: The number of attributes requested is greater than the listed
 number (MAXCOD in SIZE.INS). Modify the retrieval, specify
 fewer statistical acronyms, or change MAXCOD and reinstall the
 conversion software.

TEXT: ERROR: Number of records > ___
SOURCE: GWSTAT and QWSTAT
ACTION: The number of records in a group is larger than the maximum
 number that can be stored in the software (MAXOBS in SIZE.INS).
 Modify the retrieval, change the key field, or change the value
 of MAXOBS and reinstall the conversion software.

TEXT: ERROR: Number of thresholds (___) exceeds maximum (___) for
 parameter ___
SOURCE: IPRMDL
ACTION: The listed number of different censoring thresholds for a group
 of data is more than the listed maximum (MAXTHR in MDL.INS)
 for the listed water-quality parameter code. Modify the
 retrieval of data, or change the value of MAXTHR and reinstall
 the conversion software.

TEXT: ERROR: -POINTS and -RELATE are mutually exclusive options
SOURCE: NWISARC
ACTION: These two storage approaches cannot be performed at the same time. Remove one of the arguments from the command line.

TEXT: ERROR: -POINTS and -STATS are mutually exclusive options
SOURCE: NWISARC
ACTION: These two storage approaches cannot be performed at the same time. Remove one of the arguments from the command line.

TEXT: ERROR: Problem opening GW data dictionary
SOURCE: GWDICT
ACTION: The conversion software is unable to access the GWSI data dictionary. The local computer system may be having hardware problems or you may have insufficient access privileges to the NWIS data-base system.

TEXT: ERROR: Problem opening QW parameter-code dictionary
SOURCE: QWDICT
ACTION: The conversion software is unable to access the QW parameter-code dictionary. The local computer system may be having hardware problems or you may have insufficient access privileges to the NWIS data-base system.

TEXT: ERROR: Record length (___) exceeds maximum ___
SOURCE: ILDINF and IJNINF
ACTION: The INFO file-management system cannot store records containing more than 4,096 bytes. Retrieve fewer fields from NWIS, or specify fewer statistical acronyms.

TEXT: ERROR: Record too long
SOURCE: GWDICT and QWDICT
ACTION: The maximum number of characters (IRECLN in SIZE.INS) that can be stored in a character-record buffer has been exceeded. Retrieve fewer fields, specify fewer statistical acronyms, or modify the software. If the software is modified, several subroutines will need to be changed (table 4). Modification of the software may cause the INFO 4,096-byte record length limit to be exceeded (see above error message).

TEXT: ERROR: -RELATE and -ATTRIBUTES are mutually exclusive options
SOURCE: NWISARC
ACTION: These two storage approaches cannot be performed at the same time. Remove one of the arguments from the command line.

TEXT: ERROR: Required file not present in workspace: ___
SOURCE: NWISARC
ACTION: While performing the conversion of data using the -PART 2 specification, at least one file was not found. Use the same specifications during both steps of the conversion and ensure that all the files have transferred from the computer system where the -PART 1 operations were performed.

TEXT: ERROR: Too many attributes
SOURCE: GWDICT and QWDICT
ACTION: The number of attributes has exceeded the maximum number that can be processed with the conversion software (MAXCOD in SIZE.INS). Retrieve fewer fields, specify fewer statistical acronyms, or modify the software. Modification of the software may cause a different error message.

TEXT: ERROR: Too many records
SOURCE: IJNINF
ACTION: This message is unlikely to occur. It indicates that the number of points in the coverage is different than the number of attribute records. Consult a programmer.

TEXT: ERROR: Too many sites
SOURCE: QSIDRD
ACTION: The maximum number of water-quality data-collection sites that can be handled has been exceeded (MAXOBS in SIZE.INS). Retrieve data for fewer sites, or modify the software.

TEXT: ERROR: -TYPE ___ is invalid. Valid types are: GW and QW.
SOURCE: NWISARC
ACTION: The listed data type is not GW or QW. Correct the value for the data-type specification.

TEXT: ERROR: Unable to open file ____
SOURCE: IOPFIL
ACTION: A file with the listed name could not be opened. There are several potential causes of this message including incorrect specification of the data type, an erroneous file name, and a typographic error in a file name specification.

TEXT: ERROR: Unable to read QW-site file for SITEID ____
SOURCE: QSIDFN
ACTION: This message is unlikely to occur. The record for listed site-identification number in the site-description file could not be read. Ensure the correct file name was specified for the site-description file. If it occurs again, consult your water-quality data-base-system administrator or a programmer.

TEXT: ERROR: Unable to find SITEID ___ in QW-site file
SOURCE: QSIDFN
ACTION: This message is unlikely to occur. Water-quality data were found in the *infile* for a site that was not found in the site-description file. Ensure the correct file name is specified for the site-description file. If the message occurs again, consult your water-quality data-base-system administrator.

TEXT: ERROR: Reading QW-data file
SOURCE: QWDICT
ACTION: This message is unlikely to occur. The conversion software was unable to read a record in the water-quality-data file. Ensure that the correct file name is specified for *infile*. If the message occurs again, consult a programmer.

TEXT: ERROR: Unable to find QW-site file: ___
SOURCE: NWISARC
ACTION: The listed file name, specified after the `-SITEFILE` argument on the command line or in the `".SITEFILE"` global variable, could not be found. If neither of these specifications were made, the file name has been assumed to be `QW.SITES`. Correct the specifications for the file name or data type.

TEXT: ERROR: Unable to find user-supplied code file: ___
SOURCE: NWISARC
ACTION: The listed file name, specified after the `-NAMEFILE` argument on the command line or in the `".NAMEFILE"` global variable, could not be found. Correct the file name.

TEXT: ERROR: Unknown variable type
SOURCE: CFMTFD
ACTION: This message is unlikely to occur. Consult a programmer.

TEXT: ERROR: Variable-file ___ does not exist or is inaccessible
SOURCE: NWISARC
ACTION: The listed file name, specified after the `-INPUT` argument on the command line, could not be opened. Correct the specifications.

Description of Programs and Data Files

The NWISARC program invokes other programs that perform specific operations during the conversion process (fig. 5). All of the programs shown in figure 5 may not be run, depending on the options specified. An explanation of the operations performed by each program is presented in table 5, and discussed in the following paragraphs.

The conversion process consists of 20 operations, determined by the options specified, that can be performed by the NWISARC program as follows.

- (1) Variables are read from the command line and initialized.

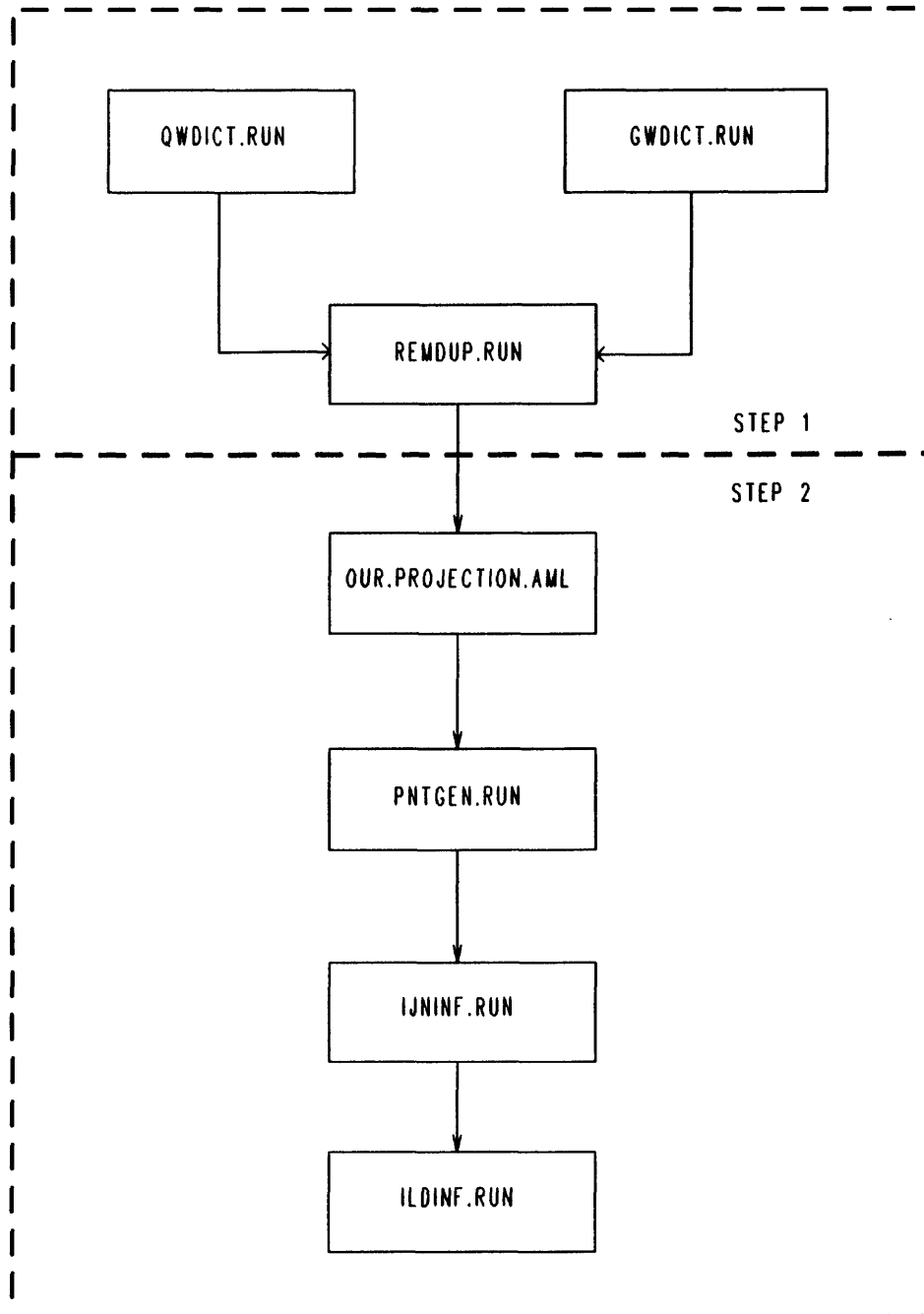


Figure 5.— Simple flow diagram of the programs invoked by the NWISARC program during the conversion process.

Table 5.— *Descriptions of the programs that comprise the conversion software*

Name of program	Description
NWISARC.CPL	Performs options specified by the user during conversion process by running other programs
OUR.PROJECTION.AML	Converts latitude-longitude coordinates to two-dimensional map coordinates
BUILD.GWLOOK.F77	Creates the subroutine GWLOOK from a formatted file that describes site-specific naming conventions
BUILD.QWLOOK.F77	Creates the subroutine QWLOOK from a formatted file that describes site-specific naming conventions
GWDICT.F77	Defines attribute names and formats, reformats data and attribute descriptions, and computes statistics for data retrieved from the GWSI data-base system
QWDICT.F77	Defines attribute names and formats, reformats data and attribute descriptions, and computes statistics for data retrieved from the QW data-base system
REMDUP.F77	Removes records that duplicate a key field
PNTGEN.F77	Reformats coordinate data
ILDINF.F77	Defines and stores data in a separate attribute file
IJNINF.F77	Adds attribute data to a point-attribute-table file

- (2) Any unneeded files left from a previous usage of the program are deleted.
- (3) Variables are read from a global-variable file, if the `-INPUT` option is specified.
- (4) The specified options are checked for errors. If an error is found, a message is displayed.
- (5) When statistical conversion is specified, the statistical acronyms are checked.
- (6) If a directory named `INFO` does not exist, it is created.
- (7) If attributes are to be stored in a separate `INFO` file and no name has been provided for the `INFO` file, the default name is assigned and a warning message is displayed.
- (8) If the conversion process is being performed in two steps, then a partial list of files needed is prepared. If the `-PART 2` option is specified, then operations 9 through 12 are skipped.
- (9) Unless the `-POINTS` option is specified, a program is run to write two files that contain descriptions of the attribute data, calculate statistics when requested, and write a file containing the attribute data. These operations are performed by the `GWDICT` program when the data type is `GW`, and by the `QWDICT` program when the data type is `QW`.

Both of these programs create several files while performing these operations. Four files are created for transferring data to subsequent programs. Three of these files are created in the `INFO` directory. Attribute descriptions are stored in a file named `DEFINE.FLDS`. Attribute data are stored in a file named `RFMT.DATA`. The attribute description for the key field is stored in a file named `KEY.FIELD`. A fourth file is created above the `INFO` directory, named `TRANSPORT.ERROR`. This file is used to store warning and error messages.

Three files are written and deleted by the `QWDICT` or `GWDICT` program. These *temporary files* are used to store data temporarily, during processing. The names of these three files are `QW.SORT.TEMP`, `RFMT.TEMP.1`, and `RFMT.TEMP.2`.

- (10) Error and warning messages stored in the file named `TRANSPORT.ERROR` are displayed, and the file is renamed to `outcover.ERROR`. If error messages are present, the conversion process stops.
- (11) When the `-NDUP` option has been specified, the `REMDUP` program is invoked to remove records that duplicate the key field. A temporary file named `SRTLL` is used for sorting the data. A file named `NDUPLL` is created for use by subsequent programs. This file contains the data for unique key fields.
- (12) If the `-PART 1` option was specified, files needed for the second step are transferred to a remote computer system, and the conversion process stops.
- (13) If the `-PART 2` option was specified, the software checks for the presence of files that are needed to complete the conversion. If the required files are not present, a message is displayed and the conversion process stops.

- (14) If the **-ATTRIBUTES** option was specified, operations 14 through 18 are skipped. Otherwise, a map-projection program is run that creates a file named **PROJECTED.POINTS**.
- (15) The data in the **PROJECTED.POINTS** file is reformatted using the **PNTGEN** program and written to a file named **PREGENERATED.POINTS**. The **PROJECTED.POINTS** file is deleted.
- (16) If a coverage with the name of *outcover* exists, it is removed with the **ARC/INFO KILL** command. The **ARC/INFO GENERATE** command is used to create a point coverage, then the **PREGENERATED.POINTS** file is deleted.
- (17) The **ARC/INFO BUILD** command is used to create a point-attribute-table file.
- (18) If the **-POINTS** option was specified, operations 18 and 19 are skipped. If the **-RELATE** option was specified, the key-field attribute(s) is added to the **PAT** file with the **IJNINF** program, and the **KEY.FIELD** file is deleted. Otherwise, all the attribute data are added to the **PAT** file.
- (19) If the **-RELATE** or the **-ATTRIBUTES** option is specified, then a separate attribute file is created using the **ILDINF** program.
- (20) The files **DEFINE.FLDS**, **RFMT.DATA**, and **NDUPLL** are deleted if they exist, and the conversion process is finished.

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**APPENDIX A.—EXAMPLE LITERAL CONVERSION
OF DATA FROM THE GROUND-WATER SITE
INVENTORY DATA-BASE SYSTEM**

File named GW.SUBF containing the data retrieved from GWSI.

365228	982136
341501	961454
363853	1003110
354412	981727
351308	983416
352423	983417
353107	974537
364452	1021910
350822	972337
342619	961442
343536	983422
364705	951353
355510	962935
354112	984306
361415	944525
361535	994659
363235	995928
344656	980314
344143	995606
352006	950801
341245	965351
345908	950130
351122	944039
351002	943144
354510	964050
354525	972422
361442	980921
335337	944511
352325	951626
352705	972812
352749	972226
352726	972249
352449	972932
352910	972317
362935	962915
365229	945202
350249	953411
343457	964045
354527	994705
352419	942704
363033	1014407
352149	991219
365150	984055
361257	991039
361725	993158

File named GW.SUBF.LIST containing a description of the contents of the subfile.

1FIELD	CODE	DESCRIPTION	LOC	LEN
1	C009	Latitude	1	7
2	C010	Longitude	8	8

File named MY.GWPARMS containing user-specific naming-conventions

C009	LATITUDE
C010	LONGITUDE

The two files are converted into a coverage in the following session:

```
OK, R PC>RUN>NWISARC GW.SUBF GW.COVER -NA MY.GWPARMS
NWISARC: Convert NWIS QW or GWSI data for use in ARC-INFO
[Revision 3.2]
Filename of data elements is GW.SUBF.LIST
Filename of input data is GW.SUBF
User-supplied code name file is... MY.GWPARMS
Sorting component codes... 2 codes read
Statistical options are ...
                ...not in use
Record-grouping key is ...C001
Defining fields... 2 fields processed
                  2 items defined
                  15 bytes / record
Reformatting... 45 records processed.
**** STOP

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ARC Version 4.0.1 (4 April 1988)
Arc: &R PC>RUN>OUR.PROJECTION.AML *>INFO>RFMT.DATA '(1X,3I2,1X,I3,2I2)'
```

Please define the input and output map projections.
Use INPUT to define the input projection, OUTPUT
to define the output projection, and END to finish.

```
Arc: &SYS OPEN PROJECTED.POINTS 1 1
Arc: &SYS OPEN PREGENERATED.POINTS 2 2
Arc: RESUME PC>RUN>PNTGEN.RUN
Preparing for generate... 45 point(s) prepared for generate
```

**** STOP

Arc: &SYS DELETE PROJECTED.POINTS
Arc: GENERATE GW.COVER
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[GENERATE Version 4.0 (24 June 1987)]

Generate: INPUT PREGENERATED.POINTS
Generate: POINTS
Creating points with coordinates loaded from PREGENERATED.POINTS
Generate: QUIT

Externalling BND and TIC...

Arc: &SYS CLOSE PREGENERATED.POINTS
Arc: &SYS DELETE PREGENERATED.POINTS
Arc: BUILD GW.COVER POINT
Building points...
Creating attribute file for GW.COVER
Arc:
Arc: RESUME PC>RUN>IJNINF
Directory of INFO data base is <GIS>PC>REPORT>EX>INFO
INFO username is ARC
INFO data filename is GW.COVER.PAT
Field-definition file is *>INFO>DEFINE.FLDS
2 fields added
2 items added
0 redefined items added
24 bytes / INFO record
Data file is *>INFO>RFMT.DATA
45 INFO records written
**** STOP

Arc: QUIT
Exiting ARC ...

A coverage was created named GW.COVER, and attribute data were stored in the INFO file named GW.COVER.PAT (table A1).

Table A1.—*Contents of the INFO file named GW.COVER.PAT*

[Field-type codes: F = binary real and B = binary integer]

	Attribute name					
	AREA	PERIMETER	GW.COVER#	GW.COVER-ID	LATITUDE	LONGITUDE
Storage width (bytes)	4	4	4	4	4	4
Display width (columns)	12	12	5	5	7	8
Field type (code)	F	F	B	B	B	B
Number of decimal places	3	3	-	-	-	-
Record 1 contents	0.000	0.000	1	1	365228	982136
Record 2 contents	0.000	0.000	2	2	341501	961454
Record 3 contents	0.000	0.000	3	3	363853	1003110
Record 4 contents	0.000	0.000	4	4	354412	981727
Record 5 contents	0.000	0.000	5	5	351308	983416
Record 6 contents	0.000	0.000	6	6	352423	983417
Record 7 contents	0.000	0.000	7	7	353107	974537
Record 8 contents	0.000	0.000	8	8	364452	1021910
Record 9 contents	0.000	0.000	9	9	350822	972337
Record 10 contents	0.000	0.000	10	10	342619	961442
Record 11 contents	0.000	0.000	11	11	343536	983422
Record 12 contents	0.000	0.000	12	12	364705	951353
Record 13 contents	0.000	0.000	13	13	355510	962935
Record 14 contents	0.000	0.000	14	14	354112	984306
Record 15 contents	0.000	0.000	15	15	361415	944525
Record 16 contents	0.000	0.000	16	16	361535	994659
Record 17 contents	0.000	0.000	17	17	363235	995928
Record 18 contents	0.000	0.000	18	18	344656	980314
Record 19 contents	0.000	0.000	19	19	344143	995606
Record 20 contents	0.000	0.000	20	20	352006	950801
Record 21 contents	0.000	0.000	21	21	341245	965351
Record 22 contents	0.000	0.000	22	22	345908	950130
Record 23 contents	0.000	0.000	23	23	351122	944039
Record 24 contents	0.000	0.000	24	24	351002	943144
Record 25 contents	0.000	0.000	25	25	354510	964050
Record 26 contents	0.000	0.000	26	26	354525	972422
Record 27 contents	0.000	0.000	27	27	361442	980921
Record 28 contents	0.000	0.000	28	28	335337	944511
Record 29 contents	0.000	0.000	29	29	352325	951626
Record 30 contents	0.000	0.000	30	30	352705	972812
Record 31 contents	0.000	0.000	31	31	352749	972226
Record 32 contents	0.000	0.000	32	32	352726	972249
Record 33 contents	0.000	0.000	33	33	352449	972932
Record 34 contents	0.000	0.000	34	34	352910	972317
Record 35 contents	0.000	0.000	35	35	362935	962915
Record 36 contents	0.000	0.000	36	36	365229	945202
Record 37 contents	0.000	0.000	37	37	350249	953411
Record 38 contents	0.000	0.000	38	38	343457	964045
Record 39 contents	0.000	0.000	39	39	354527	994705
Record 40 contents	0.000	0.000	40	40	352419	942704
Record 41 contents	0.000	0.000	41	41	363033	1014407
Record 42 contents	0.000	0.000	42	42	352149	991219
Record 43 contents	0.000	0.000	43	43	365150	984055
Record 44 contents	0.000	0.000	44	44	361257	991039
Record 45 contents	0.000	0.000	45	45	361725	993158

**APPENDIX B.-EXAMPLE STATISTICAL CONVERSION OF DATA
FROM THE WATER-QUALITY DATA-BASE SYSTEM**

File named A.DATA containing water-quality data in the P-STAT format.

07242350	19851031	1530	-	-	
27.000	8.1000	0.650	40.000	<100.00	<0.100
07242350	19850118	1330	-	-	
13.000	8.0000	1.4000	10.000	100.00	<0.100
07242350	19850328	1130	-	-	
84.000	7.7000	1.2000	100.00	<100.00	<0.100
07242350	19850618	1300	-	-	
17.000	8.2000	0.170	30.000	<100.00	0.100
07242350	19850815	1330	-	-	
68.000	7.8000	0.760	50.000	<100.00	0.200
07242350	19850911	1400	-	-	
12.000	8.2000	0.140	20.000	<100.00	0.300
07242350	19850214	1400	-	-	
25.000	8.0000	0.950	20.000	<100.00	<0.100
07242350	19850409	0930	-	-	
65.000	8.2000	0.370	30.000	<100.00	-
07242350	19850521	1530	-	-	
43.000	8.2000	0.530	50.000	<100.00	<0.100
07242350	19851125	1400	-	-	
19.000	8.2000	1.1000	30.000	<100.00	<0.100
07242350	19851209	1430	-	-	
25.000	8.2000	1.5000	30.000	<100.00	<0.100
07242350	19860331	1130	-	-	
14.000	8.2000	<0.100	30.000	<100.00	<0.100
07242350	19860918	1200	-	-	
41.000	7.5000	0.380	<10.000	<100.00	<0.100
07242350	19860613	1430	-	-	
19.000	8.2000	<0.100	10.000	<100.00	<0.100
07242350	19870831	1200	-	-	
22.000	7.6000	0.100	20.000	-	<0.100
07242350	19861208	1000	-	-	
18.000	7.6000	3.8000	40.000	<100.00	<0.100
07242350	19870218	1400	-	-	
18.000	8.0000	2.2000	20.000	<100.00	<0.100
07242350	19870325	1300	-	-	
24.000	7.8000	0.470	30.000	<100.00	<0.100
07242350	19870416	1400	-	-	
17.000	8.1000	0.340	20.000	<100.00	<0.100
07242350	19870519	1400	-	-	
<10.000	8.4000	3.8000	20.000	<100.00	<0.100
07242350	19870612	1300	-	-	
<10.000	7.3000	0.290	50.000	<100.00	0.100
07242350	19870914	1600	-	-	
28.000	8.2000	23.000	810.00	<5.0000	<0.100
07242350	19861029	1345	-	-	
150.00	7.8000	0.890	<10.000	<100.00	<0.100
07242350	19861113	0945	-	-	
-	7.6000	5.8000	10.000	<100.00	<0.100
07242350	19870709	1430	-	-	
39.000	7.6000	<0.100	30.000	<100.00	0.300

File named A.SITES containing the description of a water-quality data-collection site.

USGS 07242350	DEEP FORK NR ARCADIA, OK	353850 097213540109	900.0011100303	105.00	464000100
---------------	--------------------------	---------------------	----------------	--------	-----------

File named MY.QWPARMS containing user-specific naming conventions.

00340	COD
00400	PH
00631	NO2NO
01046	FE
01049	PB
71890	HG

File named A.DATA.CMND containing descriptions of the water-quality data using P-STAT commands.

BUILD A.DATA.P, FILE A.DATA; VARS STATION.NUMBER:C DATE:C TIME:C END.DATE:C END.TIME:C P00340 P00400 P00631 P01046 P01049 P71890 \$

A global-variable file is created and options are specified with the commands:

```
DEFGV NWISARC.GVAR -CREATE  
SET_VAR .NAMEFILE MY.QWPARMS  
SET_VAR .SITEFILE A.SITES  
SET_VAR .STATS ALL
```

The conversion is performed in the following session.

```
OK, R PC>RUN>NWISARC A.DATA QW.COVER -T QW -INPUT NWISARC.GVAR -RELATE  
NWISARC: Convert NWIS QW or GWSI data for use in ARC-INFO  
[Revision 3.2]  
WARNING: INFO attribute file name set to QW.COVER.DAT  
Filename of data elements is A.DATA.CMND  
Filename of input data is A.DATA  
Filename of site-description data is A.SITES  
User-supplied code name file is...MY.QWPARMS  
Sorting parameter codes... 6 codes read  
Statistical options are ...#NM #M #0 #<0 AVG MAX MIN IQR P25 P50 P75 STD #<T #>T #T <T >T R  
Record-grouping key is ...SITEID  
Defining fields... 6 parameter codes read  
114 attributes defined  
894 bytes / reformatted-record
```

Reformatting... 25 QW records processed.
Calculating statistics...
1 group(s) summarized
**** STOP

WARNING: The following message(s) are for key = 07242350
WARNING: Insufficient uncensored data for parameter 01049

Above messages preserved in the file QW.COVER.ERRORS

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ARC Version 4.0.1 (4 April 1988)
Arc: &R PC>RUN>OUR.PROJECTION.AML *->INFO>RFMT.DATA '(1X,3I2,1X,I3,2I2)'

Please define the input and output map projections.
Use INPUT to define the input projection, OUTPUT
to define the output projection, and END to finish.

Arc: &SYS OPEN PROJECTED.POINTS 1 1
Arc: &SYS OPEN PREGENERATED.POINTS 2 2
Arc: RESUME PC>RUN>PNTGEN.RUN
Preparing for generate... 1 point(s) prepared for generate
**** STOP

Arc: &SYS DELETE PROJECTED.POINTS
Arc: KILL QW.COVER
Killed QW.COVER
Arc: GENERATE QW.COVER
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[GENERATE Version 4.0 (24 June 1987)]

Generate: INPUT PREGENERATED.POINTS
Generate: POINTS
Creating points with coordinates loaded from PREGENERATED.POINTS
Generate: QUIT

Externalling BND and TIC...

Arc: &SYS CLOSE PREGENERATED.POINTS
Arc: &SYS DELETE PREGENERATED.POINTS
Arc: BUILD QW.COVER POINT
Building points...
Creating attribute file for QW.COVER
Arc:
Arc: RESUME PC>RUN>IJNINF
Directory of INFO data base is <GIS>PC>REPORT>EX>INFO
INFO username is ARC
INFO data filename is QW.COVER.PAT
Field-definition file is *->INFO>KEY.FIELD
3 fields defined
2 items added

0 redefined items added
55 bytes / INFO record
Data file is *>INFO>RFMT.DATA
1 INFO records written
**** STOP

Arc: TABLES
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ESRI's TABLES, Rev 4.0 (24 June 1987)
=====

Enter User Name: ARC

Enter Command: \$KILL QW.COVER.DAT
Successful Deletion of QW.COVER.DAT

Enter Command: Q STOP
Arc: RESUME PC>RUN>ILDINF
Directory of INFO data base is <GIS>PC>REPORT>EX>INFO
INFO username is ARC
INFO data filename is QW.COVER.DAT
Number of overhead bytes is 0
Field-definition file is <GIS>PC>REPORT>EX>INFO>DEFINE.FLDS
114 fields defined
114 items added
0 redefined items added
487 bytes / INFO record
Data file is <GIS>PC>REPORT>EX>INFO>RFMT.DATA
1 INFO records written
**** STOP

Arc: QUIT
Exiting ARC ...

A coverage named QW.COVER was created, and two INFO files were created. Each INFO file contains one record (tables B1 and B2).

Table B1.—*Contents of the INFO file named QW.COVER.PAT*

[Field-type codes: F = binary real, B = binary integer, and C = character]

Attribute format					
Attribute name	Storage width (bytes)	Display width (columns)	Field type (code)	Number of decimal places	Contents
AREA	4	12	F	3	0.000
PERIMETER	4	12	F	3	0.000
QW.COVER#	4	5	B	-	1
QW.COVER-ID	4	5	B	-	1
SITEID	15	15	C	-	07242350
SNAME	24	24	C	-	DEEP FORK NR ARCADIA, OK

Table B2.—*Contents of the INFO file named QW.COVER.DAT*

[Field-type codes: F = binary real, B = binary integer, and C = character]

Attribute format					
Attribute name	Storage width (bytes)	Display width (columns)	Field type (code)	Number of decimal places	Contents
LATITUDE	4	7	B	-	353850
LONGITUDE	4	8	B	-	972135
DATE.MIN	4	6	B	-	850118
DATE.MAX	4	6	B	-	870914
SITEID	15	15	C	-	07242350
SNAME	24	24	C	-	DEEP FORK NR ARCADIA, OK
COD.#NM	4	4	B	-	24
COD.#M	4	4	B	-	1
COD.#<T	4	4	B	-	2
COD.#>T	4	4	B	-	22
COD.#0	4	4	B	-	0
COD.#<0	4	4	B	-	0
COD.#T	4	4	B	-	1
COD.<T	4	10	F	0	10
COD.>T	4	10	F	0	10
COD.MIN	4	10	F	0	12
COD.MAX	4	10	F	0	150
COD.P25	4	10	F	1	17.0
COD.P50	4	10	F	1	23.0
COD.P75	4	10	F	1	40.5
COD.IQR	4	10	F	1	23.5
COD.AVG	4	10	F	1	33.3
COD.STD	4	10	F	1	31.7
COD.R	4	10	F	1	1.0
PH.#NM	4	4	B	-	25
PH.#M	4	4	B	-	0
PH.#<T	4	4	B	-	0
PH.#>T	4	4	B	-	25
PH.#0	4	4	B	-	0
PH.#<0	4	4	B	-	0
PH.#T	4	4	B	-	0
PH.<T	4	10	F	2	-99,998.00
PH.>T	4	10	F	2	-99,998.00
PH.MIN	4	10	F	2	7.30
PH.MAX	4	10	F	2	8.40
PH.P25	4	10	F	2	7.65
PH.P50	4	10	F	2	8.00
PH.P75	4	10	F	2	8.20

Table B2.—*Contents of the INFO file named QW.COVER.DAT—Continued*

Attribute format					
Attribute name	Storage width (bytes)	Display width (columns)	Field type (code)	Number of decimal places	Contents
PH.IQR	4	10	F	2	0.55
PH.AVG	4	10	F	2	7.95
PH.STD	4	10	F	2	0.29
PH.R	4	10	F	2	-99,998.00
NO2NO3.#NM	4	4	B	-	25
NO2NO3.#M	4	4	B	-	0
NO2NO3.#<T	4	4	B	-	3
NO2NO3.#>T	4	4	B	-	22
NO2NO3.#0	4	4	B	-	0
NO2NO3.#<0	4	4	B	-	0
NO2NO3.#T	4	4	B	-	1
NO2NO3.<T	4	10	F	3	0.100
NO2NO3.>T	4	10	F	3	0.100
NO2NO3.MIN	4	10	F	3	0.100
NO2NO3.MAX	4	10	F	3	23.000
NO2NO3.P25	4	10	F	3	0.230
NO2NO3.P50	4	10	F	3	0.650
NO2NO3.P75	4	10	F	3	1.450
NO2NO3.IQR	4	10	F	3	1.220
NO2NO3.AVG	4	10	F	3	1.999
NO2NO3.STD	4	10	F	3	4.596
NO2NO3.R	4	10	F	3	0.987
FE.#NM	4	4	B	-	25
FE.#M	4	4	B	-	0
FE.#<T	4	4	B	-	2
FE.#>T	4	4	B	-	23
FE.#0	4	4	B	-	0
FE.#<0	4	4	B	-	0
FE.#T	4	4	B	-	1
FE.<T	4	10	F	0	10
FE.>T	4	10	F	0	10
FE.MIN	4	10	F	0	10
FE.MAX	4	10	F	0	810
FE.P25	4	10	F	1	20.0
FE.P50	4	10	F	1	30.0
FE.P75	4	10	F	1	40.0
FE.IQR	4	10	F	1	20.0
FE.AVG	4	10	F	1	60.4

Table B2.—*Contents of the INFO file named QW.COVER.DAT—Continued*

Attribute format					
Attribute name	Storage width (bytes)	Display width (columns)	Field type (code)	Number of decimal places	Contents
FE.STD	4	10	F	1	157.4
FE.R	4	10	F	1	0.9
PB.#NM	4	4	B	-	24
PB.#M	4	4	B	-	1
PB.#<T	4	4	B	-	23
PB.#>T	4	4	B	-	1
PB.#0	4	4	B	-	0
PB.#<0	4	4	B	-	0
PB.#T	4	4	B	-	2
PB.<T	4	10	F	0	5
PB.>T	4	10	F	0	100
PB.MIN	4	10	F	0	100
PB.MAX	4	10	F	0	100
PB.P25	4	10	F	1	-99,998.0
PB.P50	4	10	F	1	-99,998.0
PB.P75	4	10	F	1	-99,998.0
PB.IQR	4	10	F	1	-99,998.0
PB.AVG	4	10	F	1	-99,998.0
PB.STD	4	10	F	1	-99,998.0
PB.R	4	10	F	1	-99,998.0
HG.#NM	4	4	B	-	24
HG.#M	4	4	B	-	1
HG.#<T	4	4	B	-	19
HG.#>T	4	4	B	-	5
HG.#0	4	4	B	-	0
HG.#<0	4	4	B	-	0
HG.#T	4	4	B	-	1
HG.<T	4	10	F	1	0.1
HG.>T	4	10	F	1	0.1
HG.MIN	4	10	F	1	0.1
HG.MAX	4	10	F	1	0.3
HG.P25	4	10	F	1	0.0
HG.P50	4	10	F	1	0.0
HG.P75	4	10	F	1	0.1
HG.IQR	4	10	F	1	0.1
HG.AVG	4	10	F	1	0.1
HG.STD	4	10	F	1	0.1
HG.R	4	10	F	1	0.9

APPENDIX C.

SUMMARY OF THE CONVERSION-SOFTWARE OPTIONS

USAGE: R *pathname*>NWISARC *infile* *outcover* *arguments*

Where *infile* is the name of the input-data file retrieved from the NWIS. For GWSI data, the input-data file is a retrieval in the subfile format that contains C009 and C010 as the first two fields. For QW data, the input-data file is a retrieval in the PSTAT format. The name of the input-data file can be supplied on the command line or stored in the global variable named “.INFIL” in a global-variable file (see -INPUT argument discussion below).

The *outcover* is the name of the coverage to be created. The name of the coverage may be supplied on the command line or in the variable named “.OUTCOVER” in a global-variable file. The *arguments* specify the options for the software and are described in the following paragraphs.

-HELP (-HEL, -HE, -H) displays an explanation of software-usage options. This option may not be used with any other options.

-INPUT *file_name* (-INP, -IN, -I) enables input of some or all command-line data from a global-variable file identified by *file_name*. A global-variable file is created and maintained using commands in the Primos operating system (DEFGV, SET_VAR, LIST_VAR, and DELETE_VAR). The user may supply data to the software on the command line, in a global-variable file, or both places. Command-line data override global-variable-file data, when both specify data for the same option.

-TYPE *data_type* (-TYP, -TY, -T) specifies the data type. *Data_type* is either **GW** for NWIS-GWSI in the subfile format, or **QW** for NWIS-QW data in the PSTAT-file format. The *data_type* can be defined in a global-variable file by setting the “.TYPE” variable to either **GW** or **QW**.

-NAMEFILE *user_code_file* (-NA, -N) provides the file name of a user-specified code-name file in *user_code_file*. A user-specified code-name file is used for supplying the names to be used for INFO variables containing the attributes. Use of a user-specified code-name file can be specified in a global-variable file by setting the “.NAMEFILE” variable to the name of the file. User-specified code names override both site-specific code-names and default code-names. The content and format of the code-name file differs, depending on the value of *data_type*.

For **-TYPE GW**, a record in the code-name file contains the GWSI component code, the corresponding INFO-variable name, (optionally) the INFO-variable-type code, and (optionally) the number of decimal places. The Fortran format of this record is:

‘(A5,1X,A16,1X,A1,1X,I1)’.

For **-TYPE QW**, a record in the code-name file contains the QW parameter code, (optionally) the corresponding INFO-variable name for the numeric data, and (optionally) the

corresponding INFO-variable name for the remark code. The Fortran format of this record is:

'(A5,2(1X,A16))'.

-SITEFILE *qw_site_file* (-SI, -SITE) specifies the name of a file containing information about water-quality sites. The file is created by QW retrieval software when an affirmative response is given to the query:

Do you wish to save the list of sites with QW data ?

the name of this file can be provided in a global-variable file by setting the variable ".SITEFILE" to *qw_site_file*. If no file name is provided for **-TYPE QW** data, the software will try to use data in a file named QW.SITES.

-PROJ *proj.aml* (-PRJ, -PR) provides the name of an Arc Macro Language (AML) program for projecting site locations from latitude-longitude to a Cartesian map-coordinate system. The name of the AML program can also be supplied in the global variable named ".PROJ". If no *proj.aml* is provided, the software uses the site-specific program named OUR.PROJECTION.AML.

-NDUP (-NDP, -ND) causes the software to create only one point in the output coverage for each group of records in the input data with the same key-field value. Only records with unique key-field values are placed in the coverage. The key field is identified with the **-KEY** option (discussed later). This option be specified only with **-RELATE** or **-POINTS** options. This option cannot be specified in a global-variable file.

If the **-NDUP** option is not specified, records are placed into the output coverage without regard to the key field. However, if the **-STATS** option is used (discussed later), records with duplicate key-field values are not placed in the output coverage, because the key field is used for aggregating the data into statistical groups.

-PART *part_number* (-PA, -PAR) specifies the *part_number* of the conversion process to be performed. The conversion process is normally performed in its entirety, when **-PART** is not specified. However, when NWIS data on one computer is being used to create a coverage on a second computer, the process can be divided into two parts. After retrieving the data on the NWIS-computer system, NWISARC is run with the **-PART 1** option. The conversion process is partly completed, files are transferred to the second computer system, and NWISARC is run again with the **-PART 2** option. The *part_number* can be stored in the global variable ".PART". The same conversion-software options need to be specified during both runs of the software when conversion is performed in two parts.

-STATS *stats* (-STAT, -STA, -ST) specifies which summary statistics are to be computed for numeric fields in the input data. *Stats* consists of one or more statistical acronyms, as shown below. The acronyms for the statistics desired can be placed on the command line, or stored in the global variable named ".STATS". In either case, multiple statistical acronyms are separated by spaces. The list of acronyms needs to be enclosed in single quotation marks when more than one statistical acronym is specified on the command line. Data are aggregated using the field specified with **-KEY**. If the **-STATS** options is not specified, statistics are not computed.

The following statistics are applicable to both GW and QW data types:

ALL	All applicable statistics for data type.
NONE	No statistics (used to override global variable).
#NM	Number of non-missing values.
#M	Number of missing values.
#0	Number of zero values.
#<0	Number of values less than zero.
AVG	Average value.
MAX	Maximum value.
MIN	Minimum value.
IQR	Inner-quartile range (75th–25th percentiles).
P25	Lower quartile (25th percentile).
P50	Middle quartile (50th percentile) or median.
P75	Upper quartile (75th percentile).
STD	Standard deviation.

The following statistics are applicable only to the QW data type:

#<T	Number of censored values.
#>T	Number of non-censored values.
#T	Number of thresholds (detection limits).
<T	Minimum threshold.
>T	Maximum threshold.
R	Correlation coefficient of log-normal model.

-KEY *key_field* (**-KE**, **-K**) provides the field name in *key_field* to use for grouping records in the input file. The **-KEY** option may be used to specify the key field for statistical aggregations, or for removing records that duplicate the key field. The key field may also be stored in the global variable named “.KEY”. If *key_field* is not specified, either on the command line or in the global variable “.KEY”, the site-identification number is used for the key field.

For ground-water data, any retrieved spatial component may be used for the key field. For water-quality data, valid key-field names are shown below. The corresponding GWSI field names are shown parenthetically.

SITEID	Site-identification number	(C001)
STATE	State code	(C007)
COUNTY	County code	(C008)
FIPS	Combined state and county code	(none)
HUC	Hydrologic-unit code	(C020)
GUNIT	Geologic-unit code	(C714)

-POINTS (**-PNTS**, **-PTS**, **-PT**) specifies creation of a coverage with no attributes. This option cannot be used with either the **-ATTRIBUTES** or **-RELATE** option. If **-POINTS** is not

specified, a coverage of points is created and attributes also are processed into an attribute file. This option cannot be specified with a global variable.

-ATTRIBUTES *info_filename* (**-ATTR**, **-AT**) specifies processing of only attribute data. An INFO file is created with the name *info_filename* which contains the attribute data and no coverage is created. This option cannot be specified using a global variable, however, the name of the INFO file can be specified by setting the global variable “.ATTRFILE” to *info_filename*. If **-ATTRIBUTES** is specified on the command line without *info_filename* and the “.ATTRFILE” variable is not defined in a global-variable file, the INFO file will be named *outcover.DAT*. This option cannot be used with either the **-POINTS** or **-RELATE** option.

-RELATE *info_filename* (**-REL**, **-R**) specifies that attribute data are to be stored in a separate INFO file with the name *info_filename*. A point coverage is created, but the only field added to the point-attribute file is the key field. If the key field is the station-identification number, the station name also is added to the point-attribute file. As with the **-ATTRIBUTES** option, the INFO filename can be stored in the global variable “.ATTRFILE”. If the INFO filename is not specified by this global variable or on the command line, the INFO file containing the attribute data will be named *outcover.DAT*. The **-RELATE** option cannot be specified with either the **-POINTS** or **-ATTRIBUTES** option.