SYSTEM REQUIREMENTS SPECIFICATION FOR THE U.S. GEOLOGICAL SURVEY'S NATIONAL WATER INFORMATION SYSTEM II

S.B. Mathey, Editor

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PREFACE

The Systems Requirements Specification is the integration of work done during the past 2 years by many individuals. These individuals are members of eight user requirements analysis groups, each group based on one area of technical expertise. The eight user groups are: Biological, Ground Water, Surface Water, Sediment, Spatial, National Water Data Exchange, Water Quality, and Water Use. The members of the user groups worked many hours defining and documenting the user requirements for their area of expertise within the Water Resources Division of the U.S. Geological Survey. Our thanks to the following members of the groups for a job well done.

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SYSTEM REQUIREMENTS SPECIFICATION FOR THE U.S. GEOLOGICAL SURVEY'S NATIONAL WATER INFORMATION SYSTEM II

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ABSTRACT

The U.S. Geological Survey's Water Resources Division is designing and developing a new computer software system for processing and storing hydrologic data. This system, the National Water Information System (NWIS-II) will replace the current water-data and information systems: the National Water Data Storage and Retrieval System (WATSTORE), the National Water Data Exchange (NAWDEX), and the National Water-Use Information System, as well as thecurrent National Water Information System (NWIS-I). The new system will be utilized across the Nation on the Distributed Information System (DIS-II), a network of 32-bit microcomputers on a wide-area network of desktop workstations and related hardware.

The purpose of the NWIS-II System Requirements Specification is to integrate requirements described by eight User Groups representing the disciplines for Surface Water, Ground Water, Water Quality, Water Sediment, Water Use, Biology, Geographic Information, and National Water Data Exchange. The requirements specified in this document will serve as the framework for subsequent design and development activities throughout the life cycle of NWIS-II to ensure that the development products reflect the needs of the users. Specification details and associated data-base plans are contained in the description of the integrated functional requirements, the logical data model and the data dictionary, the plan for transferring data from the existing system to NWIS-II, and the descriptions of performance requirements and design constraints.

The NWIS-II will be consistent across hydrologic disciplines and the other major Division software systems. The color-graphics desktop environment of NWIS-II will utilize multi-window and multi-tasking capabilities with multilevels of help for the users. Data will be distributed among nodes and be automatically accessible during input, editing, verification and analysis of data. Hydrologic data will be cataloged independent of the Environmental Protection Agency's storage and retrieval (STORET) codes. Character, digital, and graphical data will be entered into NWIS-II from digital and analog recorders, external files, or keyboard through standard and user-defined input forms. Data will be verified manually or automatically during input, retrieval, and editing of data. Numerous reference lists will be maintained so that entry of codes on forms will not be required. User-defined series of computer actions for standard programs will be supported for processing basic data and other frequently repeated processes. Data will be verified and exchanged through links to other DIS-II software, including a Geographic Information System, and selected external software. Quality assurance of data will include aging of data through change on status type and tracking access violations. Output of data will be to a variety of media in standard and user-defined formats. The data base will be preserved by operations such as backup, recovery, audit trails, archiving, and data histories. In addition, an index of water data from USGS and other agencies will be maintained.

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CHAPTER 1. INTRODUCTION

O.O. Williams

1. Background

The U.S. Geological Survey's (USGS) Water Resources Division (WRD) began the process of designing and developing a new National Water Information System (NWIS-II) with the establishment of the Strategic Planning Group (SPG) on June 30, 1988. The SPG consists of most of the senior managers in WRD, including the five Assistant Chief Hydrologists and the four Regional Hydrologists. The purpose of the SPG is to provide the overall policy and guidelines for the implementation of NWIS-II. They also are responsible for determining the scope of the NWIS-II effort.

The goal of the NWIS-II effort is to develop and implement a highly flexible hydrologic data management and processing system; one that can be easily changed and expanded in a rapidly changing technological environment. The NWIS-II will replace the National Water Information System (NWIS-I), which is distributed across a network of minicomputers, and the National Water Data Storage and Retrieval System (WATSTORE) and the National Water Data Exchange System (NAWDEX), both of which reside on the mainframe computer at USGS headquarters in Reston, Virginia. The new system will be distributed across a national network of 32-bit microprocessors utilizing local-area network (LAN)[1] and wide-area network (WAN) technology.

In January 1989, the SPG selected 47 WRD scientists to represent the user community in describing WRD's current and future hydrologic information systems needs. Eight User groups were formed from the 47 scientists to represent specific disciplines or functional areas, including surface water, ground water, quality of water, sediment, water use, biology, spatial data, and the NAWDEX group that represents the non-USGS users of WRD's data bases.

Each of the User Groups were tasked to prepare a document describing their specific requirements for data storage and representation, data processing, and major system performance expectations. In stating their requirements, the users described their current methods and procedures (both manual and automated) and assessed their future needs. The documents produced by each of the User Groups were completed September 30, 1990.

The SPG developed plans in July 1989 to assemble a design and development (D&D) team, consisting mainly of WRD personnel. While the team was staffed and organized throughout 1990, work on requirements analysis began immediately. The method used to develop clear, complete, agreed-upon and feasible requirements for NWIS-II was adopted from Charles F. Martin's, *User-Centered Requirements Analysis* (1988). In so doing, the D&D team kept the User groups and SPG involved in all important decisions and oriented the system description of NWIS-II towards the

1. The use of trade or firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

users rather than the development team. The team also adhered to the methodology by addressing both the functional requirements and the data requirements in parallel to ensure that the data described by the users and the data derived during functional process descriptions are considered.

2. Purpose and Scope of the System Requirements Specification

The purpose of the NWIS-II Systems Requirements Specification (SRS) is to integrate the eight User Groups' needs into one document that demonstrates to the users that the developers fully understand their requirements. This specification will serve as the framework for subsequent design and development activities throughout the life-cycle of NWIS-II in formal software reviews to ensure that the development products reflect the needs of the users. This report presents the results of the requirements analysis performed by the D&D team and includes the integrated functional requirements description, the integrated data requirements description, performance requirements, operation constraints, and documentation of the existing systems (NWIS-I, WATSTORE, NAWDEX).

A formal review of this document was conducted by the NWIS Review Team appointed by the SPG to review the NWIS-II design and development life-cycle products. The review ensures that WRD requirements are stated properly. The Review Team's comments were transmitted to the SPG, who decided whether the SRS should be approved. Approval of the SRS allows the design of the NWIS-II to continue. The SRS will not be a static document; a Configuration Management Board was appointed by SPG to review proposal modifications to this document during the entire life cycle of the system.

3. Overview of the System Requirements Specification

The SRS is divided into seven chapters, each chapter describing one aspect of the NWIS-II requirements. All the chapters within the SRS combine to fully describe the requirements for the design and development of NWIS-II. The following paragraphs describe the function of each chapter and its relationship to the other chapters.

This Introduction chapter discusses the purpose and scope of the SRS as it relates to the development of NWIS-II and the approval and modification process of the SRS. Also included are the general structure of the SRS, interrelations among the chapters, and a list of all acronyms used in the document.

The NWIS-II General Description chapter discusses the NWIS-II software in general terms. It outlines the purpose, the objectives, the general description of the features of the software as defined by the requirements from chapters 3, 4, 5, and 6; and the profiles of the intended users of the software.

The Functional Description chapter contains the written specifications for the operations of the NWIS-II system. Included are specifications for the "look and feel" of the system to the user, and the methods of retrieving data, protecting the data, inputting hydrologic data into the system, verifying correctness of the data, computing the data, outputting the data, managing the system, and managing projects.

The Data Base Description chapter contains the logical data model describing the NWIS-II data requirements. This model consists of the entity-relationship diagram and the extended logical entity list, which provide a conceptual

description of the NWIS-II data base. This data base provides the central component of NWIS-II from which many of the functions will operate. The functional requirements specify data base inputs, retrievals, and many maintenance functions.

The Data Transfer Description chapter contains descriptions of the data contained in current systems that will be replaced by NWIS-II and specification about the process to transfer that data into NWIS-II. The Data Transfer Description chapter is closely related to the Data Base Description chapter.

The System Performance chapter discusses requirements related to the performance of the system. These requirements describe performance the users expect in the system and give information and specification for the D&D team to test the performance. These requirements will relate to the specifications outlined in the Functional and Data Base Description chapters.

The Design Constraints chapter discusses items that will affect the development of NWIS-II and describes the hardware on which the system will operate or utilize. The chapter discusses the operating system and other software and how they will affect the implementation of the functional and data base requirements. It also discusses the areas of responsibility among NWIS, Program Coordination and Technical Support (PC&TS), Branch of Instrumentation (BOI), Distributed Information System (DIS), Branch of Administrative Management Systems (BAM), and the National Water Quality Laboratory (NWQL), outlining which organization will provide software to meet specific system requirements or what level of cooperation or interfacing is needed to meet the system requirements.

4. Acronyms Used in the System Requirements Specification

For convenience, all acronyms used throughout this System Requirements Specification document are listed below with their definitions. Additional information regarding specific acronyms is included in the Glossary of Terms in Appendix A, where appropriate.

AAU - Applications Assistance Unit

ADAPS - Automated Data Processing System

ADR - Automated Digital Recorder

AIS - Administrative Information System

AQ - Aquifer, from GWSI

ASCII - American National Standard Code for Information Interchange

ASR - Analytical Services Request

ASTM - American Society for Testing and Materials

AWUDS - Aggregated Water-Use Data System

BAM - Branch of Administrative Management Systems

BDR - Basic data recorder

BOI - Branch Of Instrumentation

BWUI - Branch of Water-Use Information

CAS - Chemical Abstract System

CASE - Computer-Aided Software Engineering

CD-ROM - Compact Disc-Read Only Memory

CGM - Computer Graphics Metafile

COPI - Committee on Publications Improvement

CPU - Central Processing Unit

D&D - Design & Development

DBA - Data-Base Administrator

DBMS - Data-Base Management System

DCP - Data Collection Platform

DECODES - DEvice COnversion and DElivery System

DIF - Data Interchange Format

DIS - Distributed Information System

DIS-II - Distributed Information System II

NESDIS - National Environmental Satellite, Data, and Information Service

DROT - Direct Read-Out Terminal

DSDL - Distributed Spatial Data Library

EASR - Electronic Analytical Services Request

EDL - Electronic Data Logger

EFN - Electronic Field Notebook

EPA - United States Environmental Protection Agency

ESTWAT - ESTimate WATer

EUOWITUS - Estimated Use Of Water In The United States

FIPS - Federal Information Processing Standards

FK - Foreign key

GIS - Geographic Information System

GOES - Geostationary Orbiting Earth Satellite

GPS - Geo-positioning system

GW - Ground Water

GWSI - Ground-Water Site Inventory

HIF - Hydrologic Instrumentation Facility

IMSL - Interactive Mathematical and Statistical Language

LAN - Local Area Network

LANDSAT - Land Satellite

LIMS - Laboratory Information Management System

LRGS - Local Read-Out Ground Station

LSD - Land Surface Datum

LWDI - Local Water Data Index

MIS - Management Information System

MPN - Most Probable Number

MWDI - Master Water Data Index

NASQAN - National Stream Quality Accounting Network

NAWDEX - National Water Data Exchange

NGVD - National Geodetic Vertical Datum

NOAA - National Oceanic and Atmospheric Administration

NODC - National Oceanic Data Center of NOAA

NTC - National Training Center

NWDI - Non-USGS Water Data Index

NWIS or NWIS-I - National Water Information System

NWIS-II - National Water Information System II

NWQL - National Water Quality Laboratory

PC&TS - Program Coordination and Technical Support

PK - Primary Key

QA/QC - Quality Assurance/Quality Control

QW - Quality of Water

RDBMS - Relational Data-Base Management System

SATIN - Satellite and Telemetry Input

SIC - Standard Industrial Classification

SIM - Scientific Information Management

SMS - Sample Management System

SPG - Strategic Planning Group

SQL - Structured Query Language

SRS - System Requirements Specification

SSWUDS - Site-Specific Water-Use Data System

STORET - EPA's Water-Quality Data Management System--Storage and Retrieval

SW - Surface Water

SWRA - Selected Water Resources Abstract

TWRI - Techniques of Water Resources Investigations

USGS - United States Geological Survey

UTC - Universal Time Coordinated

UTM - Universal Transverse Mercator

VDD - Version Description Document

WAN - Wide-Area Network

WATSTORE - National Water Data Storage and Retrieval System

WDSD - Water Data Sources Directory

WORM - Write Once Read Many

WMRM - Write Many Read Many

WRIR - Water Resources Investigation Report

WRD - Water Resources Division

WRSIC - Water Research Scientific Information Center

WU - Water Use

WUDS - Water-Use Data System

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CHAPTER 2. GENERAL DESCRIPTION

J.D. Christman and S.M. Trapanese

1. Purpose and Scope

The purpose of the NWIS-II software is to provide the Water Resources Division (WRD) with the capability to input, edit, process, store, verify, index, retrieve, manipulate, and output all types of hydrologic data and the data related to the collection and quality assurance of that hydrologic data. NWIS-II will provide the functionality required by all WRD hydrologic disciplines and the current functionality of the four data bases in NWIS-I to input, edit, process, store, verify, index, retrieve, manipulate, and output. NWIS-II will replace the WATSTORE, NAWDEX, and NWIS-I systems with modern software. All features of this software will be available for use by all WRD personnel on DIS-II and by WRD cooperators with full compatibility with DIS-II. Other WRD cooperators, Federal, State, and local agencies and the general public will have the ability to view, retrieve and output data with a character terminal or an X-terminal.

NWIS-II and the three other major software systems essential to the mission of WRD (Hydrologic Analysis and Modeling System, Administrative Information System and the Distributed Spatial Data Library) will operate under the UNIX multiuser, multitasking environment and have a common "look and feel" to the user. Mechanisms will be available for efficient transfer of data among systems. (See CHAPTER 7. DESIGN CONSTRAINTS for a discussion of the relation of NWIS-II to the other software systems.)

2. Objectives

Development of the NWIS-II involving a complete user-requirements analysis, system design, and implementation of software will fullfil the following objectives:

- Provide a comprehensive data-base management system to support hydrologic analyses for USGS studies, including those of the Federal-State Cooperative Program, hydrologic investigations, Thrust Programs, National Water Summary, and National Research Program
- Provide a national water data base and index
- Serve as an archive for all data used in completed and published work products of WRD
- Provide data-handling and data-storage procedures that are uniform across all disciplines of WRD
- Provide a flexible and expandable system that is easy to use and understand by both WRD and outside users
- Provide data security and protection to ensure the integrity of the data within the data base
- Implement with ANSI, FIPS, and industry software standards to minimize dependencies on hardware platforms and single vendor suppliers

- Serve as a clearinghouse of sources of water-resources data
- Provide a fully integrated water-quality data capability for the NWQL and other laboratories

3. Features

NWIS-II will have the following features:

- Consistent "look and feel" across disciplines and the other major WRD software systems
- Desktop environment utilizing multiwindow and multitasking capabilities of UNIX and X-windows standards
- Menus in user-selectable colors and also appropriate shades for monochrome monitors
- Multilevels of help at the option of the user
- Entry of data from DCP's, ADR's, strip chart recorders, EDL's, radios and telephones, external files, and keyboard through standard and user-defined input forms
- Graphical input, editing, and analysis
- Verification invoked manually or automatically during input, retrieval, and editing of data,including system-defined and used-defined checks
- Entry of data by the use of numerous reference lists so entry of codes is not required
- Cataloging of data independent of EPA's STORET codes
- Taxonomic reference list that is coordinated with other agencies
- Automatic access of data during input, editing, verification, and analysis
- Interface to a Geographic Information System to assist in the entry, quality assurance, error-checking, spatial verification, editing, retrieval, and display of hydrologic data in a geographic context
- Standard navigation paths for ease of use and efficient processing of basic data
- User-defined scripts for frequently repeated processes
- Data-aging through change on data status type
- Access-violation tracking
- Output to a variety of media in standard and user-defined formats
- Efficient data entry and retrieval by external software through such provisions as subroutine libraries and data piping between processes
- Links to other DIS-II software
- Data base preservation operations of backup, recover, audit trails, and archiving
- Store data histories
- An index of water data of USGS and other agencies
- Ability to transfer data between NWIS-II and STORET data bases

4. Intended Users of NWIS-II

The potential users of NWIS-II have a broad range of hydrologic knowledge and computer experience. Within WRD, the user will range from the Chief Hydrologist to the Hydrologic Technician. Outside WRD, the users will include those from other Divisions within USGS; Federal, State, and local agencies; cooperators who fund WRD projects; the legislative branch of Government; and the general public. Therefore, hydrologic knowledge, computer fluency, or experience using the NWIS-II should not be prerequisites for using NWIS-II.

The intended users of NWIS-II are people who 1) work on hydrologic or scientific data, 2) maintain computers or software, or 3) need to obtain water-related information and water data. Some users will simply want to know whether data exists and, if so, view the data. Other users will want to use NWIS-II to store, manipulate, and display data. Still other users will tend to managerial and administrative duties using the NWIS-II data base. In addition, the main function of some users will be to support and maintain the NWIS-II and related systems.

NWIS-II will provide its users with the functionality, flexibility, and assistance needed to complete work that involves water data. A profile of the potential users of NWIS-II give designers necessary background information that will help accomplish these tasks. Just as many of the functional requirements of this document overlap, so do many of the user profiles overlap. This section of the SRS is a profile of some of the intended users of the NWIS-II and their expected uses of the software and the data base. Users described below are categorized as WRD and non-WRD personnel. Each of these categories is then further subdivided.

4.1 Water Resources Division Personnel

WRD's frequent movement of personnel between offices and its many job types offer the opportunity to broaden the NWIS-II user's background. WRD personnel make up the largest portion of users of the current NWIS software. Many of these people will require access to NWIS-II to perform tasks associated with more than one user category. The NWIS-II users working within WRD have been categorized below.

4.1.1 Administrators

The administrators are people who manage the administrative activities of the Division. They include District Chiefs, Studies Chiefs, Administrative Officers, and Budget Specialists. These users often interact with non-USGS offices to handle monetary contracts. They track the progress of the personnel and programs under their supervision and impose the necessary authority to complete tasks on time. These users will use NWIS-II to monitor projects along with funding, current and future plans, and deadlines. They may access the data base to provide background information about a particular type of project or geographic area of interest.

4.1.2 System Managers

The system managers are the people responsible for upkeep of the computer system. There are two types of system managers, the site administrator (SA) and the data base administrator (DBA). The SA is responsible for the installation and maintenance of the node's computer hardware and software. The DBA is responsible for the management of the NWIS-II data base and data at a node.

4.1.2.1 Site Administrator

Duties of the SA related to NWIS-II may include the following:

- Computer Systems Hardware
  - Backup files
  - Recover files
  - Maintain disks
  - Install and configure input/output devices

- Computer Systems Software — Install and Maintain
  - DIS-II operating system
  - DIS-II software
  - Third-party software
  - NWIS-II software

4.1.2.2 Data Base Administrator

Duties of the DBA related to NWIS-II may include the following:

- Start and stop interaction with the relational data base
- Change parameters that define the characteristics of the data base and optimize its performance
- Maintain the data base
- Define and maintain project setups and protect project data
- Maintain the data and their integrity
- Archive unused data
- Update reference lists and associated files
- Assist in the training of NWIS-II users

4.1.3 External Users

The external users are people who will access the NWIS-II through some sort of external connection. These users will take advantage of the interoperability between computer systems to mutually use information stored in one or more data bases.

4.1.4 Project-Associated Users

A majority of the NWIS-II users will be associated with a WRD project in the form of a cooperative study, basic data collection, experimental-methods developers, or research project. These people probably will use the NWIS-II most frequently.

4.1.4.1 Project Chief

Duties of the project chief related to NWIS-II may include the following:

- Assign security levels on data to other users
- Review project data

- Input, process, or compute project data
- Retrieve, format, output, or manipulate project data

4.1.4.2 Project-Data Reviewer

Duties of the project reviewer related to NWIS-II may include the following:

- Review project data
- Retrieve, view, format, output, or manipulate project data
- Approve data for public release

4.1.4.3 Project Worker

Duties of the project worker related to NWIS-II may include the following items.

- Input, process, or compute project data
- Retrieve, format, output, or manipulate project data

4.2 Non-WRD Personnel

There are several types of non-WRD personnel who require access to the NWIS-II software and data base. These users include personnel from other Divisions of the USGS, other government organizations, private organizations, and the general public. Unless these non-WRD users are associated with a project, they usually will not require the ability to manipulate data. Therefore, in most cases, non-WRD personnel are only provided with the ability to retrieve and output data.

4.2.1 Cooperators

Cooperators are organizations that provide resources for a project. They may actually assist with the project by providing help to collect data; by providing data collected by the cooperating organization to WRD for input to the NWIS-II data base, or by inputting the data directly into the NWIS-II data base. Cooperators may be associated with a Federal, State, or local government organization. Most cooperators work closely with a project with which they are associated and may not need immediate access to the data in the NWIS-II data base. Project data not yet approved for release cannot be viewed by anyone not associated with the project; however, if required, immediate access to the data can be provided by the project chief.

4.2.2 General Public

The general public includes unaffiliated individuals, as well as representatives of corporations, consulting firms, universities, research institutes, public utilities, and other institutions. General-public users will possess varying degrees of knowledge about the water information they need; some may need help formulating their request, while those familiar enough with the system may wish to search specific parts of NWIS-II on their own.

People from other USGS offices probably fall into the general public category, when it comes to access to data. This is explained later in the SRS.

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CHAPTER 3. FUNCTIONAL DESCRIPTION

INTRODUCTION

This chapter describes the functional characteristics of NWIS-II and is partitioned into nine sections that represent the primary functions of NWIS-II. Each section consists of descriptions that contain one or more subfunctions and requirements that identify the user's needs. These requirements are written specifications of the actions that the automated system must perform. (Martin, 1988, p. 87). The descriptions define the scope of the function, explain special concepts involved, and describe the intended use of the function.The descriptions are numbered, and functional requirements are labeled. Each subfunction will have its own subsection, and may itself be subdivided. Requirements stated for a function pertain to all subfunctions of that function; top level requirements must provide for the actions of its subfunctions.

Purpose and Scope

The purpose of the functional description is to provide users and developers of the NWIS-II software with clear and concise descriptions based on the users' needs. All of the specifications that could be designed into the software are not necessarily stated in the requirements. Some of the specifications may be implied or explicitly stated elsewhere in the functional descriptions. Other specifications have been identified that may be constrained by associated hardware and software. These specifications are presented in CHAPTER 7, DESIGN CONSTRAINTS.

Approach

When attempting to describe functionality, computer analysts employ the techniques of functional decomposition. Functional decomposition subdivides a complex problem into manageable parts, which can be subsequently subdivided. When decomposing a large complex system, analysts first partition it into logical areas (Gillenson and Goldberg, 1984). The criteria for partitioning can be one or more of the following: time; user types; input, manipulation and output of data; and the business organizational structure. The NWIS-II design and development team chose the last two criteria to partition the NWIS-II functional characteristics into nine sections:

1. User Interface—function that describes how NWIS-II will interact with users
2. Data Retrieval—function of accessing the data base
3. Data Protection—function of protecting stored data
4. Input and Edit—function for storing and updating data
5. Data Verification—function of error-checking and review
6. Computations—function of manipulating data
7. Data Output—function of displaying information
8. Project Management—function designed to help the manager of a project
9. Maintenance—function that covers the upkeep of NWIS-II

Two components of NWIS-II -- the NAtional Water Data EXchange (NAWDEX) and a geographic information system (GIS) -- do not fit into the functionality described above. NAWDEX is a nationwide program managed by the USGS, and is designed to assist users of water data and water-related data in identifying, locating, and acquiring available information. NWIS-II will be the repository of indexed information that is managed by NAWDEX. A GIS is a complex set of computer programs designed to manage geographically referenced information. Hydrologic investigations often require the ability to manage and spatially display site locations and to link attributes of these sites. NWIS-II will perform these functions by providing an interface with a GIS. NWIS-II will use GIS to manage, manipulate, and display site locations and associated attributes within NWIS-II.

1. User Interface

S.M. Trapanese, D.W. Stewart, S.J. Cauller, and T.E. McKallip

The user interface (UI) is the hardware and that part of a software package that allow persons, i.e., users, to communicate and interact with the computer system. The user interface accepts commands from a person and displays information from the system (Christian, 1988). With a good user interface, users can intuitively learn, customize, and use the system to perform tasks easily and quickly with a minimum of eye strain and fatique. Thus, users are in control of the system, and the users' job satisfaction is increased.

The user interface function can be described as the "look and feel" of the NWIS-II, because it affects users: 1) perceptually (e.g.,via the computer screen), 2) physically (e.g.,via the mouse), and 3) conceptually (via the mental image of the model). One of the goals of the NWIS-II is to provide a consistent and relevant "look and feel" across disciplines by providing standardized functionality and displays. In order to attain this goal, NWIS-II will utilize the multi-user and multi-tasking capabilities of a UNIX platform. The NWIS-II will support the use of various computer peripherals for data input and output (e.g., digitizers, digital-tape readers, scanners, plotters and printers). The exact models of peripheral devices that will be supported are those procured under the DIS-II contracts and selected peripheral devices that existed prior to the DIS-II. Due to the use of graphical windows and menus in NWIS-II, only color-graphics display devices that support the X-Window System will have the ease-of-use and total functionality of NWIS-II. Gray-scale terminals that support the X-Window System will have the total functionality of NWIS-II but not the same ease-of-use as color-graphics display devices. Character-based terminals will have limited functionality.

The discussion of the user interface is divided into six sections: desktop environment, geographic information system (GIS) interface, help system, status message board, navigation paths, and interaction with external systems and files. The desktop environment section describes the commands and tools that are part of the user interface. The GIS interface section describes how a user will display, manipulate and manage data in a spatial context. The help system section describes accessibility and content of help that will be available. The status message board section describes how a user will obtain information about the availability and accessibility of the NWIS-II software and data, and the DIS-II operating system and peripherals. The navigation paths section describes how the execution of standard processes wil be streamlined by presenting a user only those options that are applicable to the user's standard processes. The interaction with external systems and files section describes the ability of the user interface to communicate with external system and files.

Requirement 1-1 Provide multi-windowing and multi-tasking capabilities

NWIS-II software shall work within the multi-windowing and multi-tasking environment provided by DIS-II hardware. Thus, users can start NWIS-II and non-NWIS-II jobs or processes while running other jobs and processes. As an example, users could read mail in one window while viewing a table of NWIS-II data in another window. The NWIS-II menus or functions can be executed in one or more windows. The multi-windowing environment allows users to view data in tabular and graphical form at the same time in one or more windows. Users shall be able to copy and paste text from one window to another.

Requirement 1-2 Support 80- and 132-column character terminals

NWIS-II users will be able to perform some processes over the network via a character terminal but display of graphics will not be possible with this type of terminal. Functions that will operate from a character-based menu system will be determined. Functions and functional software with the highest priority for implementation as character-based applications are:

(1) a NWIS-II data base retrieval system;

(2) user-modifiable forms for data input and output;

(3) remote user batch job submittal for data input, verification, computations and tabling.

1.1 Desktop Environment

The NWIS-II will provide a "desktop environment" that facilitates a user's interaction with NWIS-II. The desktop environment is a metaphor that relates the computer display screen to a person's desktop: The objects displayed on the screen (windows, menus, and icons) resemble the objects on a desktop (papers, reports, notes and gadgets). The desktop objects communicate the data, concepts, and functions of NWIS-II. Users will control the desktop environment via the mouse, keyboard, or other pointing device. Users can customize the color, size, and placement of the visual objects to organize and enhance the desktop readability and to display only those options pertinent to a user's application in NWIS-II. Options will also be tailored to a user's experience or data access rights. Users will thus be able to navigate through the network of desktop objects to choose a desired process.

Wherever possible, the number of keystrokes or clicks on the mouse-button needed to perform functions will be minimized. For example, users will be able to type "Alt-h" to start the help function. Users will be able to perform some functions by typing a single keystroke, called a "hot-key," e.g., typing "F1" to exit. Users also will be able to use mouse selection, e.g., double-clicking the left button while the pointer is on an icon, to select menu options or to start a function.

Certain desktop functions, called global functions, will be available from any point within the desktop or user interface. The desktop environment will provide for the scheduling of command execution and the utilization of peripheral hardware. It will enhance the users' visual model of the NWIS-II data by using the geographic information system to display data in a spatial context. Figure 1 is an example of what the NWIS-II desktop environment might look like.

Requirement 1.1-1 Provide user navigation through NWIS-II

Users will have a logical and consistent desktop environment that helps to navigate through NWIS-II.

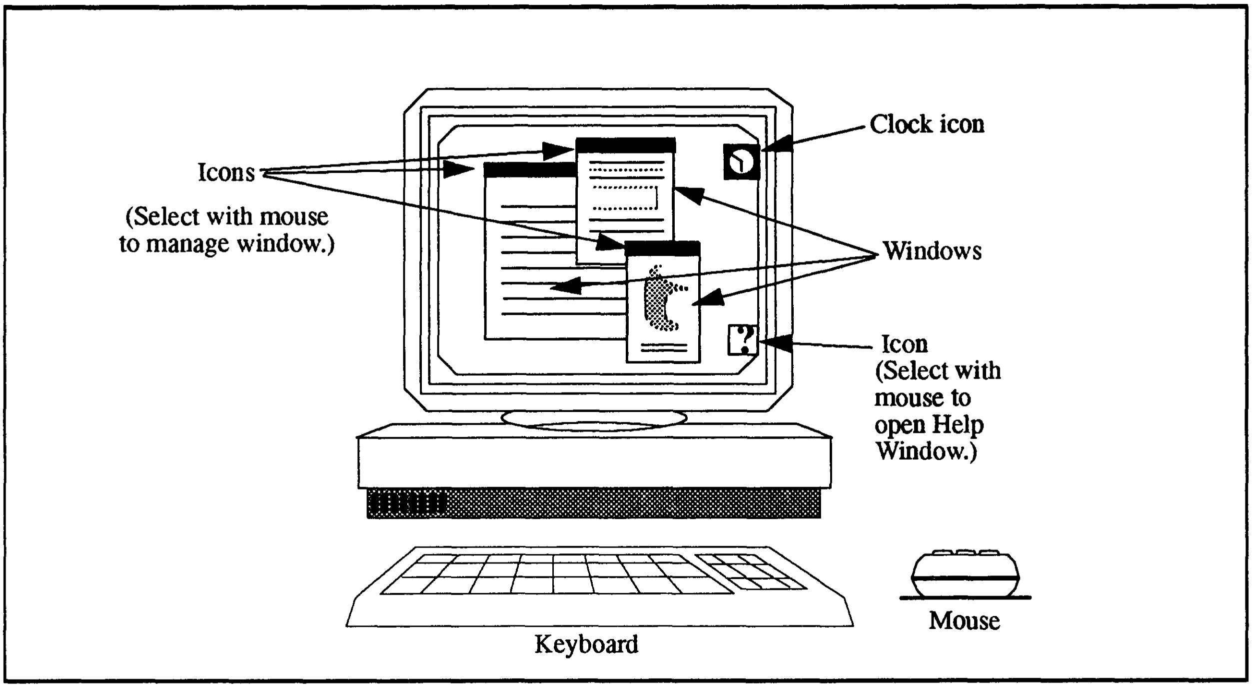


Figure 1. -- Desktop display for the National Water Information System II.

1.1.1 Global Functions

The NWIS-II users will have a set of global functions or operations that will be accessible from anywhere within NWIS-II, regardless of the window, menu or application in which a user is working. Global functions can be executed by selecting from one or more of the following: a global-functions menu, icon, or simple keyboard shortcut. Global functions incorporate the concepts of accessing the operating system and the control of commands that a user has specified while performing functions or tasks within NWIS-II.

Requirement 1.1.1-1 Provide access to the operating system

During an interactive session within NWIS-II, users shall have access to the computer operating system in order to: (1) send and receive electronic mail over the network, (2) execute UNIX commands, and (3) run directory and file management utilities on a user's personal work space (e.g., ability to search for files or examine directory structures). Access to the operating system will be provided by the DIS-II environment by opening another window.

Requirement 1.1.1-2 Support 'type ahead' capability

A 'type ahead' function shall be available so that users are not slowed by system response time when entering information. NWIS-II shall provide the ability to store keystrokes in a 'type ahead' buffer.

Requirement 1.1.1-3 Provide the ability to undo a command

Users shall be able to undo a sequence of previous commands one at a time. Except for commands that the system warns cannot be undone, users will be able to undo all the commands entered during a window session.

Requirement 1.1.1-4 Provide the ability to redo an undone command

Each time a command is undone, the user shall be able to reinstate that command by issuing a redo command.

Requirement 1.1.1-5 Provide an exit from NWIS-II

Users will be able to select an exit command or type a "hot-key" to escape to the operating system and leave NWIS-II from any location within NWIS-II. This exit command shall close open files that are not associated with already initiated processes.

Requirement 1.1.1-6 Provide the ability to quit a process

The "quit" command shall stop a process and return users to a previous menu. This quit command shall close all open files specifically associated with that process. When the quit is issued inside a window or menu with a specific process, a "hot-key" can be used. If at any time there are multiple processes executing and the system cannot determine clearly which one to stop, the user will see a list of processes and be queried to select the processes to be stopped.

Requirement 1.1.1-7 Provide the ability to print the desktop

A command selection or "hot key" shall be used to copy the contents of the desktop display (all the windows and their contents, and icons) to a file for subsequent output to a designated printing device. This action is analogous to a screen dump.

Requirement 1.1.1-8 Provide the ability to print output files

Users will be able to print text and/or graphics files. A list of files whose contents are based upon the context of the window, application, or user-supplied directory or path name shall be presented to the user. In addition, a list of applicable printing devices shall also be displayed. The user then selects the file(s) and printing device(s), and the desktop environment submits the job for printing.

1.1.2 Window Functions

The desktop window is a viewing area or portal for data objects on the computer screen that is roughly analogous to sheet(s) of paper or documents on a user's desk. As with the desktop metaphor, there can be multiple windows on the NWIS-II desktop (Figure 1). Each window is a context for interpreting commands and is not constrained to a particular size or application. In addition to allowing command interpretation, windows can contain other desktop visual objects (child windows, menus, and icons). All NWIS-II windows will have a set of functions that increase the readability and understanding of the information presented in the window and desktop. These functions include the ability to:

(1) control the size, number and location of the windows

(2) zoom-in or -out of the image (graphics or text) that is displayed in the window

(3) scroll horizontally and vertically, and "page" the image/file in the window

(4) search a window for a text string match

(5) flush the contents of a window to a file for either redisplay or printing

Requirement 1.1.2-1 Control the size, number and location of windows

To organize and reduce the clutter of the NWIS-II desktop, users shall be able to modify the size, number, and location of windows. Users also shall have the ability to shrink and expand a window's boundaries both vertically and horizontally. Windows shall be able to be moved to any location in the desktop, including in front of or in back of other windows on the NWIS-II desktop. NWIS-II shall allow users to create or remove windows from the desktop. Additionally, windows can be reduced to icon representations so that they occupy less space on the desktop but still remain active and can be reopened to their previous size.

Requirement 1.1.2-2 Zoom-in or zoom-out of window images

Users shall be able to zoom-in or zoom-out of the image (a "file" of text or graphics) that is contained in that window. Zooming in shall allow selected portions of the image in the window to be enlarged for closer detail inspection. Zooming out shall allow an image to be examined in its entirety.

Requirement 1.1.2-3 Provide horizontal and vertical scrolling, and paging

Since the image size allowed in a window is not constrained by a window's current size, the window shall provide a feature to reposition or move the image inside the window's current boundaries. To achieve this, NWIS-II shall provide vertical and horizontal scrolling of the window, and a vertical "paging" feature. Horizontal and vertical scrolling of the window image display shall provide the functionality to move in small increments bidirectionally through any information that has been directed to that window. Paging shall allow users to view text images or "files" in subsections constrained by the window's current length. Paging is a metaphor for a page from a book so paging through a window shall be similar to turning the pages of a book. NWIS-II shall allow users to go to the next page of the text image by scrolling vertically forward through the image one window's length at a time. Additionally, the NWIS-II paging feature shall allow users to go to the first or last page of the text image, or to skip forward or backward a specified number of pages.

Requirement 1.1.2-4 Search a window for a text string

Users shall be able to enter a text string for searching the contents of a selected window containing textual information. This requirement shall only be available for the information output described in: (1) the User-Defined Postprocessing, section 7.5.2; and (2) the Continuous and Discrete Data, section 4.7.1. The user-specified text string shall then be used to locate the line(s) of text in the text image that match. When the first match is found, it will be highlighted and the text image shall be positioned in the window display area so that the matched text

string is centered vertically. The user may then continue searching for subsequent matches by using a hot key to go to the next match which would be highlighted and centered vertically in the window.

Requirement 1.1.2-5 Provide a window dump

A command or a 'hot key' will allow users to copy the image contained within the boundaries of a particular window (the current window's display size) and place it in a file which could be subsequently output to a designated printing device.

1.1.3 Menus

Menus provide the paths that lead users through the selection and completion of the NWIS-II functions. All menus in NWIS-II are linked together to form a treelike structure or network. Each function in NWIS-II has an associated set of menus in the network which occur in a sequence or path. In other words, a particular function has a unique set of menus that proceed in a logical order. The NWIS-II menu network provides the logic that allows users to easily traverse the network of menus. Within a particular menu path, variability can exist between what different users actually see. The NWIS-II will only display those menus and options that the individual user has access to. Additionally, the textual content of menu presentation can vary in detail depending on whether a user has requested novice or experienced level menus (see User Levels, section 1.3.1).

Each menu in the network displays a list of items, usually within a desktop window, from which users make an appropriate selection. When many related fields of data items are required for selection in a path of menus, a fill-in-the-blank type form can be used to group the related items into one menu. Typically the entire form type menu would be displayed in a single desktop window that would not need to be scrolled or paged. An example of a form type menu would be a menu for setting a printing parameters. The menu would resemble a one page form with selection fields for setting the paper size, number of copies, double or single sided printing, and other such items. Any menu can utilize submenus to display lists of choices or options for a particular menu selection field or window operation. Submenus, such as pop-up, pull-down, or cascading menus, are context sensitive and are activated in response to a user clicking a mouse button or typing a keyboard shortcut (Figure 2).

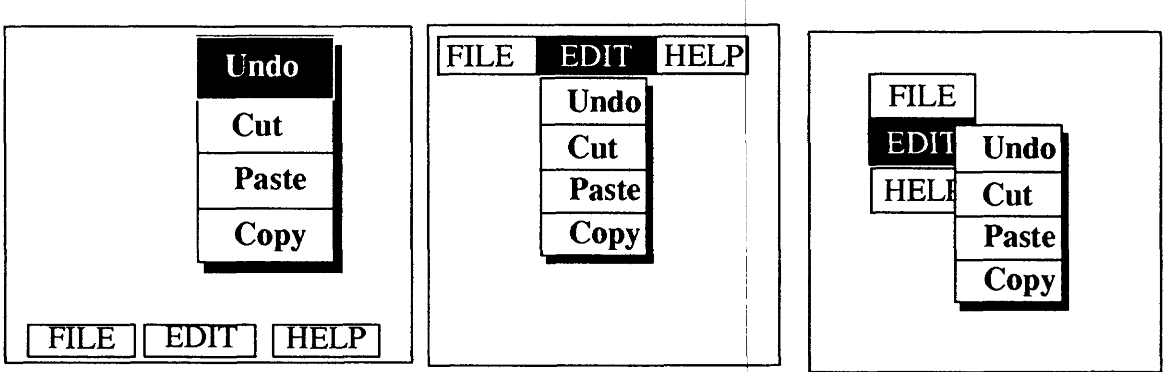


Figure 2. -- Submenus: A pop-up menu, a pull-down menu, and a cascading menu.

The NWIS-II menu network can contain several layers of menus and selections. Traversing a menu path could become tedious for frequent users. To allay the tedium, several menu shortcut techniques will be employed. The shortcuts allow a user to skip certain menu selections in a path or to quickly cross into a new menu path if applicable. The shortcut techniques will include:

(1) use of preset default menu item selections,

(2) type-ahead capability for known menu choices,

(3) direct access to menus by name, and

(4) menu macros for frequently used menu sequences.

Requirement 1.1.3-1 Allow menu navigation

Users will have a visual representation or map of the entire menu network. A user's current path in the menu network will be highlighted. To simplify the menu network map, only the major paths in the network shall be depicted. Users shall traverse specific menu paths in logical sequence. Users may backup through the menu path or jump to a new menu path in the menu network.

Requirement 1.1.3-2 Control menu content

Users shall see menus that are relevant to the performance of specific functional tasks, based on user answers to fill-in-the-blank-type query forms. Where applicable, menus shall list possible choices for each menu selection item or data field. Not all users shall be able to perform every task in NWIS-II; therefore, only those menus and options to which a user has access shall be seen (see Data-Access Rights, section 3.2.3).

Requirement 1.1.3-3 Provide submenus for option selections

Submenus shall be used to select options and execute some functions of the software. Any area in the desktop that is dedicated to a submenu shall be clearly marked. Submenus can have submenus or "child-submenus".

Requirement 1.1.3-4 Provide menu shortcuts

NWIS-II shall provide the following four menu shortcuts.

(1) Certain NWIS-II menus are used to set options that may change infrequently for an individual user, project, or computer node; for example, the setting of printer definitions, project data definitions, and pathnames to work areas. Once a user has designated choices for these particular types of menus, the user shall never be queried or presented these menus during the performance of other NWIS-II functions. The user, however, shall always be able to change default parameters by accessing these menus directly using either a specific name, "hot-key," or icon.

(2) Users shall have the ability to select menu items without having to wait for the menus to be displayed. Users shall type in a string of letters and numbers corresponding to the order of the menus and menu selection items they wish to perform. The NWIS-II menu system shall then

execute the string of options while suppressing the applicable menu displays until the last string option is completed. The next menu in the path shall then be displayed.

(3) The top-level menus for each discipline shall have unique names so that users can evoke a particular menu by typing its name.

(4) Users shall be able to define, name. and store menu macros and link this macro to one or a group of sites. To define a macro, a user shall invoke a provided menu macro utility. The user then traverses the menu path, selecting all desired options. When finished, the user closes the menu macro utility and names the macro. To reexecute the macro, the user types in its name. Macros shall be stored in the user's work area. NWIS-II shall provide a tool for displaying a selectable list of the user macros.

Requirement 1.1.3-5 Menu color selections

In order to conform to industry accepted UI design criteria (Shneiderman, 1987; and Galitz, 1989), the NWIS-II menus shall utilize a group of three to four main colors to accent and improve the visualization of the menu information. Users shall be able to choose from a default menu color palette and at least one alternate menu color palette. The alternate color palette could be modified so that any three to four color combinations for menus could be selected by users.

1.1.4 Icons

Icons are visual symbols for files, programs, or commands (e.g., quit, exit, delete or copy). The icons supplied in the NWIS-II desktop environment will be based on meaningful metaphors. An icon in the shape of a push button might be used to represent a particular option, selectable with the click of a mouse. Slide bars (a type of scrolling icon) may be useful mechanisms for quick selection of gradational options, such as the scale of a graphical display of gage height. When used creatively, icons can be powerful visual organizers of functions. For example, a user might display a weather map with user-modifiable icons representing precipitation, wind-speed and temperature information. Another user might create a unique QW-table icon to represent a process to retrieve a user-selected group of sites and constituents and to ouput the data in a user-specified table format.

Requirement 1.1.4-1 Provide meaningful icons

Icons representing the entities and actions of the NWIS-II shall be provided. These icons shall be based on metaphors that are meaningful to the users.

Requirement 1.1.4-2 Provide ability to customize NWIS-II icons

Users shall be able to customize the color and shape of most of the icons supplied with NWIS-II. This shall be possible because the form or visualization of the icon shall be maintained separately from its function. Therefore, if a user customizes the color or shape of a icon, the NWIS-II software shall not need to be modified or recompiled to allow this change. Subsequent releases of NWIS-II software shall not destroy the user-modified icons.

Requirement 1.1.4-3 Provide ability to add new icons

A user shall be able to add new icons to the NWIS-II desktop. When added to the desktop, the icons shall be accessible and functional from within the NWIS-II user interface.

1.1.5 Command Execution

Users will be able to execute commands in a variety of ways: interactively, in a background environment (giving users control of their workstation), or as a batch job. A batch job is a series of non-interactive commands executed outside of the user interface. Any command can be executed on the current CPU (computer processing unit) or can be distributed to other CPU's. The software will query the operating system and any peripheral devices needed to complete a command(s) and will provide alternatives for a quick and efficient execution of the command.

Requirement 1.1.5-1 Provide flexible command execution

Users shall have the ability to execute commands in a variety of ways: interactively, in a background environment, or as a batch job. Interactive and background environment commands shall be submitted for immediate execution. Batch jobs are submitted but begin their execution at the user-specified time.

Requirement 1.1.5-2 Provide the ability to execute commands on other CPU's

Users shall be able to submit commands for execution on other CPU's. If users desire to execute commands on a CPU other than their own and do not specify the alternate CPU, the NWIS-II user interface shall display a list of CPU's available for command processing. The list of CPU's shall contain qualitative information that describes a CPU's execution speed or availability. For example, the CPU's availability could be described as "immediate: within about an hour," "same day: within 4 to 8 hours," or "overnight: over 8 hours." Users can then select the desired CPU from the list. The list of available CPU's is maintained by the site administrator (see Device-Configuration List Maintenance, section 9.2.6).

Requirement 1.1.5-3 Provide the ability to select peripheral devices

When the execution of a command involves the utilization of peripheral devices supported by NWIS-II (e.g., printers, plotters, tape drives or digitizers), users shall have the ability to select the devices. Users shall have the ability to select and edit a default set of peripheral devices for use in all their command executions. If a command involves the use of a device not already selected by the user, NWIS-II shall display a list of applicable peripheral devices. The user can then select the needed peripheral device(s). The list of available peripheral devices is maintained by the site administrator, and unavailable peripherals will be "ghosted" in menus and not selectable (see Device-Configuration List Maintenance, section 9.2.6). Users will be able to ascertain the status of peripherals via the status-message-board window (see Status Message Board, section 1.4)

Requirement 1.1.5-4 Allow NWIS-II to suggest alternatives for command execution

When users submit commands for execution, NWIS-II shall query the system resources needed to complete the command to determine if system performance will be seriously compromised if needed peripheral devices are

unavailable. NWIS-II shall inform users of any potential problems and allow them to edit and resubmit commands. Whenever possible, the NWIS-II shall suggest alternative processing modes (e.g., an alternate CPU or deferred batch job) and peripherals for executing commands more efficiently.

Requirement 1.1.5-5 Provide the ability to schedule batch jobs

Users shall have the ability to set a clock time or delay interval to indicate when a batch job shall begin execution.

Requirement 1.1.5-6 Store batch job scheduling information for re-use

This batch job scheduling information that determines the CPU, peripheral devices, and time to start execution shall be stored in the user's work area for reuse at a later time.

1.2 Geographic Information System Interface

NWIS-II users will be able to display, manipulate, and manage digital geographic data through an interface to a GIS. These data will include NWIS-II site locations and their associated attribute information. The purpose of this interface is to provide menu access to spatial data layers, known as coverages, without prior knowledge of the specific GIS software. A GIS coverage is a digital analog of a single map sheet and usually represents a single theme or data layer. Thematic map layers of a specific geographic extent could include surficial geology, land use, political boundaries, or well locations, for example, and may be displayed individually or overlain collectively as coincident layers. To help orient the user visually, NWIS-II will automatically overlay thematic map layers on visual displays of NWIS-II sites. The thematic map layers will be context-sensitive to the feature type of the site. For example, a screen display of surface-water (feature type) gaging stations (sites) could include distinct map layers such as streams, hydrologic units, and political boundaries in the background. The selective use of meaningful colors and symbols to represent relevant thematic map layers will provide a backdrop to the display of NWIS-II sites. The ability to overlay other available data layers or to selectively remove data layers at a user's discretion shall be provided from menu selections.

The level of detail of thematic map layers displayed on the screen shall be determined by the geographic extent specified by users, within feasible limits of scale and content. For example, if a user selects surface-water gaging stations for the conterminous United States, only first order (major rivers) streams would be displayed. Yet, if the area of interest is a specific county, all orders of streams would be displayed. Screen displays should not take more than about 20 seconds to draw, regardless of detail.

Requirement 1.2-1 Provide access to a standard library of thematic maps

A library of thematic map layers will be available for display during the input, edit, verification and/or retrieval of NWIS-II sites and their associated attribute information. These maps will also be used to automatically populate the geographic attribute information of a new site upon input (see Site Location and Attribute Information, section 4.7.2). The following thematic maps are required:

- USGS and NAWDEX sites
- political boundaries
- hydrologic units
- hydrography
- hypsography (elevation)
- public land survey (township and range) boundaries
- transportation
- census tracts

Users shall have the ability to add thematic maps to this library. Optional map layers to be added when they become available include, but are not limited to:

- land use / land cover
- surficial geology
- population data
- aquifers
- precipitation

Requirement 1.2-2 Display default thematic map layers, relevant to NWIS-II site type

A backdrop of thematic maps relevant to the site type shall be displayed for each type of feature being queried. Widely applicable themes, such as surficial geology, shall be available for overlay as menu options. In addition, users will have the ability to remove default thematic map layers from the current display. The following are examples of the default thematic maps for selected NWIS-II site types:

NWIS-II site type	Default thematic maps
Surface-water site	Hydrography (streams, water bodies), hydrologic units, elevation, political boundaries, and transportation
Ground-water site	Aquifers, surficial geology, political boundaries, and transportation
Precipitation site	Elevation, hydrologic units, political boundaries, and transportation

Requirement 1.2-3 Display thematic map layers at the appropriate level of detail

The NWIS-II shall have the ability to display thematic map information at the appropriate detail for the geographic area selected. The geographic extent specified by users may limit the detail of spatial data displayed to provide rapid drawing time and uncluttered screen displays. Users shall be able to zoom-in on a smaller portion of a map to obtain more detailed enlargements.

Requirement 1.2-4 Provide the ability to graphically display site location(s) and attributes

Users shall have the ability to graphically display site locations in geographic space. Meaningful colors and symbols shall be used to distinguish different site types and thematic map overlays. Within a selected area, station at-

tributes (e.g., elevation) and data attributes (e.g., mean annual discharge) will be selected from pull-down menus. The following features shall be available with the display of site locations:

1. Display feature type:

   The screen heading shall display the type of site or feature being established.

2. Delimit site or feature:

   The site or feature being established or selected for analysis will be highlighted so it can be distinguished from the others.

3. Selection of scale:

   NWIS-II shall automatically determine a scale to display selected site locations, based on the minimum and maximum positional coordinates of these sites. Users also shall be able to change the scale or specify default scales to meet project needs.

4. Zoom-in or -out the graphics display:

   Users shall have the ability to zoom-in a graphics display several times, displaying additional detail (if available from the original coverage) and to zoom-out to the original view.

5. Panning on graphics:

   Users shall have the ability to pan in any direction across a screen graphic.

6. Overlay other data layers:

   Users shall have the ability to overlay other data layers and/or other thematic maps. The data layer could be other types of sites and features in the general area.

7. Remove overlaid data layers:

   Users shall have the ability to remove data layers or thematic maps.

Requirement 1.2-5 Provide the ability to display site location attributes in tabular format

Users shall have the ability to display locational data of NWIS-II sites in tabular form. The tabular data display shall consist of a vertical listing of the geographic attributes. For example:

- NWIS_ID - 27
- NAWDEX_ID - 66
- latitude- 38 47 22
- longitude- 77 37 42
- State - Virginia
- County - Fairfax

- Hydrologic unit code - 12345678
- Township / Range code - 333
- Elevation - 330
- Census tract - 129584

1.3 Help System

The NWIS-II help system provides immediate and specific information in response to user problems and inquiries. The amount of information and level of detail provided varies greatly from one user to another to accommodate differences in levels of user experience . Although the majority of the content of the help system information is specialized, much of the information can be derived from online and offline technical documentation and manuals. When using the NWIS-II help system, users can request help by typing in commands, or by selecting options or desktop objects (i.e., windows, menus, or icons) that provide help information related to the user's current location in the NWIS-II. In addition to the help system, information and assistance will be provided to all users via the various NWIS-II manuals, training activities, and telephone support (see chapter 7, Organizational Environment, section 3.).

1.3.1 User Levels

Users' experience depends on relative expertise in three areas: basic computer skills, familiarity with the software, and knowledge of the task or application. As a user increases frequency of use of NWIS-II, skill levels and help needs will change. A user may be casual with one part of the system, but experienced with some other application of the system. Therefore, the help system must accommodate the differing experience levels within the functionality of the NWIS-II. In an attempt to accommodate differing levels of experience, a help topic will have a hierarchial grouping of help information that ranges from terse to verbose. The terse level of help, which contains the least detail, will be a simple identification of the topic, menu item, or options. Users with little experience may request the verbose level of help, which contains the most detail and may include an example, if an example is applicable. Although the capability to customize an environment to provide a default or global level of help will be given each user, users will always be able to request more detailed information on a topic. Since users could frequently switch experience levels or categories during a session and over a period of time, NWIS-II will allow users to specify help options to override their global level.

Requirement 1.3.1-1 Provide terse and verbose levels of help

The NWIS-II help system shall provide a hierarchial grouping of two levels of help: terse and verbose. The terse or expert level shall contain a single sentence identifying the topic and possible options, if applicable. A verbose or novice level shall contain a full description of the topic to include possible options, limitations, example(s) and an index of related topics.

Requirement 1.3.1-2 Provide a user-defined global level of help

A user shall have the ability to set a global level of help to be used throughout the NWIS-II. In addition to setting a global level of help of either terse, medium or verbose, a user shall be able to request the suppression of help messages entirely.

Requirement 1.3.1-3 Provide the ability to specify levels of help at any help query

Despite a user's global level of help, users shall be able to request additional information when making a help query by:

(1) Keying in a repeated help query-- For example, a single query for help, '?', may give a terse explanation of the options; a repeated query, '??', would give more detailed information; and a '???' would give examples, and an index of references to other related topics.

(2) Specifying help with options--For example, a help with a define option could provide either a terse, medium, or verbose description (help/define-v would give a verbose description). Other help information could be specified for a topic in a similar way; help/index would display a list of related commands or functions; help/constraints would provide qualifications or limitations of use; help/example would give examples of use.

1.3.2 Content

The help system will contain text and graphic information tailored specifically to aid in use of NWIS-II. The content of an individual help message will address a user's specific problem or inquiry. The help message information is context-sensitive since it is dependent upon a user's actions and current location in the NWIS-II menu network. Although some of the help information will be derived from existing online and offline documentation sources, the majority of the information will come from help files designed to provide specific assistance to user problems. The documentation sources include extractions from online NWIS-II manuals, the NWIS-II data dictionary and glossary, and offline WRD technical documentation.

Requirement 1.3.2-1 Provide context-sensitive text and graphic help information

The content of the NWIS-II help system shall contain text and graphic information designed to assist users with specific problems. The content of the help information shall be based on the user-selected objects, and a user's current location or functional path in the NWIS-II menu system network. Table 1 lists each object and describes what type of help information shall be provided.

Table 1. -- A listing of NWIS-II desktop objects and their associated help descriptions.

Desktop Object	Help description	Example(s)
Window	What is being done in the window at the current time	Data entry or retrieval
Menu	1) Purpose of the Menu and/or description of the application it addresses.	Rating curve derivation program
	2) Explanation and list of choices, options, or items	List of available math equations for rating curve expansions
Form	Directions on usage and lists of possible selections for inputting data in an input field	List of applicable parameter codes or methods; description of data type allowed
Icon	Purpose of the tool	Exit or open user's mail box
Command	Purpose, syntax, limitations, and possible options for executing commands	Delete -all, deletes all files in area

Requirement 1.3.2-2 Provide help from several sources

Help message information shall be derived from but not limited to the following sources:

(1) Extractions from online NWIS-II manuals (see chapter 7, User Documentation, section 3.3.1 through Release Documentation, section 3.3.5)

(2) The online NWIS-II data dictionary (contains data descriptions and definitions for every entity and attribute in the data base)

(3) Glossary of terms (both computer terms, NWIS-II terms, and hydrologic terms)

(4) Specific files of help information (used to supplement topics not covered adequately by the other sources)

(5) WRD and non-WRD technical documentation

The NWIS-II users have requested some specific WRD and non-WRD documentation for item (5). These documents will be managed by the USGS library, the National Water Quality Laboratory, or the Office of Program Coordination and Technical Support, as appropriate:

WRD

(a) Estimating Pumping Time and Ground-Water Withdrawals Using Energy-Consumption Data WRIR 89-4107

(b) Analytical methods

(c) TWRI's

(d) Explanation of algorithms

(e) Technical bulletins

(f) Water Supply Papers

Non-WRD publications

(g) Material safety data sheets (MSDS)

(h) U.S. EPA health advisories

(i) U.S. Federal Register Regulations

Requirement 1.3.2-3 Provide help from an index and cross-reference

An index of helps shall be available to select information about a specific help topic. Wherever possible, help topics shall be indexed and cross-referenced so that users can explore related topics if a initial help is not useful. Users can select from the index by asking for help and typing a keyword contained in the glossary or index, or the user may access the index and select topics from a list(s).

1.3.3 Usage

The use of the NWIS-II help system involves users activating a help and controlling the display of the information in the help-message window. Users can activate a help and the subsequent provision of help topic information by specifically requesting help or having the system initiate the response to the help message. Users can request help by using the keyboard or mouse to select a help option from the NWIS-II menu or a help index, or by typing in help commands. In some instances, users also may obtain help by using a mouse or keyboard to select a term, window, icon, menu item, or form field that has associated help information. In instances when the NWIS-II determines a user has committed an error, the system will automatically provide help information. Both user-requested and system-initiated help-message information will be displayed in a window area that does not interfere with or obstruct the user's application.

Requirement 1.3.3-1 Allow users to request help

Users shall be able to request help by: 1) pressing a designated help "hot-key," 2) typing help commands/words, 3) using the mouse or keyboard to select a help icon or option within a menu, and 4) requesting an index of help topics from which a particular topic can be selected by mouse or keyboard.

Requirement 1.3.3-2 Provide user- requested help options

Whenever users request help, several options are selectable by mouse or keyboard to: 1) display a particular level of help message, 2) request more help (e.g., an example or different level), 3) request a global help index or index of cross-referenced topics only, or 4) quit the help.

Requirement 1.3.3-3 Provide hypertext and hypermedia help

Many major visual objects (terms, windows and icons, menu items or options, form fields, and control commands) used in NWIS shall provide help directly when a user selects the object with a mouse or keyboard. Once the object is selected, the system will display the associated help information, termed hypertext if textual and hypermedia if graphical. This help information itself could contain additional help items or options that would provide further elaborations.

Requirement 1.3.3-4 Provide command-name completion

Users shall be able to type in the partial name of an NWIS-II command and the help system shall list the possible completions. Users shall then be able to select the appropriate command for execution or quit the command-

selection operation. If there is only one possible command-name completion, the system shall execute that command.

Requirement 1.3.3-5 System-initiated help response after user error

The NWIS-II shall automatically provide help following user errors. After a system-initiated help message has been displayed, users shall be able to request more help, redo the action that caused the error, or abort the action and continue just prior to the start of the action causing the error.

Requirement 1.3.3-6 Display help information

Users shall be able to designate whether help-message information should be displayed or printed in a desktop window and/or printable file. Most help messages displayed in a window shall overlap but not obscure the desktop item (window, icon, menu or form) from which the help was requested. For consistency, certain help information topics may appear in a specific message area (e.g., see Status Message Board, section 1.4).The help information shall be sized to fit in the help window message area whenever possible. The help message window shall be scrollable and pageable like other desktop windows. Users shall be able to keep a help message window open until removed by the user, or select an option that logically removes the help window.

1.3.4 Extensibility

NWIS-II users will be able to supplement or extend the capability of the help system to meet their individual needs, or their project's or district's needs. For example, a user could add specific notes or instructions to an input form that are applicable to the site's unique characteristics; the user could then share the notes or instructions with other users. To ensure the integrity of the original NWIS-II help files, users will not be allowed to delete or modify the existing NWIS-II help information, only add help information.

Requirement 1.3.4-1 Allow user to add information to NWIS-II help system

Users shall be able to supplement information to the NWIS-II help system. Users shall be able to add synonyms or aliases and cross-references to the NWIS-II glossary and help index. Users shall be able to add information to the specific NWIS-II help files described in Requirement 1.3.2-2 item (4). Users' additions to these files shall be kept separate so that subsequent revisions to NWIS-II do not destroy the users' additions to the help file. Users shall be able to share their supplemental help files with other users.

1.4 Status Message Board

A status message board is a special desktop window that displays messages about the accessibility and performance of software, data bases, and hardware. This window contains a display area for critical messages and provides selectable options for viewing the critical-message log file and selections from NWIS-II Version Description Document (see chapter 7, Release Documentation, section 3.3.5) in separate desktop windows. Critical messages inform users of problems or events that will cause immediate effect on the use of the system (i.e., inaccessibility or damage to data bases or files, or the failure of a hardware device such as a disk drive or printer). These critical messages are broadcast to all online users' status message boards by the site or data base administrator or computer

system. If the window is iconified or overlain by other windows, the user is notified of a new critical message without disruption of interactive processes. The critical-message log file contains all critical messages that are still applicable (i.e., a file is still inaccessible or a printer still unavailable), whether or not the user has seen them previously. The status message board will provide access to an index of selected topics from the NWIS-II Version Description Document (VDD). Users can query this index to obtain the VDD information on such subjects as version number and installation date of the software, known errors and possible workarounds, or differences from the previous version.

Requirement 1.4-1 Provide a special status message board window

A status message board window shall display critical messages and provide the ability to display the critical message log file and selected topics from the NWIS-II VDD in separate desktop windows. The status message board window shall always remain visible to users who are actively running the NWIS-II. The window shall have a specific size and location on the desktop. This window shall allow scrolling and paging, but cannot be removed, moved, or resized. The status message board window shall be able to be changed to an icon and subsequently changed back to a window. Users will be alerted when a critical message has been sent to the status message board. The window may pop forward, change color, beep, or flash; if the board has been iconified, the icon may revert back to a window, change color, beep, or flash.

Requirement 1.4-2 Provide critical messages to online users

Critical messages that are broadcast by the site administrator, data base administrator or operating system shall be displayed immediately inside the status message board window. The following are possible types of critical messages that might be displayed.

(1) inaccessible/damaged/unavailable data bases or files
(2) operating system problems
(3) selected software errors
(4) scheduled maintenance that will disrupt use of NWIS-II
(5) hardware and communication problems
(6) Any change in status to the above problems

Requirement 1.4-3 Provide the ability to access the critical-message log file

The critical-message log file shall contain a copy of all the critical messages that have been broadcast to the users, whether or not they have been logged onto the system. If critical messages were added to the log file while a user was logged off the system, that user will be informed about new information in the critical message log file when logged back onto the system. The critical-message log file shall be maintained by the site and/or data base administrators to ensure that it contains only current and applicable messages. Users shall access the critical-message log file via an option in the status message board. When accessed, the critical-message log file shall be displayed in a separate desktop window.

Requirement 1.4-4 Provide selected topics from the NWIS-II Version Description Document

Selected topics from the NWIS-II Version Description Document (VDD) shall be accessible to users from an option in the status message board. When accessed, an index of the selected NWIS-II VDD topics shall be displayed in a separate window. When users select a topic, the textual information about that topic shall be extracted from the online source of the NWIS-II VDD.

1.5 Navigation Paths

A navigation path is a series of sequential execution options for processing data. Users can use navigation paths to perform standard processes, which are often specific to a discipline, e.g., print daily discharge values. A user could perform all of the procedures in a navigation path using general NWIS-II menu functions; however, the user might have to search the entire menu system for the desired options for processing. In the navigation paths, the user only sees a series of menus and output displays that are specific to the standard process chosen, and retrievals and information transfers occur automatically. For example, a navigation path "print daily discharge values" would ask for the station name and time period, and then check the data base for the equipment at the station and pertinent data for executing the process: original unit values, edited unit values, time corrections, datum corrections, shift adjustments, and a rating table. If critical data were missing, the system would alert the user and begin the interaction session at the point needed to complete the process "print daily values." Then, during the session, the system would present only logically pertinent menus and options to the user in the appropriate order, based on business rules and past choices made by the user. The user would not be presented menus about equipment that was not at the station, and the user would not have to select printer options at the end of the session.

Requirement 1.5-1 Provide navigation path functionality

The processing of data in navigation paths shall occur in a series of steps. Each step within the navigation path must be completed in a specified sequence. User interaction with a navigation path shall start when a user uniquely identifies a path and the data to be processed. If data identified has already been processed by the navigation path, the user shall be positioned at the end of the last completed step. Once inside the path, the user shall be able to view the position relative to the path's beginning and end. The user shall then be able to continue in the navigation path or choose to interact at an already completed step. If user interaction at a previously completed step alters data, all subsequent steps (processes) dependent on the altered data must be executed again.

Users shall be able to designate navigation paths as characteristics of stations, when applicable. This shall allow a user to specify a data element (e.g., discharge) and automatically enter the navigation that is a characteristic of, and therefore a default for, the station and data element.

At the start of each user's session, the navigation path shall search the data base for data that are potentially missing or inaccessible to retrieval by the navigation path. The user shall then be informed of the data that are not available to the path. This allows the user to preemptively fix problems with data before a navigation path fails. At the end of each step, data shall be saved to a file so that data can be recovered if processing is disrupted. If the execution of a

navigation path fails, the position of user interaction within the navigation path shall revert to the last step completed.

Requirement 1.5-2 Provide for user-defined navigation paths

Users shall have the ability to create user-defined navigation paths with all or some of the standard navigation functionality. Users shall be responsible for providing functionality and maintaining these paths.

1.5.1 Standard Navigation Paths

Data in standard navigation paths are directed through a scenario of NWIS-II functionality described in Figure 3. Input and edit, data verification and computations correspond to sections in this document where their general functionality is discussed. User review has a similar correspondence with a subsection of verification. Data flows through standard navigation paths until reaching user review. If there are additional steps in a navigation path or the user reviewer determines that previous steps need to be executed again, data can then be directed through any or all of input and edit, data verification, and computations. The last step or steps in a navigation path are always the user review. A path ends when the reviewer thinks the data are ready for formal colleague review.

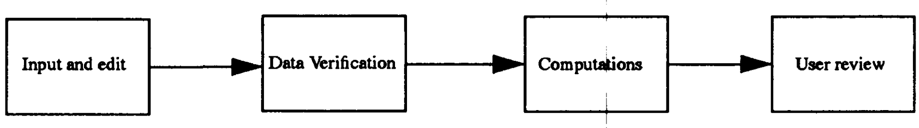


Figure 3.-- The flow of data in a standard navigation path

Requirement 1.5.1-1 Provide standard navigation paths

Standard navigation paths shall be provided to direct users through the standard processes associated with WRD data input and processing techniques. A partial list of navigation paths follows:

- Water-quality monitor data
- Suspended-sediment and constituent loads
- Bedload and total sediment discharge
- Bed-material and empirical-sediment discharge
- Site-specific water use
- Water-use aggregation
- Tide stage
- Stage and discharge
- Slope discharge

- Rate-of-change-in-stage
- Velocity-index
- Flow at control structures
- BRANCH model
- Reservoir/lake stage, elevation, and contents
- Climatic data
- Ground-water levels

Users have identified several other specific functions that may be navigation paths. Whether these functions shall be standard navigation paths or various menus in NWIS-II will be determined during the development of NWIS-II. A partial list of these functions follows:

- Creation and verification of a site
- Biological-tissue analytical data
- Biological-organism identification
- Species diversity
- Field measurement, sample collection, and sample analysis
- Tabling and editing
- Verification and quality-assurance checks
- Ground-water model
- Aquifer test

1.6 Interaction with External Systems and Files

The NWIS-II user interface will support access to external applications and programs, external data bases, and offline sources of data. External software is software residing on the DIS-II computer network, such as programs and applications that are not part of NWIS-II. External data bases are sources of data maintained outside of WRD. Offline sources of data that can be accessed by DIS-II are magnetic and optical media, such as magnetic tape and CD-ROM.

1.6.1 External Applications and Programs

"External applications and programs" refers to the software that is accessible on DIS-II computer network but is separate from (and not supported by) NWIS-II. Unlike some of the applications and programs PC&TS will produce, this type of software does not interact directly with the data base. However, there is a need for easy access to this software from the user's desktop environment.

Requirement 1.6.1-1 Provide a user interface that supports external software

External applications and programs shall be accessible through a window in the user's DIS-II desktop environment.

1.6.2 External Data Bases

External data bases are sources of data maintained outside of WRD, such as data bases maintained by other agencies, universities, or businesses. External data bases can be accessed with the standard terminal emulations and windowing environments provided as part of DIS-II. To access these data, a remote link must be established. Users may need to log on to external hosts via a modem or through INTERNET.

Requirement 1.6.2-1 Provide software for linking to external data bases

DIS-II software shall be provided to link users to external systems, which are accessible by 1) disk server, 2) 'hard' link (e.g., LAN), or 3) telecommunications hook-ups. This software shall contain telephone and INTERNET addresses for external data bases and shall allow users with proper access rights to log in at those addresses.

Requirement 1.6.2-2 Access to commercial data and software on magnetic and optical media

Users will have access to commercial data and software on external magnetic and optical media that are hardware- and software-compatible with DIS-II. Common types of magnetic and optical media that contain commercial data are: magnetic tape, WORM (write once, read many) platters, WMRM (write many, read many) platters, and CD-ROM disks.

2. Data Retrieval

T.E. McKallip, S.E. Hammond, W.R. Roddy, S.M. Trapanese, and D.W. Stewart

Data retrieval is the process of users selecting data from a data base. Data retrieval will function in an integrated, physically distributed system. All WRD hydrologic data, including selected National Water Quality Laboratory data, will be stored in the NWIS-II as one data base, rather than in separate discipline-specific data bases. Hence, the data retrieval function will be the same for all disciplines. Data from other WRD data bases (e.g., the electronic mail system and the Administrative Information System) also will be accessible by applications implemented in the NWIS-II. Retrievals from these data bases will function as if the data were within NWIS-II. In some cases, as with a standard navigation path (see Navigation Paths, section 1.5), retrieval will function automatically and be transparent to users. Online indexes of the availability of data within the NWIS-II and in other data bases will be accessible by the retrieval function. NWIS-II data will be physically distributed among a network of nodes located throughout the Nation. Retrieval will function the same at any node.

The process of locating and transferring data across nodes is referred to as polling. Because each node will be maintained independently, there will be times when maintenance activities at a node, such as backups, might require that the node be closed to polling. Closing a node to polling takes it off the network of polled nodes. If a retrieval request involves polling data from a closed node, polling at that node will be suspended until the node is reopened, but the polling process may proceed to poll from other open nodes involved in the request.

The discussion of data retrieval is divided into retrieval execution, retrieval specification, and retrieval scenarios. Retrieval execution discusses the process of submitting a retrieval for execution. Retrieval specification discusses the tools and techniques available to users for specifying what data will be retrieved. Section 2.3, Retrieval Scenarios, discusses how a series of retrieval specifications can be used.

Requirement 2-1 Provide the ability to retrieve on data elements in other WRD data bases

The retrieval function shall allow access to data elements in other WRD data bases, such as the Administrative Information System (AIS) and WRD's EDOC User-identification Data Base (USIDDB).

Requirement 2-2 Provide seamless data retrievals

NWIS-II shall support seamless data retrievals between scientific disciplines, between data bases, and across the network.

Requirement 2-3 Provide transparent data retrieval for computations and analysis

NWIS-II shall support direct and transparent retrieval of data for processing and applications.

Requirement 2-4 Provide polling in data retrievals

NWIS-II shall be able to provide user-controlled and automatic polling for retrievals that cross nodes. Retrieval of data from any node will depend on users' access rights. In retrieval requests, users shall be able to specify the nodes

to be polled and when the nodes will be polled. Users also shall be able to allow the NWIS-II to automatically implement the polling necessary to complete a retrieval.

2.1 Retrieval Execution

Before data of interest are extracted from the data base, messages that assess the success of extracting the data are produced. These are "pause and warn" and "summary" messages. The "pause and warn" message contains a list of potential problems, which may cause the extraction of data to fail. The "summary" message contains information about the data to be extracted from the data base. These messages can be directed to any or all available output devices. A retrieval execution can be suspended at the time that messages are produced. Users then would have the option of continuing, rescheduling, or canceling a retrieval. Retrievals submitted interactively will automatically be suspended for messages. If the retrieval is submitted in a batch mode, users will be able to choose whether a retrieval should be suspended for any message or only for designated messages. If for any reason an extraction of data of interest is taking a long time, users will be able to access the data already extracted and then continue or cancel the retrieval.

Requirement 2.1-1 Provide the ability to pause and warn about potential problems

As a default, users shall receive status messages before data associated with retrieval requests are extracted, if any of the following occur:

- completion of the retrieval will take a long time
- an excessive number of records will be produced
- the user's allocated disk space will be exceeded
- other nodes will be polled
- data with restricted access are being requested

Requirement 2.1-2 Provide the ability to suppress pause and warn and summary messages

Users shall have the ability to suppress the default pause for warning and summary messages and direct the output of these messages to a file.

Requirement 2.1-3 Provide a retrieval summary

A default summary of a retrieval request shall be provided before the request is submitted. This summary shall consist of the results of the retrieval specifications, which will include a list of the data elements requested, their frequency of occurrence, and a status flag indicating whether they are original record, in working status, review status, or final status. Users will be able to retrieve only those records for which they have viewing rights. Users shall be able to access status information about polling at nodes. This status information will inform users about which nodes are closed to polling and provide a schedule for the known closing and opening time periods.

Requirement 2.1-4 Provide the ability to access a retrieval before it is complete

If there is a system failure or any other event that causes the extraction of data from the data base to take a long time, users shall be able to access data already extracted and either continue or cancel the retrieval execution.

2.2 Retrieval Specifications

Retrieval specifications are commands or scripts that use boolean operators and text string matching facilities to limit the size of a data set being selected. Boolean operators are listed in Table 2.

Table 2. -- Boolean operators used for retrievals.

Boolean operators	
equal to	equal to null
not equal to	not equal to null
greater than	equal to missing
greater than or equal to	not equal to missing
less than	in range
less than or equal to	not in range
contain	and
not contain	or

Boolean operators can be used in data retrievals in conjunctive statements with the "**and**" and "**or**" operators to specify a set of conditions. The operators can be used to narrow the number of observations retrieved by specifying a range or a match of numeric or character data. They can be used to retrieve on the basis of null values, where a data value field is held in reserve or they can be used to retrieve on the basis of no value, where the data value field is blank (missing).

Some data stored in the existing system have associated qualifier codes (remark codes), which are needed in application software or for tabling purposes (Table 3). In the NWIS-II data base, some or all of these qualifier codes will continue to be used, subject to the needs of the users and new application software. Thus, users could retrieve all data where the qualifier code contains **TNTC** and could calculate species diversity indices on retrieved data sets containing the qualifier code **NC**. Some of the qualifier codes may not be used: For example: the symbols **M, <**, and **>** may be contained in the numeric field and not be needed as qualifier codes in NWIS-II.

The system should logically evaluate comparisons with qualifier codes. A retrieval specification for data within a certain range would get those values qualified with codes, as well as the code with which it is associated. For example, a range request for values that are less than a minimum reporting value would retrieve results with values less than the minimum, including those denoted with the < symbol, and would also get those results denoted by qualifier codes (**NC**, **ND**, and **ZC**) as less than some detection limit.

Table 3. -- Qualifier codes used or needed in existing system

Qualifier codes (associated with a real value)	Definition
<	less than value shown
>	greater than value shown
E	value estimated
ND	not detected in sample
NC	sampled but not counted in grid
L	organism count less than 0.5%
D	organism count dominant at greater than or equal to 15%
&	organism estimated as dominant
K	based on colony count outside acceptable range
TNTC	too numerous to count
NICC	not in colony count
ZC	zero counts
M	missing or not collected
UN	value unknown
NE	value available but not yet entered
NA	not applicable

Text matching provides the means of specifying retrievals based on matching textual data elements, such as remarks associated with sample events or site descriptions. Text strings can be searched for and matched for any textual data element specified by users. A text string is a user-defined combination of characters. Case sensitivity for text strings is optional. The data elements can include numeric or alpha characters, graphical images, and such characteristics as verification flags and protection statuses.

Data elements can be grouped into user-specified associations. An example of a user-specified group would be all the wells specified in an aquifer test. Retrievals can be specified based on combinations of any of the data elements or groups of data elements. Data elements can also have associations specified by the retrieval software. These associations are discussed in section 2.3, Retrieval Scenarios.

A common way to specify a retrieval is to use a combination of the data elements: hydrologic feature, location, time, and name. Hydrologic feature and locations are points, lines, and areas and can be specified using a Geographic Information System. For example, a specific observed or measured value could be selected by requesting a retrieval by hydrologic feature (river), by latitude and longitude (location), by day and hours (time), by sample medium (bottom sediment), or by QW constituent name (parameter).

Some data in the data base have many similar attributes (i.e., split samples, reruns, and samples taken at the same time and location but analyzed by more than one laboratory). If more than one observation (data that are essentially duplicates) can be selected by similar retrieval specifications, a preferred data flag could be set at the data working level so that only the preferred value could be generally retrieved. Observed values not designated as preferred could also be selected for retrieval by either specifying the data elements that are unique to the observation or by selecting an option to ignore the preferred data flag.

Key-word matching is another function that should be provided in NWIS-II. Key words are combinations of characters that will be defined in NWIS-II. The availability of key words for use will be based on data elements or

groups of data elements. Key words could be used one at a time or in combination with other key words. The boolean operators "and", "or", "contain", and "not contain" are associated with their use. Key-word matching also will include the option to retrieve on probable misspellings of key words in textual data elements.

Requirement 2.2-1 Provide the ability to use boolean logic for retrieval specification

The boolean operators listed in Table 2 shall be available for specifying retrieval requests.

Requirement 2.2-2 Provide the ability to retrieve by qualifier codes

Users shall be able to make retrieval specifications using qualifier codes listed in Table 3.

Requirement 2.2-3 Provide retrieval of quality assurance data

A system-defined retrieval option to retrieve quality-assurance data shall be available to users. This option will allow users to subsequently review or perform computations in the analyses of quality-assurance data.

Requirement 2.2-4 Provide the ability to retrieve on text matches

Users shall be able to retrieve by matching text in textual data elements using text strings (user-defined combinations of alpha or numeric characters). Case sensitivity for text matching shall be optional. The boolean operators "contain" and "not contain" shall be valid for text-string matches.

Requirement 2.2-5 Provide the ability to retrieve on grouped data elements

Users shall be able to retrieve by specifying previously defined groups of data elements.

Requirement 2.2-6 Provide automatic selection of preferred values for data elements

If a retrieval involves the selection of data elements with multiple values, the values that have been designated as preferred shall be selected unless all values are selected. If multiple values exist for different agency codes, the values with USGS will be flagged preferred by default.

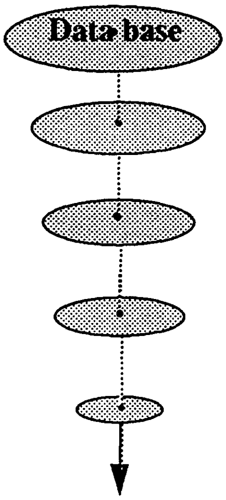
Requirement 2.2-7 Provide the ability to retrieve by key words

Users shall be able to retrieve by key words (NWIS-II defined combinations of characters). The boolean operators "and", "or" and "equal" shall be valid for key-word matches. Users shall also be able to retrieve on probable misspellings of key words.

2.3 Retrieval Scenarios

A retrieval scenario is a specification or series of specifications that identify data to be retrieved. The data may be values within the NWIS-II data base or elements within an index of data. Figure 4 depicts the concept of a retrieval scenario. Conditions defined by selections of data elements or key words using boolean operators and text-matching facilities are imposed on the data base. A data set that meets these conditions is created. Additional conditions are defined and imposed on the newly created data set, which limit its size and define a new data set. The

process of imposing conditions on an increasingly smaller data set continues until the data set the user wishes to extract from the data base is defined.



Selections in a retrieval scenario

1 The data set is restricted to data within an area
(The user selects a lake)

2 The data set is restricted by a selection of a data element
(The user selects dissolved oxygen)

3 The data set is restricted by a boolean operation on values
(The user selects values greater than 12 micrograms/liter)

4 The data set is restricted by text matching
(The user selects the keyword poor from a textual description of D.O. meter performance)

Figure 4. -- Conceptualized steps in a retrieval scenario.

Retrieval scenarios can be either user- or system-defined. These scenarios can be created using a menu or English language commands and can be saved and modified for reuse. User-defined retrieval scenarios are customized entirely by users. In system-defined retrieval scenarios some of the options for imposing conditions on a data set are predefined. This allows users to define some data sets by using fewer selections than a user-defined retrieval scenario. Users are guided through system-defined retrieval scenarios by either selected menus or English language prompts.

The steps (specifications) in a retrieval scenario can be submitted for execution one at a time or as a series. Each time retrieval specifications are executed, users will be informed of the size of the data set that has been isolated. If a series of retrieval specifications are submitted for execution at the same time, the execution of the retrieval specifications will be ordered so that the smallest possible data sets are retrieved first. Hence, users will have the option of allowing NWIS-II to determine the most efficient way of isolating a data set. Users also will be able to save, modify, and reuse retrieval scenarios.

Requirement 2.3-1 Provide the ability to save and/or modify retrieval scenarios for reuse

Users shall have the ability to save, modify, and then execute a set of retrieval specifications. If a set of specifications is created with a menu, the user shall be able to use NWIS-II menu simulation to scroll through the selections and make changes. If a set of specifications is created with English commands, the user can use an editor to make changes. Before committing to a retrieval specification, the user shall be shown the specification selected

and given a chance to make changes, if running interactively on the system. If running in batch mode, the retrieval is automatically executed with no opportunity to change the specification.

Requirement 2.3-2 Provide the ability to define a script to be used in a retrieval specification

Users shall be able to write and store scripts that can be used to make retrieval specifications, thereby requesting data in units in which they may not be stored or using algebraic notation on selected data elements to create new output variables.

Requirement 2.3-3 Provide the ability to selectively extract a specified number of records

Users shall be able to selectively extract and view a specified number of records from a data set determined by a set of retrieval specifications. Hence, users could extract a number of records from the front, middle, or end of a data set. They could extract a single record, single value, range of values, or period of record by dates.

Requirement 2.3-4 Provide the ability to retrieve by user-defined time periods

Users shall be able to define time units for use in retrieval specifications. For example a user could define a week to begin Monday and end Sunday, or a year to begin June 1 and end July 31. Certain system default time periods will be predefined, such as water year, calendar year, climatic year, month, and week.

Requirement 2.3-5 Provide the ability to suspend a retrieval data set

Users shall be able to save (suspend) the data set associated with a set retrieval specifications. This shall allow the user quick access to the data set later without requiring that all retrieval specifications be processed again. The suspended data set shall be functionally equivalent to saving a data base subset.

2.3.1 Retrieval on the Master Water Data Index

The Master Water Data Index is an index of data availability in NWIS-II and other data bases that contain water data. Users of the Master Water Data Index often are uncertain of what data are available for a given data-collection site or geographic area. A retrieval from the MWDI will help users limit the scope of a request for actual data and may lead to existing data from other sources of which users are unaware. However, users should not have to be familiar with the constituent names and parameter codes used by every agency in order to complete a retrieval from the data index. A reference list of aliases should exist that internally translates all of the various constituents from non-USGS data-index sources into the NWIS-II constituent identification system.

Users retrieving data-availability information from the MWDI will have several options. An index retrieval can be accomplished 1) interactively, 2) by requesting the attributes of one or more default output tables, or 3) by building a user-defined retrieval and associated output tables. An on-screen retrieval of data-index information will provide users with the most flexibility to choose the data categories during an interactive data search. A retrieval of default attributes will provide the information needed for predefined output tables. A retrieval of user-defined attributes will allow the user to design an MWDI output table.

For an interactive retrieval scenario, the user will be queried for information through a series of on-screen forms. The first screen would provide information that is broad in scope. Each successive screen would be narrower in scope. This would ultimately lead the user to the most specific information that can be obtained from the index. For example, the user might select information from a series of pop-up menus (Figure 2) within a retrieval form or select on a particular topic within the table of provided information (Figure 5). At each successive screen, the user will receive a summary table related to the previously selected topic. Data associated with each screen may be copied to a file or a hard copy could be obtained from an output device. At its highest (least specific) level, the user might provide information about the site type, the general location, and the data type of interest. The next screen might be used to define the type of site, data collection organization, type of data available, and data base where the data values are located. As the retrieval progresses, the user could narrow down his selection to the extent of the types of constituents collected at a site, how many times it was sampled, and how many days at least one sample was collected. At the lowest (most specific) level, the user would be provided with a yearly calendar showing the dates when at least one sample for a given constituent was collected. A calendar could be viewed for every year and every constituent that was sampled at a station. (See System Constraints and Other Related Issues.) The NAWDEX data dictionary of terms should be used as a preliminary list of items for the retrieval menus. A basic premise of this functionality is to help the user logically and systematically limit the data set that will be retrieved from the data index.

Requirement 2.3.1-1 Provide the ability to retrieve data-availability information from the MWDI through a series of on-screen retrieval forms

The NAWDEX user shall be capable of retrieving data-availability information through a series of on-screen forms.

Requirement 2.3.1-2 Provide the ability to retrieve data-availability information from the MWDI using a set of predefined attributes

NWIS-II shall provide predefined retrieval scenarios for data-availability information. Attributes of the predefined output tables shall be used to retrieve the information from the data base.

Requirement 2.3.1-3 Provide the ability to retrieve data-availability information from the MWDI using a set of user-defined attributes

NWIS-II shall provide user-defined retrieval scenarios for data-availability information. Attributes of the user-defined output tables shall be used to retrieve the proper information from the data base.

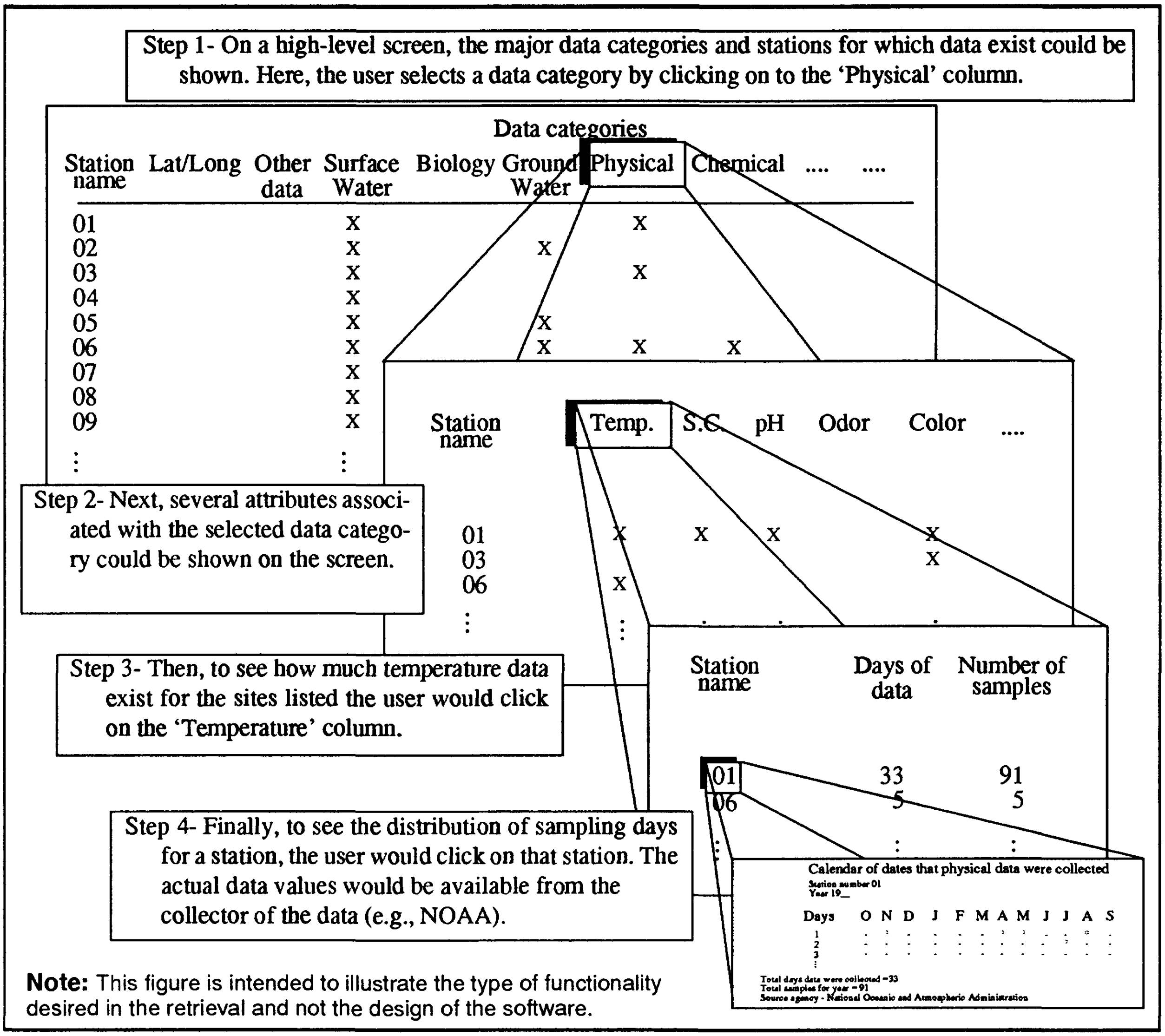


Figure 5. -- Conceptual diagram of how an on-screen, data-availability retrieval scenario might work.

2.3.2 Retrieval Specification Using a Geographic Information System

A GIS shall be used as a visual tool for selecting NWIS-II sites and associated attribute information for retrieval. NWIS-II sites graphically displayed on the screen can be selected by two methods. Sites may be individually selected using a pointing device or may be collectively selected from within a user-defined geographic extent. This functionality allows users to graphically delineate NWIS-II sites. By graphically delineating sites, users specify a data set that can be retrieved or further limited by additional GIS specifications and/or non-GIS retrieval specifications. Networked sites are logically connected with attributes of their neighboring sites and can be used to retrieve information.

Users can also retrieve information using buffer zones. Buffering is performed by the GIS to create a polygon with a consistent distance around selected points, lines or areas as shown in Figure 6. The buffering distance around selected NWIS-II sites and thematic map features shall be specified by users. Users also will be able to define the buffering distance by attributes of the NWIS-II site and thematic map features.

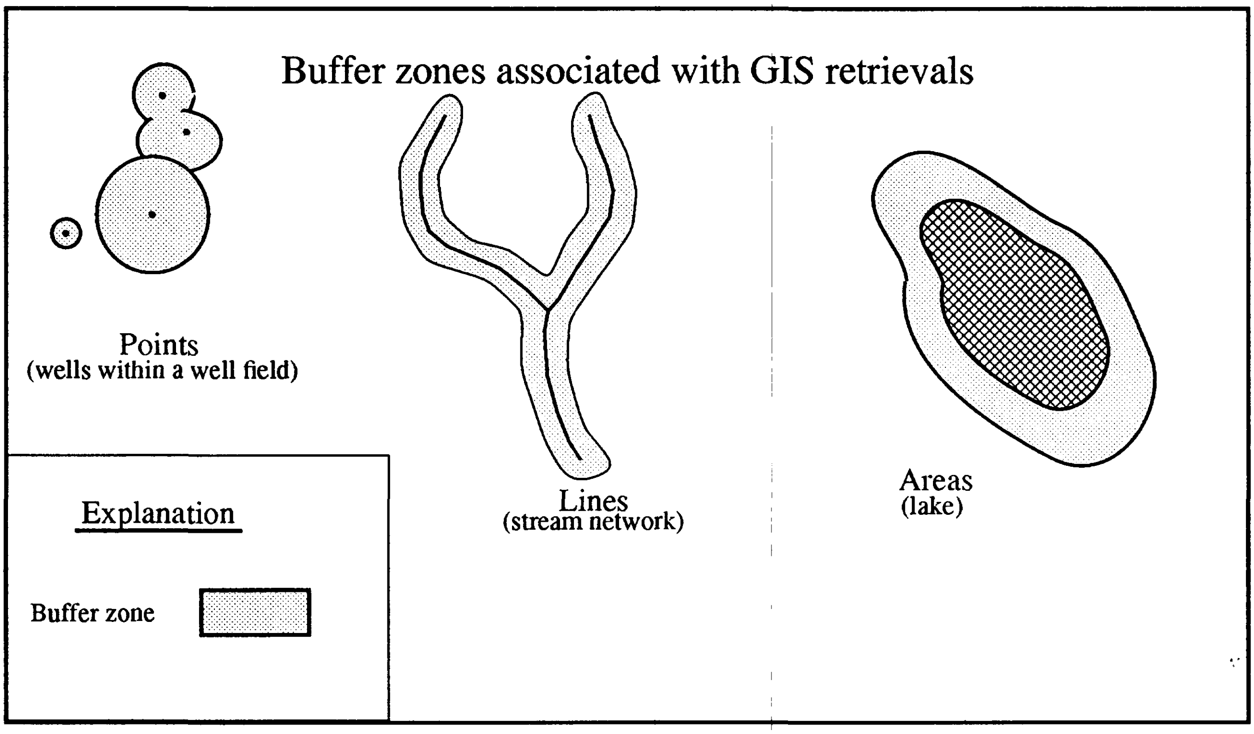


Figure 6. -- Buffer zones around points, lines and areas.

The selection of information for retrieval can also be done by comparing thematic map layers. Figure 7 demonstrates an overlay of two thematic map layers (e.g., diagrams 1 and 2) to define their geometric intersection (diagram 3). The intersection defines an area that can be used to narrow retrievals.

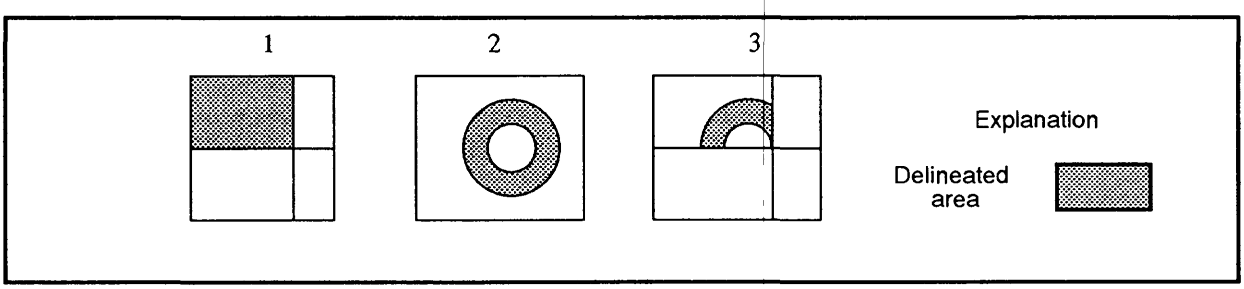


Figure 7. -- Intersection of thematic maps.

Requirement 2.3.2-1 Provide retrieval access to the Distributed Spatial Data Library

A system-defined retrieval scenario shall be available to users for accessing the Distributed Spatial Data Library Index.

Requirement 2.3.2-2 Provide the ability to retrieve data using delineated areas or points

Users shall have the ability to use a delineated area to specify a data set for retrieving information about NWIS-II sites that fall within the delineated area. The delineated area can be:

(1) selected from a thematic map. For example, users could select a county from a political boundary thematic map by pointing on the screen using a mouse and the requested information about the sites that fall within this area would be in the retrieval data set.

(2) a user-defined area. Circles, rectangles, and polygons are the types of areas users can define. They can be defined on the screen using a mouse or defined by pointing to a topographic map registered by using a digitizer.

(3) a user-defined GIS coverage. This coverage must be in the same projection and coordinate system of the supplied thematic maps.

Requirement 2.3.2-3 Provide the ability to retrieve data by selecting NWIS-II sites

Users shall have the ability to specify a retrieval data set by selecting individual NWIS-II sites with a mouse that are graphically displayed on the screen.

Requirement 2.3.2-4 Provide the ability to retrieve by latitude and longitude

Users shall have the ability to specify retrievals by latitude and longitude by:

(1) delineating a polygon with 3 to 1,000 pairs of latitude/longitude coordinates entered in counterclockwise order from a keyboard or user file

(2) delineating a circle by latitude/longitude pair and radius

(3) specifying points by a list of latitude/longitude pairs

Requirement 2.3.2-5 Provide the ability to retrieve data using a generated buffer

Users shall be able to define buffering distances around thematic map features and NWIS-II sites that define a retrieval data set of NWIS-II information within buffer zones as illustrated in Figure 6.

Requirement 2.3.2-6 Provide the ability to retrieve data by overlaying thematic maps

Users shall be able to retrieve information based on spatial commonalities of overlaid thematic maps. The common areas are used to define a delineated area and the requested information about sites that fall within the area would be in the retrieval data set as illustrated in Figure 7.

Requirement 2.3.2-7 Provide the ability to retrieve data using networked features

Users shall be able to retrieve on networked features by location and flow direction within the networked feature. It shall be possible to select features by the following specifications:

- up or down gradient of a location
- within a distance up or down gradient of a location
- between two locations
- defined segments of networked features (e.g., stream reaches of a networked tributary system)
- by gradient and number of NWIS-II monitoring sites

Requirement 2.3.2-8 Provide the capability to retrieve spatial data involving calculations

Users shall be able to specify a retrieval based on calculations of spatial data. Examples: 1) For a given set of wells, include the distance of each from a specified line (stream), polygon (lake), or point (site); 2) Locate the nearest well that has a value of fluoride concentration sampled within the last 12 months; or 3) Locate the 10 wells nearest to a specific feature.

Requirement 2.3.2-9 Provide the ability to combine GIS and non-GIS retrieval specifications

Users shall have the ability to limit retrieval data sets by using the GIS in combination with non-GIS retrieval specifications.

3. Data Protection

W.R. Roddy, T.E. McKallip, and J.D. Christman

The data-protection function is implemented to protect data and information in NWIS-II from deliberate or accidental alteration. Data are protected by restricting user access to processes that alter data. The goal of the data protection function is to give data managers a consistent method for controlling data access. The protection scheme is based on two concepts: data aging and project-associated user access. Data aging describes the flow of data as processed for approval. In NWIS-II, a "project" is considered a group of data with a definable purpose and limits on user access. A project may coincide with the project designation for the USGS Management Information System. Project data can be subdivided into smaller groups of data, which have the same protection features.

Data protection is divided into three parts: system management programs, data-base protection, and software protection. System-management-program protection provides access to programs and data for persons who maintain the integrity and usability of the data base on a local and national level. Data base and software protection provides NWIS-II users with access to the data base and to the software that interacts with the data base.

3.1 Protection of System Administration Programs

System administration programs are used to manage data (files) that help support a data base (e.g., updates to the data dictionary and reference lists). These programs will have three levels of access. A system administration level of program access will exist at headquarters; a data base administration level will exist at each district or network node; and a site administration level will exist at each district or network node.

3.1.1 System Administration Level

Individuals at the system administration level will utilize programs to manage the data dictionary and system-defined lists. Individuals at this level have the only access to programs that add, update, and delete data in the data dictionary and in system-defined lists, such as the FIPS State and county information file or the hydrologic units file.

Requirement 3.1.1-1 Provide system administrators with complete access to programs to manage the data dictionary and system-defined lists

3.1.2 Data Base Administration Level

The person responsible for data base administration at an NWIS-II node (the DBA) will utilize programs designed to manage the NWIS-II data base and related software at the district, subdistrict, or other office level. The DBA support programs will provide maintenance, such as for NWIS-II files and NWIS-II data-base protection. DBA's will have access to the functions related to the administration of the local NWIS-II data base. This includes maintenance, backup, and recovery of NWIS-II data, and management of the data base protection system.

Requirement 3.1.2-1 Provide data-base administrators with complete program access to manage the local NWIS-II data base and software.

3.1.3 Site Administration Level

The person responsible for administration of a DIS-II network node (the site administrator) will utilize programs designed to help manage the node's computer and related hardware. Site administrators will have access to functions related to the administration of the local computer site.

Requirement 3.1.3-1 Provide site administrators with complete program access to manage the local computer site

3.2 Data Base Access

The data base will be protected by controlling user access to NWIS-II data, which in this discussion is defined as hydrologic data and does not include support data and support software. The access to data and information in the data base will be controlled by the status type of the data itself and a user's user-category for a specific group of data. Status type denotes a position in the flow and processing of data to an approved and published state. The flow of data from one status type to another is referred to as data aging. Some data enter NWIS-II in a final state and do not go through the data-aging process. The protection of these data is associated only with the "project." NWIS-II data that does not age include other-agency data (e.g., STORET) and data in the Master Water Data Index. Other data that will not age are the data in other WRD data bases that can be accessed by NWIS-II. These data bases are the Management Information System, the Userid data bases, and the Distributed Spatial Data Library.

In NWIS-II, a project is a group of data with a specified purpose, areal extent, and time period that has limits on data access. Data are owned by the project when workers of that project input the data into the system. The concept of project data ownership means that the project chief and workers are responsible for the input, editing, processing, and verification of data as the data ages. The responsibility of data ownership implies that the project chief and workers have complete control over the data, thus security of the project data rests within the project. Project-associated protection of data is best understood within the context of the data-aging process.

Requirement 3.2-1 Control access to hydrologic data as the data move through various stages of processing, review, rework, approval, and revision

Hydrologic data shall be grouped by project, and the project data shall have specified types of data status. For each data status, a user shall be assigned a data-user category with data-access rights appropriate for the responsibilities of the user.

3.2.1 Data Aging

Most data input into the NWIS-II data base will be WRD project data and will follow the data-aging path shown in Figure 8 . The data-aging path describes the flow of data from one status type to another. WRD project data ages through four status types: **original, working, in-review**, and **approved**. NWIS-II data designated **original**, by authority of the Data Policy Committee, will be permanently stored in NWIS-II. Data that cannot be confirmed (such as semi-quantitative data) will have **original** status only. Original NWIS-II data will be copied and the copied data will have a status of working; and other original electronically stored data, and original data on hard copy (e.g., paper tape, paper notes) will be entered into NWIS-II with a status of **working**. Data with

working status are verifiable copies of original data and can be edited, manipulated, and/or computed. Data that age in NWIS-II can only be modified in **working** status. When modifications of **working** data are completed, the status is changed from **working** to **in-review. In-review** data are static until the data are either returned to **working** status or verified and moved to **approved** status. Data that have aged to an **approved** status are static, and the ownership is switched from the project to the data base administrator. **Approved** data have viewing access open to all. **Approved** data may return to **working** status for editing, manipulating, and/or computing until the data are verified. **Approved** data that are published will be marked as published. **Approved** data that have been superseded by a revision will be marked as *superseded,* and the revised data will be marked *revised.*

Data from other agencies that have been collected without WRD cooperation, such as some water-use data, will follow a slightly different path. These data will be classified as **Accepted-as-reported** and marked as *verified* or *not verified.* These data may then be preserved or a copy may age, depending on cooperative agreements between the WRD and other agencies.

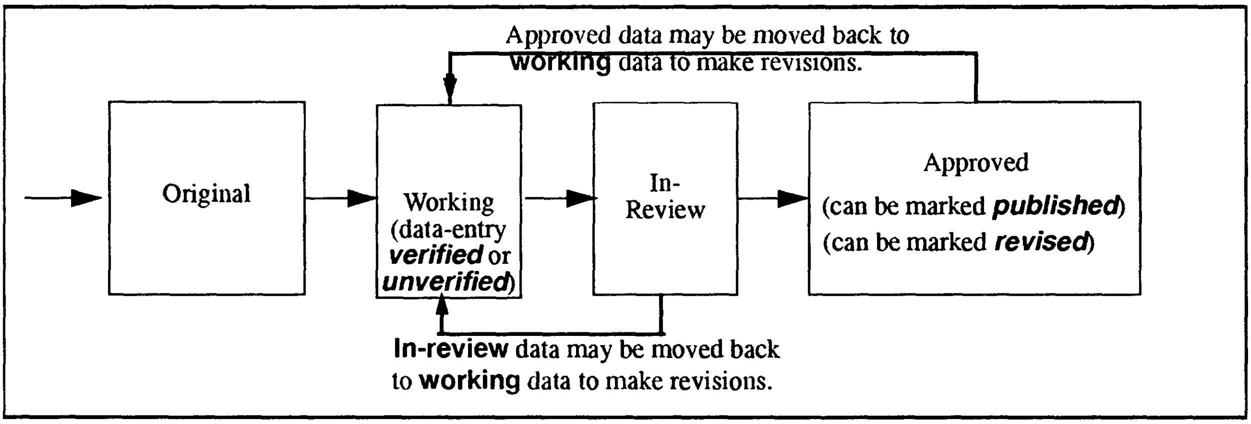


Figure 8. -- Schematic diagram of the data-aging process for project data and a listing of associated data types. The arrows indicate the direction of changes in data status.

Requirement 3.2.1-1 Provide various types of data status

Original NWIS-II data shall be labeled as **original**. Data that may be edited, manipulated, or computed shall have either **working, in-review** or **approved** status.

Requirement 3.2.1-2 Provide *accepted-as-reported* status for other agency data entered into the NWIS-II data base

Other-agency data that do not age will be reviewed for accuracy of input and will be labeled as **accepted-as-reported.**

Requirement 3.2.1-3 Mark *working* data that have been data-entry verified

Working data shall be marked **unverified** until the **original** data have been checked for data-entry errors. The user shall then accept the data or make needed changes to the **working** copy and mark the **working** copy as data-entry verified.

Requirement 3.2.1-4 Provide an automatic change of status from *working* to *in-review*

The data status shall automatically change from **working** to **in-review** after a preset time period. The default time period for data to stay in **working** status shall be 30 days.

Requirement 3.2.1-5 Mark *approved* data that have been published

Approved data that are published shall be marked in the data base as **published.**

Requirement 3.2.1-6 Mark *approved* data that have been revised

Approved data that have been superseded by a revision shall be marked in the data base as *superseded*, and the revised data shall be marked *revision*.

Requirement 3.2.1-7 Provide notification that data are *preliminary, subject to revision*

The viewing or printing of data that have not been approved shall be accompanied by a statement that the data are **preliminary, subject to revision**.

Requirement 3.2.1-8 Provide automatic notification that data have not moved out of the *in-review* status.

The NWIS-II will provide notification to the appropriate personnel if data have remained in the **in-review** status for more than about 60 days.

3.2.2 Shared and Restricted Data

Shared data are data that will be accessible to the public after verification and approval. Shared data that have been approved will be accessible to the public through the NWIS-II data base and/or through publications.

Data may be labeled **restricted** if the cooperator requests that only USGS personnel view the data. Restricted data can be proprietary data received from an outside source with an agreement that viewing be limited, or data collected by the USGS, which is restricted due to agreements with a cooperator and/or owners of the land or facilities from which the data are collected. Typically, the aggregation of restricted water-use data with non-restricted data may be open to the public.

Requirement 3.2.2-1 Provide for *shared data*

Shared data shall consist of all data in the NWIS-II data base unless otherwise noted.

Requirement 3.2.2-2 Provide public access to *shared data*

Shared data that have been approved is open to the public.

Requirement 3.2.2-3 Provide for *restricted data, not open for aggregation*

A category will be established in the NWIS-II for **restricted-data not open for aggregation.** Data in this category will have availability indexes open to project personnel only.

Requirement 3.2.2-4 Provide for *restricted data, open for aggregation*

A category will be established in the NWIS-II for **restricted-data open for aggregation.** Data in this category will have data availability indexes open for viewing.

3.2.3 Data-Access Rights

Types of data-access rights are: no access; view; edit; input; make a **working** copy of **original** data or accepted-as-reported data; and change data status to **working, in-review,** or **approved.** The view-access rights allow users to retrieve and output data. The edit-access rights allow users to modify data, including all processes and computations that alter the data. The input-access rights allow users to enter and edit data for input. The right to make a **working** copy of **original** data or **accepted-as-reported** data allows the user to preserve the originally entered data and age the copy. The change-data-access rights allow users to assign data a different status.

Requirement 3.2.3-1 Provide data-access rights

Data-access rights shall be: no access; view; edit; input; make a **working** copy of **original** data; make a **working** copy of **accepted-as-reported** data; and change the status of WRD data--from **working** to **in-review,** from **in-review** to **working,** from **in-review** to **approved,** and from **approved** to **working.**

3.2.4 Data-User Categories

The NWIS-II security system will protect data from unauthorized access by the use of data-user categories set up for project data. The DBA, who has all rights to all the data, may assign data-user categories for each project. Initially eight other user categories will be available**: data administrator, project chief, project worker, data reviewer, project viewer, in-review data viewer, public viewer,** and **NAWDEX member.** The DBA will have the right to add other user categories. These users will have specific rights to WRD project data, data from other agencies (accepted-as-reported data), MWDI data, and Userid data.

Requirement 3.2.4-1 Establish data-user categories

Eight categories of data access shall be available: **data-base administrator, project chief, project worker, data reviewer, project viewer, in-review-data viewer, public viewer,** and **NAWDEX member.** The DBA will be responsible for data in the entire NWIS-II data base and may or may not be assigned to a specific project. The **project chief** is responsible for the overall management, maintenance, and quality assurance of data for the project and has access to the userid data base. The **project chief** will also mark data as published

and is responsible for revisions of published data. The **project worker,** usually a WRD employee but sometimes an employee of a cooperator, is assigned to a specific project. The **data reviewer**, usually the district specialist, section chief, or other project chief, is responsible for the review of in-review data and has authority to change the status of in-review data to approved. The **project viewer** is considered to be associated with a project but does not have input or edit access rights to the data. The **project viewer** may be a WRD employee working closely with the project or a cooperator employee associated with the project. The **in-review data viewer** is not a WRD employee or cooperator employee but one who needs access to the data before the data are approved. The **in-review data viewer** may be a downstream water user who needs to know the amount of irrigation released or a university researcher using the data for a paper. The **public viewer** is a member of the general public who needs only to view approved data. All users not associated with a project will automatically be given **public viewer** status. This data-user category allows retrieval of data by the general public. The **NAWDEX member** is a person designated by an agency to be responsible for the data which that agency contributes to the MWDI. Access protection for **NAWDEX members** shall be the same as a **public viewer's** except for their specific MWDI data. Although the DBA will have some latitude in determining the access rights of the DBA and project reviewer, typically, each category shall have the access rights shown in Table 4.

Requirement 3.2.4-2 Establish data-user categories for a subset of project data.

Project data shall be subdividable into subsets of the project data, such as by time periods or areas, for the purpose of establishing data-user categories for the subsets with the same protection functionality as for the project data.

Requirement 3.2.4-3 Establish data-user categories for a group of projects

Project data can be combined with data from one or more other projects for the purpose of establishing data-user categories for the entire group of data.

Requirement 3.2.4-4 Provide the project chief with the ability to change the time period that data remain in *working* status

The **project chief** shall have the ability to set and change the amount of time that data in **working** status will remain in that status before being automatically updated to **in-review** status. The default time period before automatic updating is 30 days.

Table 4. -- Categories of data-access rights for shared and restricted NWIS-II data

[Data accesses: All, all rights; V, view; CW, change data status back to **working**; I, input; M, mark data as **published**; CPY, make a **working** copy of **original** data or of **accepted-as-reported** data; E, edit; CIR, change status to **in-review**; CA, change status to approved; N, no access; IO, input MWDI data owned by the user; IE, edit MWDI data owned by the user; SAME, access rights for restricted data are the same as for unrestricted data; N/A, not applicable].

Data-user category	Original Project data	Working Project data	In-review Project data	Approved Project data	Accepted-as-reported data	MWDI data	Userid data
			SHARED DATA				
Data base administrator	All	All	All	All	All	All	All
Project chief	I,V,CPY	V,E,CIR	V,CW	V,CW,M	I,V,CPY,M	V	I,E,V
Project worker	I,V,CPY	V,E,CIR	V,CW	V	I,V,CPY	V	V
Data reviewer	V	V	V,CW,CA	V	V	V	V
Project viewer	V	V	V	V	V	V	V
In-review viewer	N	N	V	V	V	V	N
Public viewer	N	N	N	V	V	V	N
NAWDEX member	N	N	N	V	V	IO,EO,V	N
			RESTRICTED DATA				
Data base administrator	SAME	SAME	SAME	SAME	SAME	N/A	N/A
Project chief	SAME	SAME	SAME	V,CW	V,CW	N/A	N/A
Project worker	SAME	SAME	SAME	SAME	SAME	N/A	N/A
Data reviewer	SAME	SAME	SAME	SAME	SAME	N/A	N/A
Project viewer	SAME	SAME	SAME	SAME	SAME	N/A	N/A
In-review viewer	SAME	SAME	SAME	N	N	N/A	N/A
Public viewer	SAME	SAME	SAME	N	N	N/A	N/A
NAWDEX member	SAME	SAME	SAME	N	N	N/A	N/A

3.2.4.1 Notification of Change in Status of Data

The DBA, data reviewers, project chiefs, and project workers will be responsible for moving data from one status to another. Depending on the change of status, the DBA or data reviewers, or project chiefs and project workers should be notified of the change of status. Thus, a project reviewer should be notified when the status of data changes from **working** to **in-review**, so that the reviewer may begin reviewing the data.

Requirement 3.2.4.1-1 Provide notification of change in data status

Users in various data-user categories shall be notified when a change of data status occurs. The various notifications are shown in Table 5.

Table 5-- Notifications to users of change in data status

[X, notification provided; -- , no notification provided]

Data-user category	Type of change in data status: Working to in-review	In-review to working	In-review to approved	Approved to working
Data-base administrator	--	--	X	X
Project chief	X	X	X	X
Project worker	X	X	X	X
Data reviewer	X	X	--	X
Project viewer	X	X	X	X
In-review viewer	--	X	X	X

3.2.4.2 Assignment of Data-User Categories

A data-user category will be assigned to a user by the NWIS-II system administrator, the data-base administrator, or the project chief. The NWIS-II system administrator will be able to assign the category of **data base administrator** with those access rights shown in Table 6 to the appropriate users. The DBA shall be able to assign any of the categories shown in Table 6 to appropriate local-node users. The project chief shall be able to assign **project worker, project viewer,** and **in-review viewer** categories to users associated with a project. By default, NWIS-II users will be assigned the category of **public viewer.**

Requirement 3.2.4.2-1 Provide the authority to assign data-user categories to users

The NWIS-II system administrator, the data base administrator, and the project chief shall have the authority to assign a category to a user, as shown in Table 6:

Table 6-- Assignments of data-user categories

[Y, has authority to assign the indicated data-user category to users; --, no authority provided]

User with authority to assign category	Data-user category: DBA	Project chief	Project worker	Data reviewer	Project viewer	In-review viewer	Public viewer	NAWDEX viewer
NWIS-II system administrator	Y	--	--	--	--	--	--	--
Data base administrator	--	Y	Y	Y	Y	Y	Y	Y
Project chief	--	--	Y	--	Y	Y	--	--

Requirement 3.2.4.2-2 Provide the DBA with the ability to assign public-viewer category to users by default

By default, users will have public-viewer access rights to a project's data. The DBA or project chief may override the default assignment and assign a user different access rights for a specified project(s).

3.3 Software Access

User access to software that interacts with the NWIS-II data base is controlled by the users' data-user category. This functionality will prevent accidental user access and possible editing of data via the software. Types of software access are **view, edit, input**, and **no access**. For example, a user with **view** access to a project will only be able to use software functions that view data (retrieval and output).

Requirement 3.3-1 Establish user's software access

User access to a software function shall be determined by a user's currently selected project and data-access category.

Requirement 3.3-2 Provide menu access

User access to menus and menu items shall be controlled by a user's access to the functions listed on the menu.

3.4 Access-Violation Tracking

Access-violation tracking consists of monitoring NWIS-II for unauthorized attempts to access data or software programs by users who do not have appropriate access rights (section 9.2.3, Data-Processing Histories).

Requirement 3.4-1 Determine access violations

Access violations are attempts to access data or software programs by users who do not have the appropriate access rights.

Requirement 3.4-2 Provide access-violation tracking

Unauthorized attempts to access data or software programs shall be logged, and the DBA and the project chief shall be notified.

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4. Input and Edit

J.D. Christman, L.E. Trotta, S.J. Cauller, and S.E. Hammond

Input functionality describes the means by which data will be entered into NWIS-II. All data will initially interact with the input process; therefore, input functionality must be both flexible and robust. It will communicate transparently with a variety of field data collection and storage instrumentation, here categorized by data transfer and transmission methods. Communication among files is an inherent part of a relational data base, as values can be imported from one file to another (or entered to a selected set of records). Keyboard, scanned-image, and digitizer input will also be supported. To provide flexibility, the process of input must be linked to the functionality of editing. Data often require manipulation to remove anomalies, errors, or false recordings. Editing on input allows a user the versatility to correct data values before they are stored in the data base (see sect ion 5. Data Verification).

An interface to a geographic information system (GIS) will facilitate the input and editing of site locations and associated attribute data. NWIS-II will support both character and graphical input and editing of data values and geographic locations. The ability to edit several parameters at the same time of the same or different disciplines will be inherent.

Discussion of the input and edit functions is divided into seven sections, which include: preprocessing of instrumentation data, index data, input formats, text input, input of scanned information, input forms, and graphical input and editing. Most of these sections involve keyboard entry to some degree. Three of the sections (preprocessing of instrumentation data, index data, and input formats) involve file-transfer entry. The input-of-scanned-information section involves scanned-image entry. Two of the sections (preprocessing of instrumentation data, and graphical input and editing) involve digitizer entry.

Requirement 4.-1 Provide the ability to enter data with a computer keyboard

Keyboard entry, with or without the assistance of a pointing device, shall be supported.

Requirement 4.-2 Provide the ability to fill in a data element with a constant value

The ability to enter a data value to a data element for each selected set of records shall be provided.

4.1 Data Collected by Automated Field Instrumentation

Hydrologic field data that are electronically or mechanically sensed and digitally recorded by various data loggers or telemetry devices must be preprocessed into a NWIS-II readable format. Users will have the ability to enter programming scripts to perform this transformation. Figure 9 shows the steps in preprocessing: 1) retrieving the time-series data from the data-transport media; 2) reading and decoding electronic data; 3) transforming instrumentation values to engineering units; and 4) transferral of values and times to a WRD standard format. The diagramming technique uses box icons to represent processing steps. The relationships between steps in the path are shown using the arrow notation. Data stores are shown as cylinders.

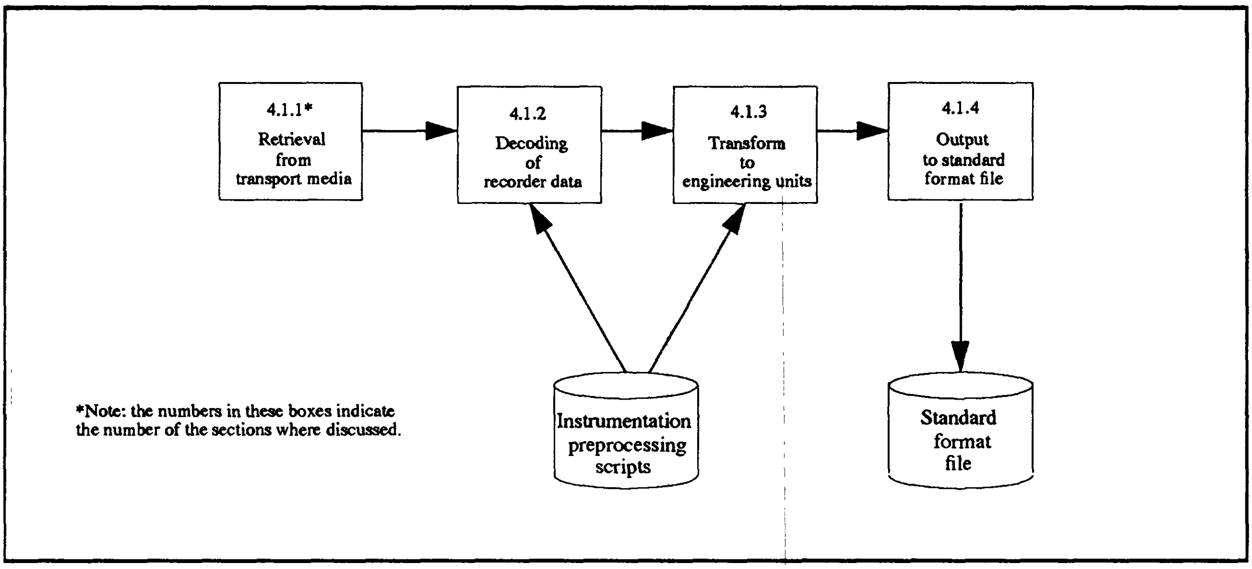

Figure 9. -- Steps involved in preprocessing of instrumentation data.

4.1.1 Retrieval from Data-storage Media

The retrieval of time series data from field storage media depends upon the transmission method used. Typically, NWIS-II will communicate with equipment that is brought to the site and receives or reads data from field storage units. Remote monitoring may be conducted with automatic data recorders, electronic data loggers, analog recorders, portable field computers, satellite-relayed data, or telephone-relayed data.

Requirement 4.1.1-1 Provide data prioritization for multiple input devices at a site

The ability to prioritize the data received from multiple instruments collecting the same types of data at a site shall be provided. Auxiliary data shall not be allowed to overwrite primary data in such a prioritized setup.

4.1.1.1 Analog-to-digital Recorders

The analog-to-digital recorder (ADR) stores data on a paper punch tape and has the capability of recording values in predefined intervals ranging from 1 minute to more than 1 hour, depending on the timer cam obtained and used. The ADR can record more than one type of data from different sensors. The digital values from the ADR are transmitted to the NWIS-II processing program through a communications program via an RS-232 interface.

Input and Edit

Requirement 4.1.1.1-1 Provide the ability to input ADR translation Information

The capability shall be provided to enter intermediate calibration/time checks that include tape time and actual watch time recorded manually during station visits. The following translation information shall be entered by the hydrographer for the processing of an ADR paper tape:

- Site number
- Instrument identification
- Starting tape date and time
- Ending tape date and time
- Starting watch date and time
- Ending watch date and time
- Intermediate clock date and time (tape and watch) checks
- Time zone and use of daylight savings time
- Comments

Requirement 4.1.1.1-2 Provide the ability to read records generated by paper-tape readers

The Mitron and Enviro-lab (or similar) paper tape readers shall be used to read the punches on an ADR paper tape and translate each punch into a digital computer readable four-digit numeric value. Depending upon the manufacturer and model of the paper tape reader, different commands are needed to control the tape reader and communicate with NWIS-II.

Requirement 4.1.1.1-3 Provide the ability to assign a date and time to each paper-tape value

Each value shall be assigned a date and time based upon the starting tape time and the ADR recording interval.

Requirement 4.1.1.1-4 Provide the ability to edit original ADR data

Automatic data recorders sometimes skip a punch or double punch because of instrument malfunction or punch a non-readable number. Therefore, editing of the ADR values is necessary. The edit function is very important for multichannel recorders because a missed or extra punch will cause the data channels to become misaligned. However, all editing will be done on a copy of the original, and the original data will be set aside for archiving. The following editing processes are needed for punching and translation errors:

- Display of recorded values (for multi-channel tapes each channel will be a column of values)
- Scanning multichannel tapes to alert users of possible misaligned values
- Addition of null values to signify missed punches
- Deletion of doubled-punched values

4.1.1.2 Electronic Data Loggers

Electronic data loggers (EDL) receive data via electronic sensors and store these data internally or on some magnetic media, such as magnetic tape or storage module. The data are transported back to the office via magnetic tape, storage module, or portable field computer. The EDL has the ability to read data on more than one channel.

Requirement 4.1.1.2-1 Provide the ability to input EDL translation information

The following translation information shall be entered by the hydrographer for the processing of an EDL record:

- Site number
- Instrument identification
- Starting record date and time
- Ending record date and time
- Starting watch date and time
- Ending watch date and time
- Intermediate date and time checks
- Time zone and use of daylight savings time
- Comments

Requirement 4.1.1.2-2 Provide the ability to read records generated from magnetic tape or storage module

Data will be read from the magnetic media by a tape drive or storage module reader and translated into digital computer readable values. The digital values are transmitted to the processing program through a communications program via an RS-232 interface.

Requirement 4.1.1.2-3 Provide the ability to assign a date and time to each EDL record value

Each value shall be assigned a date and time based upon the starting time and recording interval of the EDL record.

Requirement 4.1.1.2-4 Provide the ability to edit a copy of the original EDL data

A copy of the original EDL data shall be made available for editing when necessary based on interpretative inspection.

4.1.1.3 Portable Field Computers

Portable field computers (PFC) will be used to program data collection platforms (DCP) and EDL's in the field. Users will have the ability to enter and edit EDL and DCP programming scripts.

Requirement 4.1.1.3-1 Provide the ability to transfer data from PFC's to NWIS-II

Portable field computers will be used to interrogate DCP's and EDL's, download data from EDL's, and transport data to the office. Data will be uploaded from the PFC's into NWIS-II. The data will then be treated as an EDL record and processed as described in section 4.1.1.2, Electronic Data Loggers.

4.1.1.4 Analog Recorders

Analog recorders continuously record data on graph paper. Included are such data as gage heights, water levels in wells, and turbidity. Data recorded on these charts are read by the use of a digitizer and transmitted to the

computer processor through a communications program via an RS-232 interface. The ability to read this digitized information and enter the translated data into NWIS-II will be provided. Analog recorders may be one of several types:

- Strip chart recorder
- Bristol chart recorder
- Drum chart recorder

Requirement 4.1.1.4-1 Provide the ability to translate data from analog recorders to NWIS-II

The ability to translate the output from a digitized representation of a graphic chart and enter the translated data into NWIS-II shall be provided.

Requirement 4.1.1.4-2 Provide the ability to accept manually digitized data

The ability to enter data from an electronic digitizer in either point or stream mode to a standard file format identifiable as to its data content shall be provided. All digitizers used in NWIS-I shall be supported, including CALCOMP, ALTEK, and GTCO.

4.1.1.5 Satellite Relayed Data

Data are collected by a DCP and transmitted to the office via a radio signal that is relayed via one of several geo-orbiting earth satellites (GOES). Data may be transmitted immediately (random alert) or stored and transmitted on a set schedule.

4.1.1.5.1 Direct Read-Out Sites

Office sites that have a Direct Read-Out Terminal (DROT) will receive satellite-relayed data from the Local Read-Out Ground Station (LRGS) via an RS-232 interface. Figure 10 is a user-concept diagram constructed as a high-level overview, and shows the path of satellite data-relay communications and inputs to NWIS-II. The diagramming technique uses computer and box icons to represent input sources and output destinations. The relationships between steps in the communication path are shown using the arrow notation. Message types are shown as ovals, data bases are shown as cylinders, and networks are shown as clouds. Major communication functions are numbered to indicate sequence. Names used on the diagram are defined in the glossary and may be further explained in the remainder of this section.

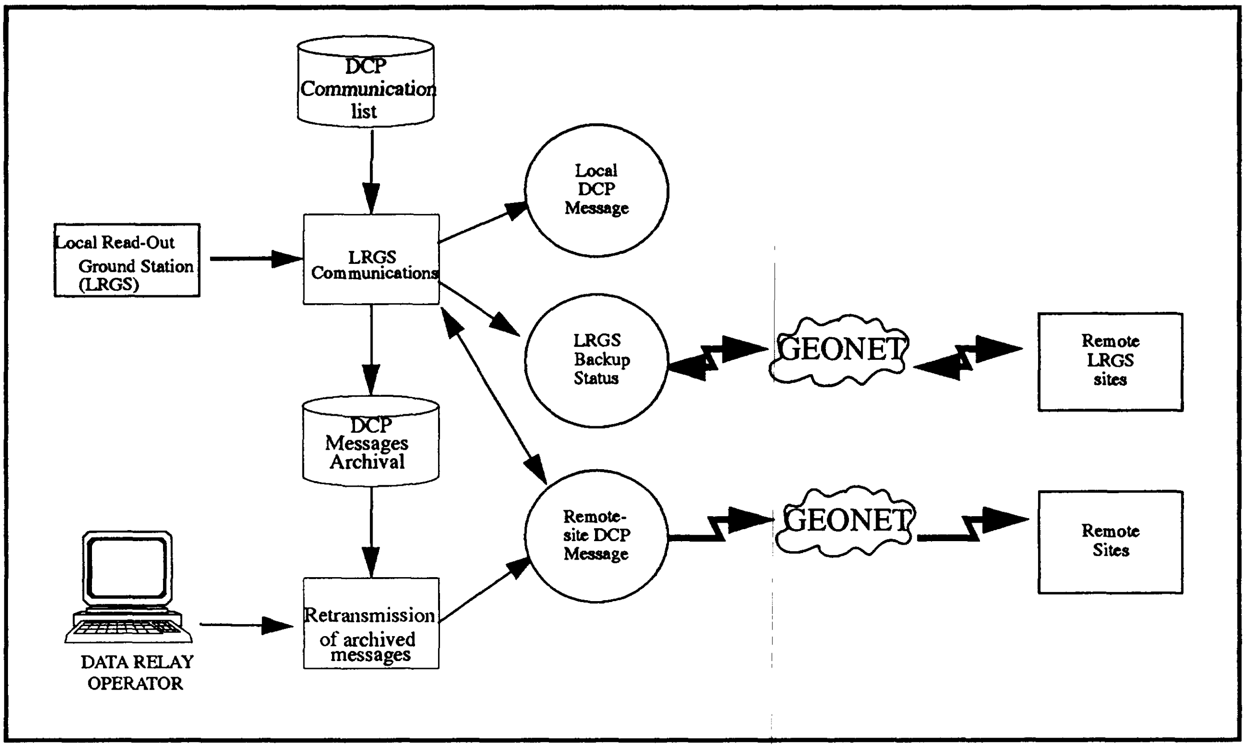

Figure 10. -- Diagram of satellite data-relay communications and inputs to NWIS-II from a Local Read-Out Ground Station site.

4.1.1.5.1.1 Communicate with Local Read-Out Sites

To be able to send commands and receive DCP transmissions, NWIS-II will need two-way communication with the LRGS. This communication will probably be over an RS-232 data line.

Requirement 4.1.1.5.1.1-1 Provide the ability to send LRGS commands

The system shall be able to send commands to the LRGS to enable or disable transmission of DCP messages to NWIS-II and to execute any other commands that are necessary to manage the LRGS.

Requirement 4.1.1.5.1.1-2 Provide the ability to receive DCP transmissions

The system shall be able to receive DCP transmissions from the LRGS via an RS232 interface.

4.1.1.5.1.2 Relay to Remote Sites

USGS sites with an LRGS will not only receive DCP transmissions for their node but may also provide DCP transmissions for other nodes. These sites will have software to manage the reception and transmission of these remote node's DCP messages.

Requirement 4.1.1.5.1.2-1 Provide the ability to relay DCP transmissions

Sites with LRGSs shall have the ability to receive DCP messages from the LRGS and relay the DCP messages through the GEONET to other nodes.

4.1.1.5.1.3 Backup of Other Direct Read-Out Sites

LRGS sites within the WRD will provide automated backup services for each other. In the event of one LRGS site not working, a designated backup site will receive the others DCP transmissions and relay them over GEONET to the appropriate nodes.

Requirement 4.1.1.5.1.3-1 Send backup status messages to other LRGS's

A LRGS site shall be able to send status messages about the health of the LRGS and data relay system to other designated LRGS sites that are providing backup coverage for the site.

Requirement 4.1.1.5.1.3-2 Receive backup status messages from other LRGS's

A LRGS site shall be able to receive status messages about the health of one or more LRGS sites that it is backing-up.

Requirement 4.1.1.5.1.3-3 Initiate backup transmission of DCP messages

A LRGS site that has not received a status message, within a specified time period, from one of its other LRGS sites that it is backing-up, shall initiate transmission of DCP messages normally handled by the LRGS site being backed-up.

4.1.1.5.1.4 Retransmission of DCP messages

A LRGS site will have the need, at times, to retransmit DCP messages through GEONET to specified nodes. This is important because sometimes remote site's computer equipment or software or GEONET itself malfunctions and DCP messages do not arrive at the specified location.

Requirement 4.1.1.5.1.4-1 Provide the ability for an interactive user retransmission request

The manager of the LRGS site shall have the ability to specify certain DCP messages to be retransmitted over GEONET to the appropriate nodes. The manager shall be able to specify 1) the DCP messages by range of dates and times and by DCP ID, 2) all DCP messages for one or more nodes, or 3) all DCP messages. The selected DCP messages shall be sent automatically, through GEONET, to the nodes specified.

Requirement 4.1.1.5.1.4-2 Provide the ability for a remote site network retransmission request

Remote nodes shall have the ability to request retransmission of DCP messages through GEONET. They can specify 1) the DCP messages by range of dates and times and by DCP ID, or 2) all DCP messages for their node. The selected DCP messages shall be sent automatically, through GEONET, to the node.

4.1.1.5.2 Nondirect Read-Out Sites

Office sites that do not have an LRGS will receive satellite-relayed data from other LRGS's via the DIS-II network. Figure 11 shows a diagram of the progression of data relayed from a satellite through a non-LRGS network. The diagramming technique uses box icons to represent input sources and output destinations. The relationships between steps in the communication path are shown using the arrow notation. Message types are shown as ovals, data bases are shown as cylinders, and networks are shown as clouds.

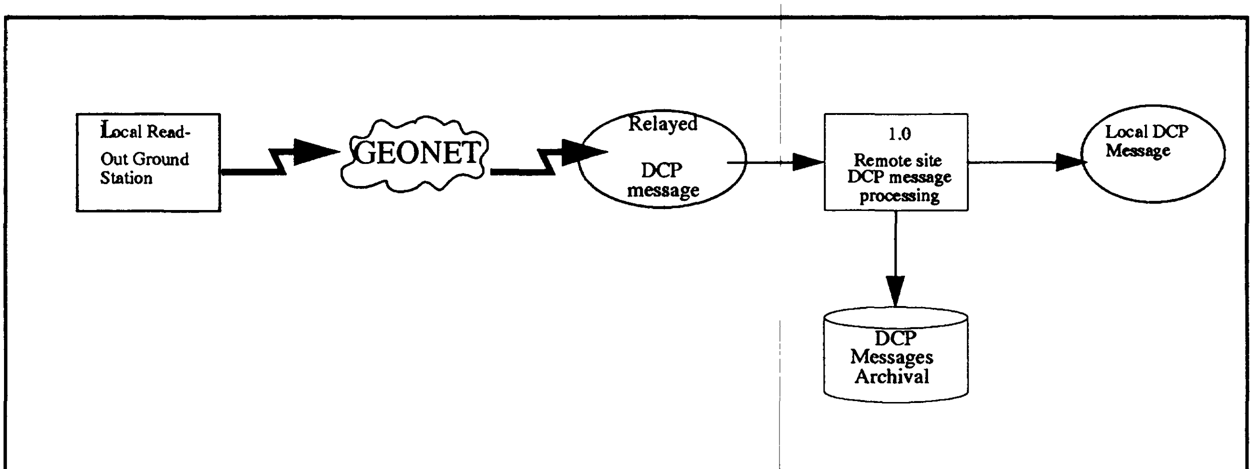

Figure 11. -- Diagram of a remote (Non-Local Read-Out Ground Station) site's reception and handling of satellite-relayed data.

Requirement 4.1.1.5.2-1 Provide the ability to scan DCP transmissions

The non-LRGS site shall regularly scan for new DCP transmission that have arrived over the DIS-II network. This scanning shall be at a local site-specified time interval and will be automatic.

Requirement 4.1.1.5.2-2 Store local DCP transmissions

Each DCP transmission received shall be stored in a temporary on-line storage area and shall be deleted after a site-specified time interval.

Requirement 4.1.1.5.2-3 Provide additional processing of DCP transmissions

All DCP transmissions received locally shall be automatically passed on to NWIS-II for additional instrumentation preprocessing and data computations.

4.1.1.6 Telephone Relayed Data

Data collected by an EDL is transmitted to the office over telephone lines.

Requirement 4.1.1.6-1 Provide the ability to receive automatic transmissions from electronic data loggers

The system shall have the ability to receive automatic transmissions of recorded field data from electronic data loggers over telephone lines.

Requirement 4.1.1.6-2 Provide the ability to connect to an EDL over a telephone line

Users shall have the ability to dial-up different EDL's, automatically or manually, and extract recorded field data.

Requirement 4.1.1.6-3 Provide automatic processing of phone relayed data

All phone-relayed data received locally shall be automatically passed on to NWIS-II for additional instrumentation preprocessing and data computations.

4.1.1.7 Radio Transmission of Data

Requirement 4.1.1.7-1 Provide the ability to receive EDL transmissions via radio frequencies

NWIS-II shall have the ability to receive recorded field data from EDL's downloaded from a radio receiver.

Requirement 4.1.1.7-2 Provide automatic processing of radio transmitted data

All radio-transmitted data received locally shall be automatically passed on to the NWIS-II for additional instrumentation preprocessing and data computations.

4.1.2 Reading and Decoding Data

Data collected by field data recorders is stored in a variety of formats. Recorders do not contain the needed information to decode the data for use by NWIS-II. For EDL's and DCP's, decoding information wil be in the DECODES (DEvice COnversion and DElivery System) instrumentation configuration files. Essentially, the functionality of DECODES in NWIS-II will be similar to its functionality in NWIS-I, to maintain backward compatibility. However, NWIS-II also will provide verification checks that will perform logic tests of the relationship between data items.

Data base information needed to decode field recorder data is listed in Table 177, Table 178, Table 179 and Table 180 in Appendix C. Information needed to transform data will be stored with instrument decoding information.

The input data for DECODES consists of data from: 1) field-recorders, 2) data-collection-platforms, and 3) other selected input sources.

Requirement 4.1.2-1 Transfer decoded-recorded field data into NWIS-II usable format

Processing of recorded field data shall consist of reading the input data of the recorder by using site- and instrument-specific decoding information supplied from the data base.

Requirement 4.1.2-2 Provide the ability to convert decoded data to UTC time standard

All data entered shall have the recorder assigned times (including daylight savings time) converted to Universal Time Coordinate (UTC), if necessary. Conversion will be based upon time and time zone information read (or keyed in from the keyboard) into DECODES, along with the data file. The UTC time standard shall be able to store time data in units as small as 0.01 of a second.

Requirement 4.1.2-3 Translate Decoded Data Into Numeric Values in an ASCII format

Instrumentation data are stored in many different formats including ASCII, binary, and pseudo-binary. All instrumentation data shall be converted into numeric values in an ASCII format.

4.1.3 Transforming Instrumentation Data to Engineering Units

As with all user input, instrumentation data may be entered in units other than standard NWIS-II storage units. Conversion to engineering units will take place within NWIS-II transparent to users.

Requirement 4.1.3-1 Transformation of decoded data to engineering units

If the recorded values are not in engineering units they shall be transformed automatically to engineering units.

Requirement 4.1.3-2 Provide transparent unit conversion

The transformation of data values to engineering units shall be transparent to users.

4.1.4 Transferring Instrument Data After Preprocessing

Instrumentation data will not be stored for use in the NWIS-II data base until the working copy has been pre-processed and verified. After preprocessing, the data will be restructured into NWIS-II "standard format". These data will be used in further data processing and computations.

Requirement 4.1.4-1 Transfer preprocessed data into NWIS-II standard format

The station and constituent identification information, time, and data value shall be transferred from data preprocessing into NWIS-II standard format. The form of the NWIS-II standard data format shall remain as close as possible to the NWIS-I standard data format to provide backward compatibility.

Requirement 4.1.4-2 Disallow editing of standard input file

No editing of the original data records shall be allowed (see Table 4).

4.1.5 Remote Data Collection and Processing

Remote data collection and processing involves a system phantom that runs continuously receiving and processing data 24 hours a day, 7 days a week. It has three input processes: satellite-relayed input, line-of-sight radio-relayed input, and telephone dial-up relayed input. These processes feed data into a decoding process that reads the particular format of the transmitting instrument, decodes the data into engineering units, and writes the data out to a standard NWIS-II format (see section 4.1). A fourth process reads the data from the standard formatted file and performs the indicated processing and computations on the data, then stores the data in the NWIS-II data base. These processes are diagrammed below (Figure 12). The diagramming technique uses box icons to represent input sources and output destinations. The relationships between steps in the path are shown using the arrow notation. Computations are shown as ovals, and data bases are shown as cylinders.

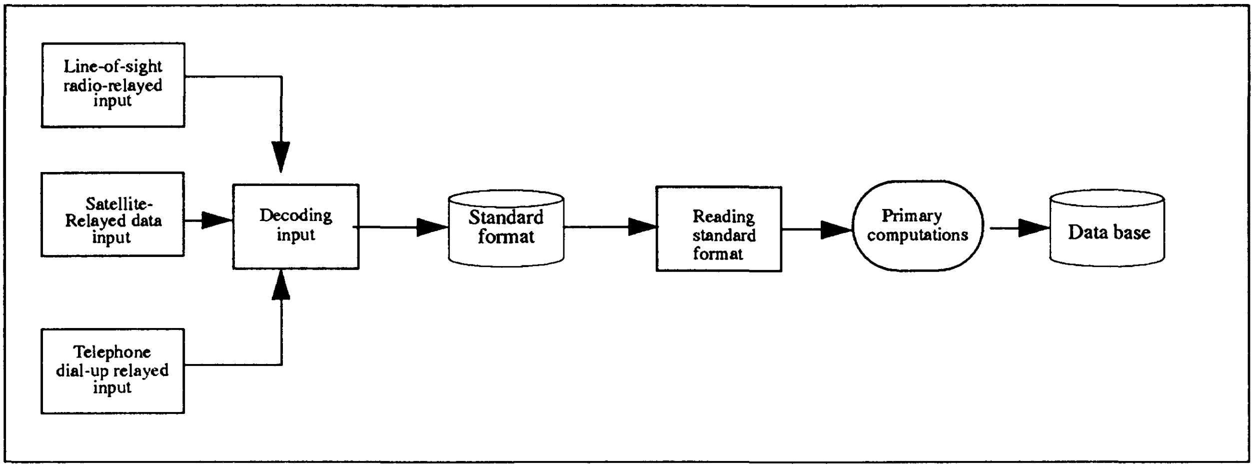

Figure 12. -- Automated data collection and processing navigation path.

4.2 Index Data

Data indexes are used to locate information stored in the NWIS-II data base as well as other USGS and non-USGS data bases. The data that are input to these indexes are not the data values that are stored as the result of data collection or data computation of values for a site. Index data describe the type of information available for the water-data site. Requirements listed in this section apply to index data only. The Master Water Data Index and the Water Data Sources Directory are two indexes within the NWIS-II data base in which information will be regularly input.

4.2.1 Master Water Data Index

Data input to the Master Water Data Index (MWDI) will enter NWIS-II in three ways. 1) Data will be indexed as a part of the process for inputting new data values to the NWIS-II data base. Once the input data are verified, indexed information will enter the MWDI. The actual data values also will enter the data base and be stored appropriately. [***NOTE: Any data values flagged as 'restricted' will not be indexed.] 2) High-volume data transfer from non-USGS sources, primarily STORET, will be input to NWIS-II via magnetic tape. The data received by NWIS-II on tape will be formatted in the standard NAWDEX input format. Non-USGS data sources must be provided with the necessary format and algorithms to prepare the data for transfer, and online help sensitive to this need will be provided (see Requirement 1.3.2-1). 3) Low-volume data input by non-USGS sources will be input to NWIS-II via computer keyboard. The data will be input through the use of on-screen prompts, interactively or as a batch job. Input forms will help format the data in the standard NAWDEX input format. Figure 13 shows how data may be input to NWIS-II for entry to the MWDI. All index data are verified upon input.

High- and low-volume input data received from non-USGS sources will include all of the constituent(s) that were sampled at that water-data site. Many non-USGS constituent's names and agency codes do not correspond to the USGS identifiers. Non-USGS constituent's names and agency codes must be translated into the NWIS-II standards (the previous name will become an alias). Each of these constituents and agencies must be verified upon input. Necessary modifications will be made on a copy of the other agency's data. Non-USGS agencies are released from responsibility for the data upon USGS modification for any purpose.

Edits and deletions of information in the water-data index are considered an input function within NWIS-II. Once information for a water-data site has been entered to the NWIS-II data base, some users will have the ability to access it for modification (see section 3.2). If a modification is necessary, the information associated with the water-data site of interest is displayed on the screen. The user can then make modifications to the appropriate data fields. If any information is modified it must be reverified for input to the data base.

Requirement 4.2.1-1 Provide the ability to input water-related index data

NWIS-II shall provide a data index (Master Water Data Index) to help users determine the existence, accessibility, and location of water data and associated information. The MWDI shall include water data and water-related data for USGS and non-USGS sources of information.

One subset of the MWDI shall be the Non-USGS Water Data Index (NWDI). The NWDI shall be established and exist as a primary source at headquarters. The other subset of the MWDI shall be the Local Water Data Index (LWDI). The LWDI shall be established and exist as a primary source at the District node where the original data values are stored. Each district may have an LWDI.

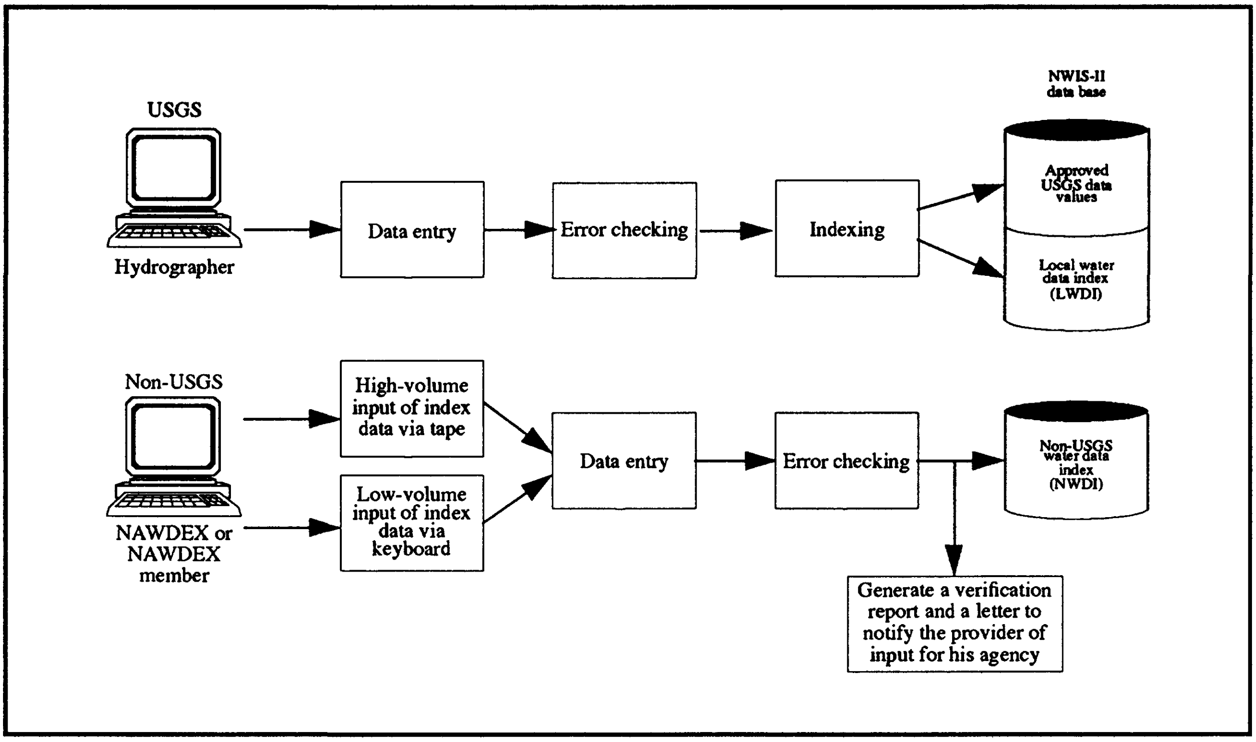

Figure 13. -- Data flow diagram for the input of USGS and non-USGS data to the water data index.

Requirement 4.2.1-2 Convert non-USGS constituent identifiers and agency codes prior to entry to MWDI

NWIS-II shall automatically convert all non-USGS constituent identifiers to identifiers in the USGS's constituent identification system prior to input to the MWDI. The NAWDEX agency codes used to identify organizations or agencies that are sources of water data shall continue to be used in NWIS-II as a reference list.

Requirement 4.2.1-3 Provide the ability to modify entries in the non-USGS water-data index

A user with the appropriate protection level of data-base access shall have the ability to modify data in the non-USGS water-data index. Non-USGS data that have been modified shall be flagged or marked to indicate this.

4.2.2 Water Data Sources Directory

The Water Data Sources Directory will store identifying information on the sources of incoming sets of water-related data. Index information for the Water Data Sources Directory will be input to NWIS-II via computer keyboard. The data will be input through the use of on-screen prompts, interactively or as a batch job. Input forms will help format the data for input. All index data are verified upon input.

Requirement 4.2.2-1 Provide the ability to input the source of water data and water-related data to an index

NWIS-II shall provide a data index (Water Data Sources Directory) to help direct users to the appropriate sources for questions regarding water data and water-related data.

Requirement 4.2.2-2 Provide the ability to modify entries in the Water Data Sources Directory

A user with the appropriate protection level of data-base access shall have the ability to modify data in the Water Data Sources Directory.

4.3 Input Formats

NWIS-II will provide several data-input formats to facilitate data entry into the NWIS-II data base from a variety of sources. In addition to supporting several default formats, a conversion [routine] will be available to reformat structured ASCII-delimited or fixed-format data files to NWIS-II standard data format. This functionality, together with online help (see Content), will provide users with a convenient mechanism to import data of varying formats from both WRD and non-WRD sources.

Provisions will be made for entering data from a cooperating agency on an ongoing basis. The cooperating agency may send:

- a complete tape of all their data that implies a total replacement of all existing data
- a tape of new sites and data that would not change existing data
- a tape of updates to existing data where some existing sites or data may need adding, changing, or deleting
- any combination of the above

Requirement 4.3-1 Provide the ability to import data stored in standard formats

Several standard formats of data storage exist within the WRD, are being developed within the WRD, or have been developed by outside agencies who exchange data in these formats with the WRD. NWIS-II shall provide a mechanism to import data stored in these standard formats. These formats include but are not limited to:

- NWIS-II standard format - this format is identical to NWIS-I standard data format and will provide backward compatibility.
- WRD laboratory format - applies to data sent through the Laboratory Information Management System (LIMS), including analytical and sample management data from the National Water Quality Laboratory and USGS sediment laboratories.
- EFN/PFC format - includes data entered onto input forms on an electronic field notebook (EFN) or personal field computer (PFC) and subsequently transferred to the DIS-II computer network.
- WATSTORE format - applies to data stored in WATSTORE card-image format.
- STORET format - applies to data obtained from the U.S. Environmental Protection Agency's STORET data base.

- NWDI format - will be used to enter data to the non-USGS water data index (NWDI) from non-USGS sources.
- WDSD format - will be used to enter data to the Water Data Sources Directory (WDSD).
- Data Interchange Format (DIF) - pertains to data stored in an electronic spreadsheet. Numerous commercial spreadsheet packages, including LOTUS 1-2-3, S20/20 and TACTICIAN, provide the ability to convert a spreadsheet data file into a DIF file to allow data exchange with other software packages.

Requirement 4.3-2 Provide the ability to import structured ASCII-delimited files

NWIS-II shall provide the ability to import data stored in a structured (i.e., fixed-format) ASCII-delimited file into NWIS-II. This would provide users with a mechanism to enter important hydrologic data presently stored in a non-supported format that have been collected by State, County, or other local governmental agencies.

4.4 Text Input

Text or descriptive data in NWIS-II are defined as character strings, paragraphs and manuscripts. Users will be able to enter distinct types of text. These include but are not limited to: annual data report headings, instrument facility descriptions, and analyses of instrument facilities.

Requirement 4.4-1 Provide the ability to enter text manually

The selection of manual entry shall invoke a word processing program. Text formatting functionality and templates for specific types of text formats, such as station analysis and station descriptions, shall be available.

4.4.1 User Comment File

A popup note file for storing user comments will be available throughout various processes in NWIS-II. The date, time, and user name will be tagged to each comment entered. Entries can be indexed and categorized by a menu selection.

Requirement 4.4.1-1 Provide the ability to update a user comment file

A user shall have the ability to input textual information into a popup comment file during the processing of data, and edit that information. Each entry in the file will be tagged with the time, date, and user name. Entries can be indexed by selections such as, but not limited to:

- equipment
- gage-height record
- datum and gage-height corrections
- rating and shifts
- discharge records
- quality assurance and control
- reviewers that approved data for release
- remarks and accuracy

Requirement 4.4.1-2 Provide a logbook of commentary information about project data

The data base will provide users the ability to store comments about a site event, a sampling event, subsample or measurement, the logic used in record computation, reviewer's comments, or remarks that may include when and how water-use information was obtained. Consequently, project personnel can retrieve a log of commentary information to complement other reports used in quality control of project data.

4.4.2 Annual Data Report Headings

Headings in annual reports are printed at the top of the data tables. The headings contain much of the same information that is in the station description and station analysis files but are shortened and in a standardized format for the annual data report. As much as possible, the Annual Data Report Headings (and other documents) will build themselves from data stored in the data base. After user modification, the final heading will then be stored independently as a text document. A user could request the complete output (text plus table) for a given station or a given water year or series of water years. This output would be the same as the appropriate page in the annual report (see Manuscript Preparation, section 7.1).

Requirement 4.4.2-1 Provide the ability to enter headings of annual data reports

Annual data report headings shall be entered and stored in NWIS-II.

4.4.3 Instrumentation Facility Description

An instrumentation facility is a configuration of data collection and associated instrumentations (e.g., gaging station, water-quality sampling site, recorder well). The instrumentation facility description contains information describing the location, measurement points, sampling or instrumentation history, and other pertinent information. This description may be of USGS instrumentation, as associated with a surface-water facility, or of non-USGS instrumentation, as associated with a water-use facility. Information about an instrumentation facility may be enhanced or modified during the facility's life. The facility description may be linked to a scanned image of a map or sketch to complete the description.

Requirement 4.4.3-1 Provide the ability to enter instrumentation facility descriptions

Instrumentation facility descriptions shall be entered and stored in NWIS-II. Each station description will be associated with a given facility and date of preparation. In the surface-water discipline, surface-water stations are established to measure stream discharge. Other disciplines can also utilize these facility descriptions, in which case the descriptions may pertain to other types of measurements.

4.4.4 Analysis of Instrumentation Facility

An analysis of a surface-water instrumentation facility typically includes: information on the procedures used in record computation, information on data collection and sampling conditions throughout the year, a synopsis of techniques used, and an equipment inventory. The analysis is generally prepared at the time the final records are

completed for publication; however, notes and textual information are generated throughout the year. Also see Requirement 4.6.1-1.

Requirement 4.4.4-1 Provide ability to enter instrumentation facility analyses

Instrumentation facility analyses shall be entered and stored in NWIS-II.

Requirement 4.4.4-2 Display of historical information associated with instrumentation facility analysis

Historical information associated with analysis of an instrumentation facility, such as processing histories, comments, or past water year station analysis, will be available for display during the input and edit of a current analysis.

4.5 Input of Scanned Information

NWIS-II will provide an interface to DIS-II scanning hardware and software. Users will be able to electronically scan images or read barcodes and enter them into NWIS-II (provided they have access to the necessary hardware and software). Scanned images will be treated like site information, sample information, or any other data element associated with a site, subsite, or system of sites. Sketches and maps will be used, along with the station description information, to produce field notebooks for hydrographers assigned to work at a site or for up-to-date reference materials for hydrographers on a regular field run. Interdisciplinary retrieval of such sketches, based on general site location, may act as a pointer to other related information or as location verification. However, scanned images are not included in the spatial data for the sites. Again, depending on available scanning hardware and software, users will be able to scan a page of text and convert it to ASCII for input to NWIS-II. For example, the NWQL user will have the ability to electronically scan barcodes or textual information transferred to laboratory analyses sheets from sample bottles. When input into the NWIS-II, these data are subject to verification checks. Already-scanned information may be input, provided the user has obtained proper authority or copy rights.

Requirement 4.5-1 Provide the ability to input scanned images

Users shall be able to input and store images of scanned photographs, maps, and sketches in the NWIS-II data base.

Requirement 4.5-2 Provide the ability to read barcodes

Users shall be able to input the information contained in barcodes, provided the necessary hardware is available to read them.

Requirement 4.5-3 Provide the ability to input scanned textual information

Users shall be able to scan a page of text (such as a field form, a laboratory form, or a page of a book) and convert it to ASCII text, which can then be used as input to NWIS-II.

4.6 Input Forms

Input forms are screen entry forms that help facilitate efficient and accurate data entry or update. These forms are only one of several methods of inputting data discussed in the opening paragraphs of section 4. Input and Edit. In this method, users enter data by filling in blanks on the form displayed on the screen. These forms may be filled in by manual keyboard entry, pointing and clicking with a mouse, a combination of these two methods, or some other pointing device. These forms will act as a template for a consistent look. The relational data base will allow values that already exist to be retrieved to the video screen. During the input or edit operation, data will move only from the form on the video screen into the data base. Once the data are in the data base, it will not be possible to tell whether they came from a standard form, a customized form, or some other source.

Data entered into NWIS-II may require the use of several input forms that combine discrete groups of information. Forms may be combined in a hierarchical sequence or have "connectability." For example, the ground-water discipline will have several layers of input forms. An upper-level form is associated with the well site and lower-level forms are associated with various aspects of the well (e.g., geophysical logs, completion schedule, pump tests). Although input forms encompassing an entire feature (e.g., stream, aquifer) have not been listed in this section, an associated reference list will provide all attribute information needed to organize output by feature, if desired.

Requirement 4.6-1 Provide the ability to move data from a screen form to the data base

A generalized input processor shall interact with the relational data base to move data from any video screen form into the data base.

Requirement 4.6-2 Automatically fill in input form fields with retrieved or calculated values from the data base

NWIS-II will automatically fill in values for data entities associated with a field on an input form. To eliminate possible duplication of effort, a field will be automatically filled in when the value has been entered previously or when it can be calculated from stored data.

Requirement 4.6-3 Provide the ability to default an entry to the same field on repetitive forms

Users shall be able to instruct the system to enter values on subsequent forms of the same type with data values from the previous form. This automatically filled-in data shall be accepted or edited by users upon input. This is useful for routine or repetitive data entry. Repetitive entries of dates will be assisted with a click-on button, which allows consecutive dates to be advanced.

Requirement 4.6-4 Provide the ability to edit values in an input form field

Users shall have the ability to edit fields on an input form that contain data values that were automatically filled in from the data base or from a previous form.

Requirement 4.6-5 Provide the ability to enter data onto forms with abbreviations

Users shall have the ability to enter data with approved or official abbreviations. Once the abbreviation has been verified, the official or approved name will be inserted into that field. This input technique also shall apply to acronyms of project names.

Requirement 4.6-6 Provide the ability to specify the units for data input onto forms

Users shall be able to specify the unit for values input with a form. Standard unit conversions to the default storage unit will be made automatically by NWIS-II.

Requirement 4.6-7 Provide for the use of a default file of user-specified units

Users shall be able to define default units for all desired data elements. Units shall be stored in a user-defaults file, and the chosen units will be displayed on the input form.

4.6.1 Script Input Forms

A script is a set of instructions that describes the steps for processing data. This series of commands or prompts can be stored and reused. Scripts are utilized when a series of processes are repeated frequently in the same sequence. A script may include processing information that specifies how and in what order operations (including verification) on the data must be performed and establishes the algorithms and procedures needed to complete a task. Once the information for a specific process is entered, it will need to be changed only if the process changes. Although most scripts are designed to be utilized by users needing an application to be completed in a given sequence, scripts can be customized for specific applications. The function to create a script by entering a series of commands to a file will be available. For some functions, such as retrieval, a menu option will be available to start and stop a script that records the options a user specifies during an interactive session. Customized scripts also may be copied from a successful portion of the data-processing history(section 9.2.3, Data-Processing Histories). Many scripts will be shared by all users for processing of similar data. Some scripts will be restricted for use with particular projects.

A library of standard programming scripts will be maintained by NWIS-II. Those scripts that are system-defined to guide users through specific menus and processes are discussed in section 1.5, Navigation Paths.

Requirement 4.6.1-1 Provide the ability to create scripts

Users shall be able to create scripts for performing subfunctions in data processing, computations, and data verification, as well as other processes. Users can create scripts that specify the order for computation procedures, as well as the variables necessary for completion of the procedures. Although certain minimum standards will apply, users can also specify which scripts to apply to their data as part of the verification of the data (see 5., Data Verification).

4.6.2 Water Resources Division Standard Forms

WRD standard input forms represent a series of data that must be grouped and entered together. This section covers old paper forms that were completed in the field or laboratory as data were collected or analyzed. Standard forms also include forms proposed by user groups for inclusion in NWIS-II. Details about input forms are provided in Appendix C.

4.6.2.1 Interdisciplinary Input Forms

Global entry and edit forms may be used by more than one discipline. Requirements for specific forms are:.

Requirement 4.6.2.1-1 Provide a site information form for geographic attributes

Users who do not have access to a GIS and/or the thematic maps require the ability to manually key-in NWIS-II site geographic attributes utilizing a predefined input form. These attributes could include but are not limited to State, county, hydrologic unit names, elevation, and aquifer type.

Requirement 4.6.2.1-2 Provide a data protection initialization and update form

This form is designed for use by the data base administrator to assign protection levels to users. (See section 3. Data Protection).

Requirement 4.6.2.1-3 Provide a verification checks form

Users shall be able to build verification procedures for such checks as remote instrument monitoring, hydrologic event notification, alert limit, instrument calibration, or equipment inspection and maintenance.

Requirement 4.6.2.1-4 Provide a sample events form

Users shall be able to describe conditions surrounding a sample event, as well as the time, place, purpose of the event, method or equipment used, and I.D. of the sampler.

Requirement 4.6.2.1-5 Provide a daily and unit values form

Users shall be able to enter and edit daily and unit values in the system by a form entry and edit function. The form will allow flagging of unit values as follows: 1) estimated, 2) greater than, and 3) less than.

Requirement 4.6.2.1-6 Provide a site remarks form

Miscellaneous information, in the form of textual notes, can be entered into NWIS-II. Notes are usually helpful in analyzing stage and discharge records, and for documenting results in the station analysis.

Requirement 4.6.2.1-7 Provide instrumentation data forms

Users shall have the ability to enter and update information needed to preprocess data from different field recording instruments. This information shall be used to: read and decode various data types and formats,

assign dates and times (if needed), convert data to engineering units, and assign to the data the proper parameter identifications used by NWIS-II. Instrumentation data forms include:

1. Site-device information form--associates a device configuration with a specific site and contains the site-specific information needed to convert the decoded data into a usable standard format for the system.

2. Site-specific sensor information form--contains information identifying the data for each sensor of the specified recording device at the site. Each sensor on the specified device will have an entry containing all information on the list.

3. Recording-device identification information form--used to identify specific characteristics about a specific model of recording device.

4. Device-recording configuration information form--used to read and decode the device formatted data into a NWIS-II usable format.

5. Device-recording-sensor configuration information form--used to identify and output the sensor data into a NWIS-II usable format. This information is duplicated for each sensor in a recording device.

4.6.2.2 Discipline-Specific Input Forms

The discipline-specific forms requested by the user groups are listed in this section. Unless otherwise specified, all tables mentioned in this section are found in Appendix C.

Requirement 4.6.2.2-1 Provide ground-water data-input forms

Ground-water data-input forms are used to enter location, facility (well construction), aquifer, and water-level information. A characteristic of well-site description data is that these data are periodically revised and/or updated. Documentation of the meaning of some field entries is found in the Glossary. Input of ground-water data will be done in a full screen environment that mimics the look of field input forms. See Appendix C for details. Users can request descriptive text for selected fields. An electronic glossary defining input terms will accompany the input forms. Electronic notebooks are expected to be used when ground-water data are input in the field. Besides the general categories of forms listed in the first sentence of this paragraph, ground-water data-input forms include but are not limited to:

1. Well lift information--describes such items as capacity and power source of the mechanism for bringing water to the surface.

2. Well registration information--used to record such items as local permit numbers and inspection status.

3. Spring, pit, pond, and tunnel site information--contains information about the individual features.

4. Ground-water discharge or recharge measurements, hydraulic properties, and logs of underground formations--contains information about the individual subjects.

Requirement 4.6.2.2-2 Provide biological data-input forms

Biological data-input forms information include but are not necessarily limited to the following:

1. Project information form--incorporates fields to enter and update information that identifies and describes various aspects of a project(s).

2. Site information form--used to input and update information about a site for where data are collected.

3. Sample characteristics form--provides information about the purpose, medium, identity, size, and weight of the sample, as well as the type of sample: routine, duplicate, replicate, spiked, etc.

4. Sample collection, preparation, and preservation form--provides information about the time, location, method, equipment, personnel involved, and feature (or source) of the sample that was collected, prepared, or preserved.

5. Taxonomic-identity information form--provides information about the taxonomic name, location, equipment used for identity, preparation and preservation, and conditions used to identify organisms.

6. Nontaxonomic-identity information form--provides information about the nontaxonomic name, location, equipment used for identity, preparation and preservation, and conditions used to identify organisms.

7. Measurement and analysis information form--provides information about analytical data, physical measurements, observational data and time-series data. Input of this information will be prompted by the system based on the computation and the method. See Computations (section 6.3.10) for details.

8. Ecological information form--provides information about interrelationships between species and their environment.

Requirement 4.6.2.2-3 Provide surface-water data-input forms

Standard surface-water hydrology forms will include discharge-measurement notes, station-level notes, crest-stage gage-inspection notes, and miscellaneous field notes. Surface-water data-input forms include but are not necessarily limited to the following:

1. Discharge-measurement notes form--includes summary information from discharge-measurement notes to be entered, edited. and stored in the system.

2. Discharge-meter spin test form--lists results of current meter spin tests.

3. Discharge-measurement gage heights form--contains gage-height readings during a discharge measurement.

4. Station-level notes form--includes summary information from periodic level notes made during surveys of a gaging stations to be entered, edited, and stored in the system.

5. Crest-stage gage notes form--contains information related to crest-stage gage inspection notes to be entered, edited, and stored in the system.

6. Stream cross-section form--contains points to define a stream cross-section

7. Miscellaneous field notes form--contains information regarding the gaging station, stream, control conditions, and other general items to be entered, edited, and stored in the system.

8. Basin-characteristics form--used for specific characteristics of a basin located above a water-data site.

Requirement 4.6.2.2-4 Provide climatic data-input forms

Information associated with the sampling of climatic data variables shall be entered, edited, and stored in the system. Climatic data-input forms include but are not necessarily limited to the following:

1. A general climatic information form--used to input data about a site established to measure aspects of the earth/atmosphere interface.

2. Temperature and pressure form--used to record temperature and atmospheric pressure at a data-collection site.

3. Wind events form--used to record wind velocities and direction at a site.

4. Solar radiation form--used to record solar radiation values at a site.

5. Precipitation-related events form--used to record precipitation values at a site.

6. Humidity, evaporation, and soil moisture form--used to record climatic variables.

7. Snow course and snow survey form--used to record results of snow surveys in a basin.

Requirement 4.6.2.2-5 Provide sediment data-input forms

Information associated with the sampling of sediment shall be entered, edited, and stored in the system. This information will be used in various sediment data-processing operations within and outside of NWIS-II. Excerpts of the sediment-sampling field notes may be forwarded to the sediment laboratory, along with the sediment samples submitted for analysis. Sediment data-input forms include but are not necessarily limited to the following:

1. A general information form--used to input data about a site associated with the collection of sediment samples. Information about the sediment samples themselves, as well as results from lab analyses, shall be entered on other input forms.

2. The suspended-sediment sample-information form--describes, in detail, how a given suspended-sediment sample was collected.

3. Bed-material sample information form--describes, in detail, how a given bed-material sample was collected. Particle-count data will be entered on an additional input form.

4. Bed-material/particle-count field-information form--describes how a particle count was conducted and the field data associated with the particles sampled.

5. Bedload-sample information form--describes, in detail, how a given bedload measurement was conducted and how bedload samples were collected.

6. Sediment-chemistry information form--describes filter size and composition. This form may be appended to any standard water-chemistry input form.

7. Concentration coefficients form--used to adjust the concentrations on a suspended-sediment curve.

8. Sediment transport curve data form--used to manually enter data to build a sediment transport curve. Each value used to define the curve can have up to 10 associated attributes. These attributes are used to describe the transport conditions and special circumstances.

9. Total sediment sample information form--used for all information about sediment samples.

10. Reservoir and lake survey information form--describes surface area and tracks bottom-sediment buildup.

Requirement 4.6.2.2-6 Provide water-quality data-input forms

Water-quality data-input forms include but are not necessarily limited to the following:

1. Water-quality monitor field notes form--used for field notes about servicing of a water-quality monitor.

2. Sample-management information form--used to record necessary information for processing the sample.

3. Electronic analytical service request (EASR) form-- This form will be designed for use in the field or at NWQL. Schedules requested on the form will be checked for validity. Sample priority and special requests may be noted on this form. Once the EASR form is completed, a list of required bottles for the requested schedules, bottle labels, and lab-codes is produced.

4. District rerun request form--used to request a reanalysis of a water-quality sample.

5. Water-quality field data form--used to record field results from either ground- or surface-water sources.

6. Additional forms--may be used to describe a water-quality-analysis event as defined by the NWQL.

Requirement 4.6.2.2-7 Provide water-use data-input forms

Water-use data-input forms include but are not necessarily limited to the following:

1. Water-user general information form--used to describe event-point location, type of use, source, destination, conveyance, site-permit, measurement, and links to other data. Entry of the type of use shall invoke any additional form associated with that use. Entries in the key component of "measurement method' shall invoke a detailed extension to the form, if appropriate, to identify aspects of the method. A "Facility" box, when invoked, shall bring up the associated form for facility information.

2. Facility information form--used to describe the facility type, permit, owner, facility location, sites owned, water rights, and links to other data. Entry of the facility type shall invoke any additional form associated with the major water use (for example, water-supply-facility delivery areas, or power-generation information).

3. Permit information form--used to describe the details of the permit issued to the site or facility to which it applies.

4. Road-log water-use form--minimal facility information is extracted from the facility form to create this form for describing facility owner, location, type of use, and size estimation. This road-log form is for use in expanding the water-user inventory from literature searches or from moving-vehicle visual surveys, with subsequent water-use estimation through the coefficient method. This road-log form is suitable for storage in an "electronic notebook." The notebook can contain needed coefficients for calculations "on the fly."

5. Power--plant information form--used to describe facilities that produce electric power (Guidelines for Preparation of State Water-Use Estimates, Solley and others, written commun., 1990, pages 52-68). Entry of power-plant type may invoke an additional form for details specific to that type.

6. Conveyance information form--used to describe the conveyance of water between points. However, if a sales point and a destination point are known due to input from another form, a default conveyance line is assigned between them using the GIS interface. Both the default line and lines established by the conveyance form can later be updated with intervening flow-measurement points (see Table 111) or graphical input.

7. Interbasin water-transfer information form--used to describe the spacial distribution of source and use points occurring in separate hydrologic units.

8. Irrigation practices and livestock-use rates form--used to record extended data on such site events.

9. Monthly and annual water-use flow-measurement information form--used to describe methods, equipment, rates, and accuracy of such site-specific monthly or annual data.

10. Water-supply information form--used to describe the connections, deliveries, internal uses and losses (Solley and others, written commun.,1990, p.16) of a public water-supply system. Entries of purchase and sale items may invoke separate forms.

11. Purchase information form--used to describe public-supply water purchased from a water company.

12. Sales information form--used to describe public-supply water sold to a water company .

13. Irrigation withdrawals, crops, and efficiency form--used to record information on such site events.

14. Waste-water-treatment information form--used to describe treatment and flow at a waste-water treatment plant (Solley and others, written commun., 1990, pages 86-88).

15. Reservoir-evaporation information form--used to record information on such site events.

16. Aggregated annual data form--used to describe annual summaries for each water-use category. Aggregation-area information may be input using a GIS, calculated from site-specific data, or loaded from a spreadsheet. Means to document methods and assess the data supplier will be included.

Requirement 4.6.2.2-8 Provide input forms associated with data indexes

NWIS-II shall provide simple, easy to understand input forms for the Master Water Data Index and the Water Data Sources Directory. Input forms for the indexes include but are not necessarily limited to the following:

1. Master Water Data Index input form--used to enter data-availability information. There are 11 major categories of data (listed below) for which data can be entered into the Master Water Data Index. The attributes associated with each of these categories are given in Appendix C (Tables 201-207).

Major categories of data for the Master Water Data Index

- site-identification information
- surface-water information
- ground-water information
- water-quality information
- biology information
- sediment information
- water-use information
- physical-analysis information
- data-collection networks
- data source and location
- meteorology information

2. Information used to catalog members of NAWDEX will be input using a Water Data Sources Directory input form. There are several categories of data (listed below) for which Water Data Sources Directory information are stored. The attributes associated with each of these categories are given in Appendix C (Tables 201-Table 209).

Major categories of data indexing for the Water Data Sources Directory

- organization
- office
- office counties
- organization-stored data
- counties where organization is located
- other source
- other-source comments
- liaison officials
- liaison States
- liaison non-US countries
- liaison comments
- total amount of data (MWDI data)
- counties with sites
- water-related data

4.6.3 Customized Input Forms

Customized input forms include both paper forms and computerized forms used to enter data. User-defined forms may cross multiple disciplines. The customized input form must contain data elements that are already part of the data base. Establishing new data elements in the data base requires a separate approval process. User-defined forms are useful in designing field and laboratory data sheets that are in a format suitable for data entry. Customized forms unused for more than 1 year will be deleted at the DBA's discretion, with specific policy determined at the District level.

Requirement 4.6.3-1 Provide the ability to edit an existing form

A project manager or system user needs to be able to change the standard NWIS-II data-input forms to delete unneeded data fields or add needed data fields not included on the standard input forms.

Requirement 4.6.3-2 Provide the ability to create a customized form

The project manager shall have the ability to produce new input forms to meet the project's special needs.

Requirement 4.6.3-3 Provide storage of a customized form

Customized or user-defined forms shall be stored in the system to be reused and shared by others. Forms will be kept in a specific area for use by more than one user, such as project input forms.

Requirement 4.6.3-4 A customized form will have an owner

Customized forms shall have levels of protection similar to those used for the NWIS-II data base. The ability to use a form may be restricted to a specific project.

Requirement 4.6.3-5 Provide a data-field addition-request form

A data-field addition-request form shall be provided to initiate the approval process for putting a new data field in NWIS-II.

4.7 Graphical Input and Editing

The graphical input and editing subfunction will provide users with a visual mechanism for data input, editing, and verification. Graphical techniques that formerly utilized graph paper and pencil will now be integrated within NWIS-II by using the graphic capabilities of a workstation along with a mouse, keyboard, and/or digitizer. Users will be able to enter and edit data graphically in a form that meets USGS standards. In addition to the graphical and tabular display of data, graphical input and editing incorporates features that include such functions as computations, verification, and output. These functions are discussed in other chapters of this document. They are also mentioned here to complete discussion of this function.

The common data types that require the ability to input and edit data graphically include: 1) continuous (time-series data), 2) discrete (fixed X-Y data), and 3) spatial (geographic) data. A large amount of the functionality in this subfunction is transferrable between data types; however, each of the data types also may have specific requirements. The difference between the operation of continuous and discrete data is so slight that they are discussed together. General requirements are listed below, before the discussion of the common data types.

Requirement 4.7-1 Provide the ability to input data graphically

Users shall have the ability to enter X-Y data graphically during an interactive session. A generic example of this would be the ability to add a data point to an X-Y plot (on the graphics screen) using the point and click functionality of a mouse.

Requirement 4.7-2 Provide the ability to edit data graphically

Users shall have the ability to interactively edit data graphically on the workstation screen.

Requirement 4.7-3 Provide specific screen format(s) for data input and editing

The edit and verify process features a split screen showing a tabular listing of values, a graphic plot of values, and options buttons for editing and verification (Appendix D). The options buttons may immediately execute a function, "pop up" a window, or pull down a menu.

Requirement 4.7-4 Provide the ability to save data entered and edited graphically

Users shall be able to save graphically entered or edited data. Users also will be able to save a correction history (a list of all corrections to the data set) and a curve construction (history and user notes about the graph and curve constructions).

4.7.1 Continuous and Discrete Data

Continuous or discrete data may be displayed for analysis by plotting the data. The data may be at evenly or unevenly spaced intervals. Input and editing of data values will be performed for only one data set at a time. However, multiple data sets can be overlaid on a single plot.

Requirement 4.7.1-1 Provide the ability to display continuous or discrete data in tabular format

The data input and editing function shall have the following tabular display features.

1. List data values:

   The tabular data display shall consist of a vertical listing of values (in the case of multiple curves only the current curve shall be displayed), one value per line, along with the date and time. Fifteen data values at a time are suggested in this listing; more can be included if space permits. The 15 data values will be referred to as one data set.

2. Input screen:

   A pull-down data-correction input screen (Appendix D), which will assist users in entering data or datum corrections, will be displayed. An editing screen for data or datum corrections is an option on the upper-level graphics screen.

3. Display of additional information:

   Users shall be able to display textual information, such as field notes. This information shall be retrieved through a scan-and-browse feature. The textual display window will 'pop up' only when data are accessed and disappear if the field is cleared of information.

4. Display previous screen:

   Users shall be able to display the previous set of values in the data set.

5. Display next screen:

   Users shall be able to display the next set of values in the data set.

6. Display first set of values:

   Users shall be able to display the values in the first data set.

7. Display last values:

   Users shall be able to display the values in the last data set.

8. Display a set of values adjacent to a specified date:

Users shall be able to go to a specific date within the file and display the data set of 15 values that follow that starting date.

Requirement 4.7.1-2 Provide the ability to display continuous or discrete data in graphical format

The data input and editing function shall have the following graphical display features.

1. Display data type:

The screen heading shall display the type of data (current curve) being edited and its units of measure. See Apendix D for examples.

2. Delimit data set:

The 15 values displayed in the tabular listing will be centered in the plot and marked by two vertical lines.

3. Automatic selection of axes scale:

- The values shall be plotted using an automatic scale selection, which uses the maximum and minimum values in the data set. At scale changes within a data set, a vertical line shall automatically show the break in scale. The vertical axis will be updated to show the new scale along with the old scale (see Appendix D).
- As an option, single auto-scaling of a series of screens may be selected.

4. Default axis scale:

Users shall be able to specify default scales to meet District, site-specific, or user-specific needs. For gage height data, the default scale shall be 1 inch = 1 foot (Y-axis), 2 inches per day (X-axis).

5. Multiple axes:

Users shall be able to overlay plots of data at different scales:

- Multiple axes shall be displayed.
- The ability to plot using normal-probability and Gumbel-probability scales on either the X or Y axis shall be provided. This ability is needed for input of sediment grain-size analysis, and editing/verification of other data types.

6. Change axis scale:

Users shall be able to change vertical and horizontal axis scales:

- for all data values through the use of multipliers;
- as the scale changes within a data set (sediment), the vertical axis showing the break in scale shall scroll along with the data. The fixed axis will be updated. For example, often sediment concentration changes dramatically at or near the onset of high-water discharges. To adequately illustrate the concentration values for multiple conditions, the vertical scale changes. See Appendix D for an example.

7. Multiple axis type:

Users shall have the option to plot a graph using logarithmic or linear scales on either the X- or Y-axis.

8. Horizontal and vertical scrolling:

Users shall have the ability to scroll the graph forward and backward in time (time-series data) and from low to high extremes. Users also shall be able to set the scrolling interval.

9. Plot miscellaneous data:

Users shall have the ability to plot miscellaneous data using symbols that are distinguishable from other symbols used in the plot.

10. Zoom in or out on a plot:

Users shall be able to zoom in on a plot to display the 15 values from the tabular listing or zoom out to display more values than are on the current graph.

11. Superimpose related data sets:

Users shall be able to select an option to superimpose multiple data sets on the graph. In combination with the multiple-axis requirement in item 7 above, this would allow time-series plots with time on the X-axis and several Y-axis parameters, such as flow and conductance.

12. Remove superimposed plot:

Users shall be able to select an option to remove a superimposed plot.

Requirement 4.7.1-3 Provide the ability to manipulate continuous or discrete data interactively

Users shall have the ability to manipulate data (e.g., mathematical computations or transformations) on a data set. The computations available will:

1. Transform values

   Users shall be able to transform a value or group of values (e.g., + or - constant, percentage, multiplier, log10, ln, draw a curve). The graph and tabular data displays shall then be updated. This function is very similar to adding a continuous data or datum correction. The difference is that the data or datum corrections are not constant.

2. Add values from different types of data

   Users shall be able to add data from two or more files (i.e., apply data or datum corrections). The graph and tabular data displays shall then be updated. Colors or shading shall show amount of adjustment and where applied.

3. Compute data or datum corrections

   Users shall be able to automatically apply corrections to a selected data set. The types of corrections to unit values of data include: 1) Constant -- constant value applied to all data, 2) Variable -- corrections based on relation defined by three or more points, 3) Percent -- correction based on percentage of observed value, 4) Time -- correction based on change in time, 5) Equation -- user-defined or standard equation, 6) Coefficient -- ratio based on input measurement-file data. Corrections may be applied individually or in combination using a variety of methods. The following adjustment methods shall be available for use in data corrections:

   - apply a constant correction to all data selected within a given time block
   - apply a constant correction based on the range of a given parameter (i.e., stage)
   - apply a variable correction based on relationship defined by three or more points
   - apply a variable correction based on percentage of observed value
   - apply a variable correction based on a user-defined or standard equation
   - apply a variable correction based on interpolation between points
   - apply a variable correction based on curve smoothing methods
   - apply a correction based on input values of an associated parameter(s)

Requirement 4.7.1-4 Provide the ability to verify continuous or discrete data graphically

Continuous or discrete data shall be verified graphically using the data input and editing subfunction. The elements of verification include:

1. Verifications tests

   Users shall be able to select an option to run verification tests on the select data set. For each threshold failure, the questionable value is centered and highlighted on the screen. The user may accept the value, edit the value and/or flag the value and then continue with verification checks. For further details on the verification process, see section 5.1.1, Alphanumeric Checks. Some verification techniques that apply from that section are duplicated here for continuity in the flow of the document. The verification tests shall include the following;

   - High rating-table threshold (highest point on current rating table)
   - Low rating-table threshold (lowest point on current rating table)
   - Parameter high and low limits (system-supplied range of possible values)
   - User-supplied high and low limits
   - Test difference between adjacent data values
   - Presence of "flat spots"
   - User-supplied shape and area thresholds for variance from a standard graph or image outline.
   - Test rate of change (data difference divided by time difference)

2. Plotting verification thresholds:

   High and low verification thresholds for the data set, shall be plotted on the graph as color-coded lines.

3. Change verification thresholds:

   Users shall be able to select an option to add or change verification threshold values.

4. Color-aided identification of threshold failures:

   Verification threshold failures shall be highlighted by using color-aided identification.

5. Plotting of maximum and minimum indicators:

   Maximum and minimum indicators of the data set shall be plotted on the graph.

6. Verification of computed data or datum correction:

   The computed datum correction shall be displayed to the user for verification before being applied to another data curve.

Requirement 4.7.1-5 Provide the ability to edit graphic or tabular data

The graphics function shall have the following editing abilities.

1. Replace a data value or groups of values:

   Users shall be able to replace data values. The new values are then plotted to update the graphical display.

2. Move (adjust) a data value:

Users shall be able to move data points on a graph. New points are then replotted to update the graphical display. (The tabular data display is also updated.)

3. Insert a new value:

Users shall be able to insert additional values via the tabularized or the graphical data display. Both data displays shall then be updated.

4. Delete a value:

Users shall be able to delete a selected value or group of values. The graph and tabular data displays shall then be updated.

5. Merge values:

Users shall be able to replace missing or erroneous values with values obtained from other data sets.

6. Flag values:

Users shall be able to mark data values with flags that correspond to various status types, data types, etc. A partial list of the available flags include:

- Estimated - value was estimated
- Interpolated - value was interpolated between known points
- Affected - value was affected, such as back-water conditions
- Erroneous - value was determined to be wrong and will not be used
- Questionable - Value may not be correct but will be used
- Missing - Expected value was not recorded and is considered missing

4.7.2 Site-Location and Attribute Information

The site-location input and editing function is a graphical process for the display, entry, verification, and editing of geographic information. Spatial data, such as site locations, will be input, verified, and maintained in NWIS-II by utilizing a geographic information system (GIS). A library of thematic map layers in GIS format will be available during the input and edit process to help orient users visually. The site type (e.g., surface water, ground water, water use, points, transects, areas, counties) of a newly entered site will be linked to context-sensitive thematic map layers. During the input process, geographic attributes of the new site from data layers that encompass it will be populated automatically. In addition, users shall have the ability to edit automatically derived geographic-attribute information. Some geographic attributes may invoke related input forms. Site-location information will be accessible by both NWIS-II and the GIS software.

Positional coordinates have an associated accuracy (i.e., plus or minus so many units). All positional coordinates (sites) shall have a qualifier that states their relative accuracy, which can be used to define the "zone of uncertainty" around sites for use in GIS analysis. This qualifier can be determined by the method used to obtain the site-locational coordinates.

Requirement 4.7.2-1 Provide the ability to input site locations in geographic space

Users shall have the ability to establish site locations spatially. Users will be required to enter the geographic location of the site to be established. This information can be entered in one of the following three ways (the first two utilizing a GIS and a standard library of thematic maps).

1. Establish site location from printed map on digitizer:

   Users shall use U.S. Geological Survey topographic quadrangle maps (available at a variety of scales, including 1:24000, 1:100000, or 1:250000) to establish site or feature locations. These quadrangle maps must be registered in geographic space using a digitizer (rectified aerial photos and other larger scale maps also may be used). Upon accurate registration, the screen would display a standard set of thematic maps to help orient users. Users would then be prompted to point to the exact location of the site or feature on the map registered on the digitizer. The site or feature could be a single point, a line, or an area.

2. Establish site location on a screen display with mouse:

   Users could display relevant thematic maps on the screen and point to the exact location on the screen of the site or feature being established by using the mouse or cursor. To allow exact positioning, it will be necessary to convert distances measured in the field to the map display scale (probably with a screen-calibration-system exhibit in a window).

3. Establish site location by input of x,y coordinates such as longitude and latitude, State plane, or township and range:

   Users shall enter the coordinates of the exact geographic locations of the site or feature to be established by using the keyboard or getting them from an ASCII file. The screen would then display these sites with relevant thematic maps in the background. This method provides an efficient mechanism to enter multiple sites.

Requirement 4.7.2-2 Provide the ability to input attribute information from GIS coverage data

The ability to place data associated with the Distributed Spatial Data Library (DSDL) site-location coverages into appropriate data elements shall be provided. For example, the area of a coverage polygon may be added, at the user's disgression, to the appropriate data element for county or reservoir area.

Requirement 4.7.2-3 Provide the ability to edit attribute information

Users shall have the ability to edit attribute information of a site location prior to storing the site within the NWIS-II data base. This includes the entry of additional information in a remark or comment field.

Requirement 4.7.2-4 Provide the ability to graphically edit site location(s)

Users shall have the ability to graphically edit site locations (on the screen) in registered geographic space. This ability is required when a more accurate site location is necessary. Editing functionality shall include the ability to:

1. Move a site:

   Users shall be able to move a site location by the procedures specified in Requirement 4.7.2-1. New attribute information may be obtained from context-sensitive thematic maps. The new location is redrawn to update the graphical display. The data base shall store both old (as an alias) and new locations. The old location is potentially important for historical purposes. When a site is moved, the time and cause of the site-moving shall be stored for system management purposes. When moving a well site, for example, decisions must be made as to whether the existing driller's log goes with the site.

2. Delete a site:

   Users shall be able to delete a selected site or group of sites.

Requirement 4.7.2-5 Provide the ability to qualify positional coordinates

Users shall have the ability to specify the relative accuracy of a site's location, stated in the units of the spatial data (i.e., feet, meters, miles), which will be stored as an attribute of the site. Where the method of obtaining the location does not sufficiently define the accuracy, this qualification shall be required of the user.

Requirement 4.7.2-6 Provide the ability to invoke input forms based on site proximity to features in a GIS coverage

Users shall be able to display distance between an input site and other GIS coverage features in close proximity. This distance computation shall be automatic in some cases, depending on the feature type. The site's proximity to a particular feature type may invoke input forms associated with that feature.

5. Data Verification

S.E. Hammond, W.R. Roddy, R.L. Moffatt, and J.D. Christman

The data-verification function is the group of processes that are invoked manually or automatically to help ensure the correctness of data in the NWIS-II data base. Data verification occurs as error checks and data review. Error checks are executed against data when initially input to the data base and after new data have been calculated and/or existing data have been manipulated in some manner within NWIS-II. Once data entry and data manipulation ends, another verification process occurs in the form of data review. Figure 14 shows when data verification occurs in NWIS-II. The rules, definitions, precision, and descriptive text associated with each verification (e.g., significant figures and precision rounding) will be outlined in the NWIS-II data dictionary.

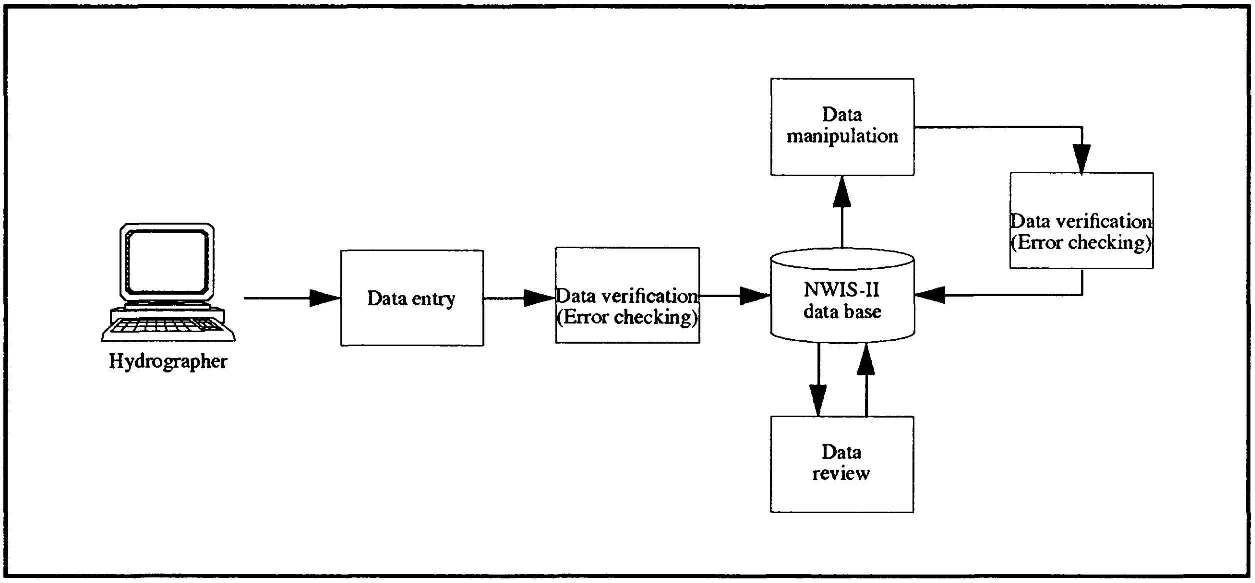

Figure 14. --Conceptual diagram for data verification within the National Water Information System II.

Verification checks fall into three categories: system-wide, user-defined, and hydrologic-event-notification. System-wide checks are standard to NWIS-II and executed on data throughout the network. User-defined verification checks are executed on specific data selected by users. These checks can be utilized to supplement system-wide verification checks or may be independent of other verification checks. Hydrologic-event-notification checks are used to check specific data for conditions that require immediate notification and/or some sort of action. For further discussion of hydrologic-event-notification, refer to Hydrologic Event Notification, section 8.3. Figure 15 illustrates the hierarchy of data-verification checks and conceivable acceptance criteria (limits).

The acceptance criteria that compose system-wide verification checks are preset elements that cannot be modified by users. These elements may be names on a reference list (e.g., geologic names) or analytical threshold values (e.g., range for pH). Data that fail these checks will be flagged as "not verified" in the data base until satisfying the conditions of the given system-wide check (the verification flag is removed). In some cases, users may be allowed to specify additional verification elements temporarily, pending an approval process. Data that are verified using a verification element, pending approval, are flagged "not verified, pending approval" until the verification request is approved or denied. If the element is approved, the acceptance criteria for the verification check is updated by

headquarters and the "not verified, pending approval" flag is removed from the data. If the element is not approved, the user who submitted the request is notified and the data are flagged "not approved, not pending approval."

User-defined verification checks generally will be associated with a District or project for specific users' needs. Once they are created, the checks can be stored and reused or deleted after use. There is a large difference between data that fail system-wide checks and those that fail user-defined checks. Data that fail a system-wide verification check are flagged as "not verified," will not "age" like verified data (see Data Aging, section 3.2.1), and will always have limited viewing access. Data that fail user-defined verification checks will continue to "age" in a normal fashion. The data can be flagged at the request of the user. User-defined verification checks can be executed independent of, or in conjunction with, system-wide verification checks. Although the criteria sometimes may be identical, user-defined checks generally will have acceptance criteria more limited than acceptance criteria for system-wide checks. However, user-defined verification checks cannot supersede a system-wide verification check.

Users can request that headquarters: 1) update an existing system-wide verification check with user-requested checks to further define criteria for entering data into the data base, or 2) create a new system-wide verification check from an independent user-requested check. In either case, a set of guidelines will be followed to create, or make additions to, system-wide verification checks. Users will be able to monitor the status of verification checks awaiting headquarters approval. The user submitting the request will be notified of its approval. [This check should include the actual verification checks requested as well as the name of the user who submitted the request. The list should be available to all users when the names are submitted to headquarters.]

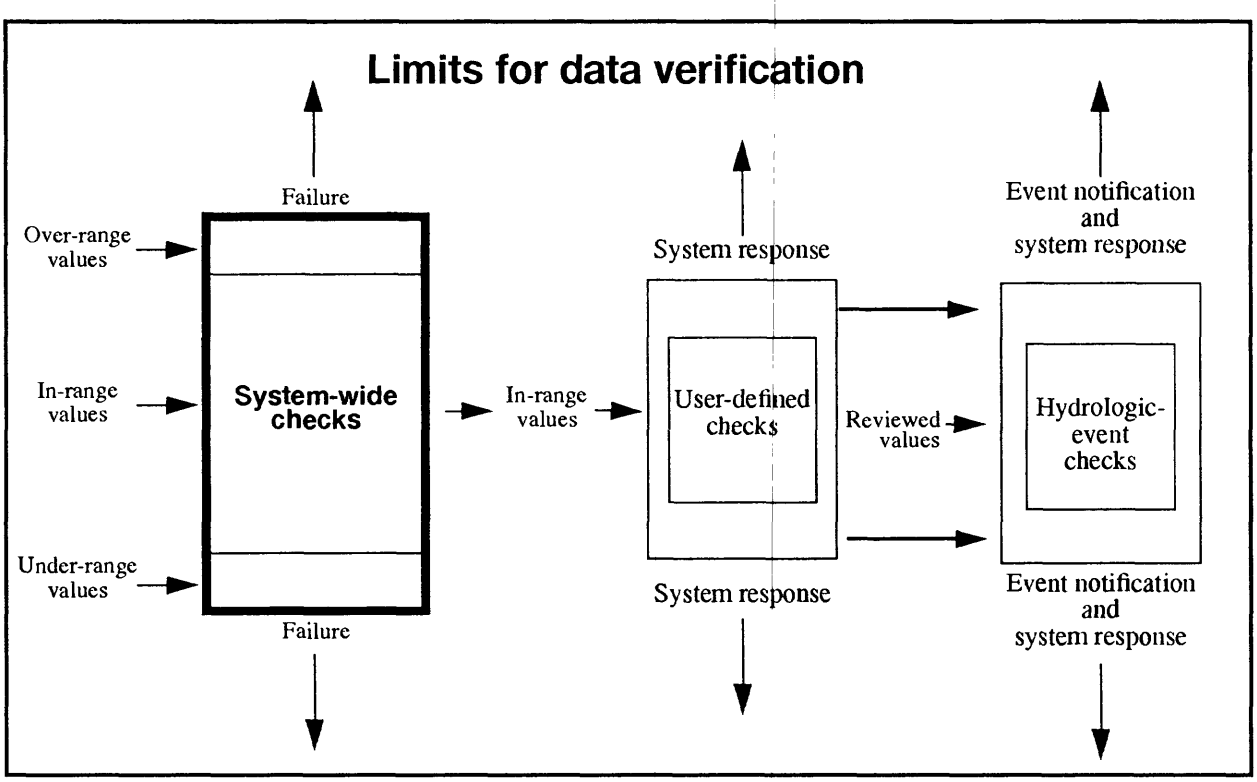

Figure 15. -- Conceptual diagram showing various categories of data-verification checks and their acceptance criteria.

Requirement 5-1 Provide system-wide verification checks

Some verification checks shall be executed system-wide to include all input data and data computed/manipulated within NWIS-II.

Requirement 5-2 Provide the ability to create user-defined verification checks

Users shall have the capability of creating verification checks to supplement system-wide checks. User-defined checks can be applied to a specific site or group of sites by selected time periods, hydrologic boundaries, or any other useful grouping of data elements. In the absence of user-defined checks, users could choose a default set of checks or no checks.

Requirement 5-3 Provide the ability to submit verification-update requests

Additions to the system-wide verification checks shall be automatically submitted to headquarters with a request to update a specific set of verification criteria. Users shall be able to submit user-defined verification checks to headquarters with a request for approval and for addition to the system-wide verification checks.

Requirement 5-4 Limit the authority to update verification checks to headquarters

The elements of system-wide verification checks shall be modified only by headquarters.

Requirement 5-5 Provide a list of verification requests

Users shall be able to generate a list of elements that have been submitted to headquarters as possible additions to verification checks.

Requirement 5-6 Provide the ability to notify user of approved verification requests

The requesting user shall be notified when a verification request is accepted or approved as an element for a system-wide verification check.

5.1 Error Checking

Error checking is the function of verifying data and information entered into the NWIS-II data base. It is performed interactively as an integral part of all manual or automatic data input, editing, and computation functions. Procedures for verification include simple "one-to-one" comparisons using alphanumeric, algorithm, reference list, visual, and geographic information system checks. Figure 16 shows the movement of data through the input-data verification process.

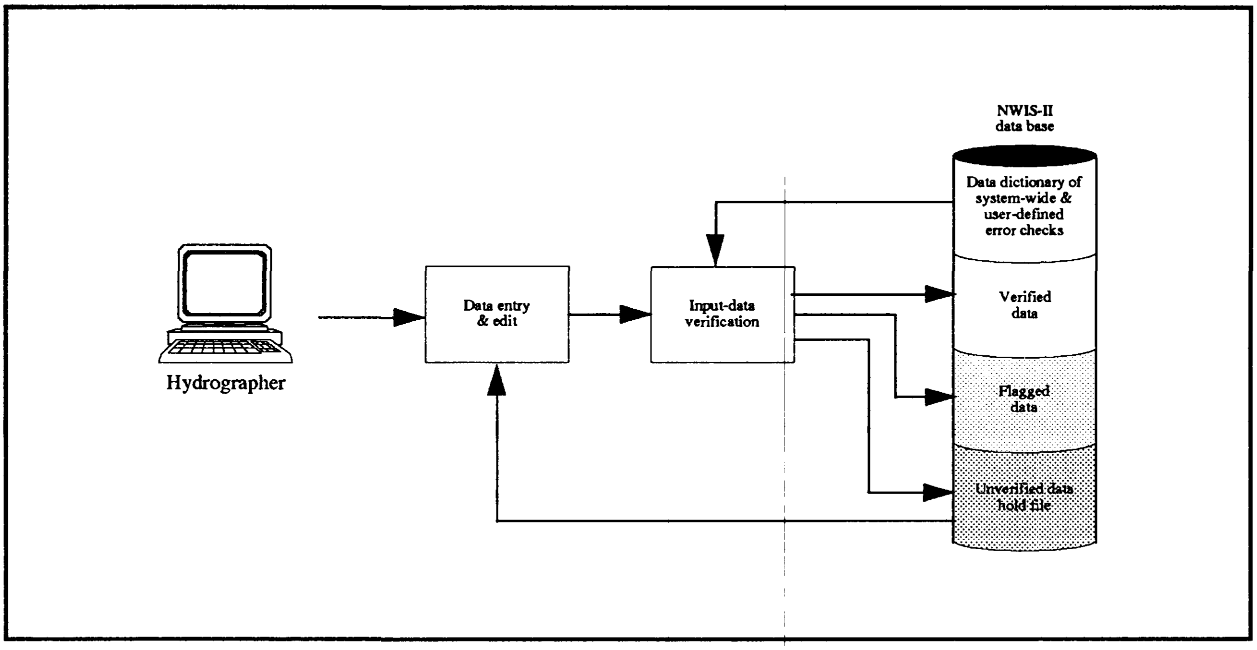

Figure 16. -- Data flow diagram for the input-data verification process.

Alpha-numeric checks are used to verify whether or not data fulfill specific data-format requirements. Algorithm checks utilize mathematical expression and statistical values (e.g., maximum and minimum) to verify the logic of data and to determine whether or not the data exceed a given threshold value(s). Reference lists are files used to verify such data as proper spelling, constituent types, biological Taxonomic Data Checks, section 5.1.3.2 and geological names Aquifer Nomenclature Checks, section 5.1.3.3, and aliases. Visual verification checks allow users to look at data or scanned images visually to consider correctness. GIS verification incorporates spatial information to verify the existence and location of field sites and also provides the capability to verify attributes associated with a site.

Verification occurs when two or more data values are compared. First, verification can be done by comparing each data value to ensure concurrence between data bases. Simple comparisons between a data base subset and the data base itself can be executed (e.g., if the main data base is updated frequently and the user wants to verify that the information being used is current). Second, verification can be done by comparing a single data value to a set of verification criteria (e.g., statistics) that describe the characteristics of a data base or its subset. A script that incorporates statistics and algorithmic relations is used to define the verification criteria. By executing the data comparison, users can assess similarities and differences between data bases. The quality of like types of new input data or existing data in other data bases can be assessed by comparing it with the calculated verification criteria. Comparisons can be based on subsets of data or all historical data can be reviewed.

Some data will fail error checks. Notification of verification failures to the users will be reported by immediate messages, by electronic mail, and by flagging data values with qualifiers. Depending on the mode of data entry (i.e., interactive or batch job), verification reports/summaries can be displayed on the screen or sent to a printer. They will provide a user with a preliminary indication of what transpired during the process and, if necessary, why the verification failed. If the failed data are new to NWIS-II: (1) the data may be rejected upon input and the user will be notified to correct or reenter the data immediately; (2) the data may be saved in a temporary hold file for

invalid data and (a) the user will be immediately notified of the failure, (b) data in the hold file will be edited, (c) when the data are verified as correct, the NWIS-II data base will be updated with the corrected data from the hold file, and (e) data in the hold file will be purged; or (3) the data may be saved in the NWIS-II data base and (a) the data will be flagged as failing verification, and (b) the user will be notified of verification failures when the input is completed. Verification failure notices will be "complete" or "brief."

A report will be generated by NWIS-II each time water-data index information is verified. This verification report will be a summary of the information input to the index for the water-data site. It will be generated whether the index data are verified or not verified. The verification report, along with a cover letter, will be sent by NAWDEX to the office that collected the data. If there are verification failures associated with the site, the failures will be noted in the report. If necessary, the provider of the information will be asked to review the information and provide an update. The cover letter and summary report sent to agencies that provide water data serves as more than a verification function. The letter also acknowledges the provider of the information and becomes a water-data index maintenance tool used to update information that already exists in the Water Data Sources Directory.

In some instances, duplicate data are collected at a site or an analysis is rerun. Although the value(s) are duplicates, each value also is a discrete data value that will be stored independent of other values. Each data value is verified and flagged accordingly. To eliminate any conflict as to which value is selected during retrieval, the data also are flagged to denote values, such as preferred, secondary, or tertiary.

Requirement 5.1-1 Provide the ability to handle error-check verification failures

NWIS-II shall have a protocol for handling error-check verification failures.

Requirement 5.1-2 Provide the ability to generate error-check verification reports

Users shall have the capability to request a diagnostic report describing the results of error checks for data submitted for verification.

Requirement 5.1-3 Provide a water-data-index verification report and cover letter to the agency that provided the data

NWIS-II shall provide a verfication report for the agency that provided the information about water-data sites. A cover letter accompanying the water-data-index verification report will acknowledge the receipt of the providing agency's information and include all information about the providing agency that is stored in the Water Data Sources Directory. The cover letter will request that the providing agency review the verification report and the information in the Water Data Sources Directory and return any warranted updates.

Requirement 5.1-4 Provide data flags for replicate, verified values

Replicate data values that are verified shall be flagged to denote values, such as preferred or secondary.

5.1.1 Alphanumeric Checks

Alphanumeric checks compare data with definitions in the data dictionary. Data are verified to ensure that the data value entered is the correct data type (e.g., fixed-width character, variable-width character, small integer,

real number). Character data also can be checked for valid characters in specified fields. Only valid numeric characters (. + - 0 1 2 3 4 5 6 7 8 9) will be allowed to occupy numeric-character fields. Likewise, only valid alphabetic characters (A-Z and a-z) will be allowed to occupy alphabetic-character fields. Grammatical characters, such as :, ", !, and special characters, such as %, &, #, <, >, @, can be specified as allowable in character fields, depending on the limitations imposed by the data base management system. Integer and real-number data will be checked for valid numeric characters. Numeric-data entries will be checked for an allowable number of significant figures, and only in-range values will be allowed.

Requirement 5.1.1-1 Reject a character entry that exceeds a specified length

The alphanumeric verification check will reject an entry that exceeds the length specified for the character field.

Requirement 5.1.1-2 Reject a character entry with invalid characters in the whole field or parts of the field

The alpha-numeric verification check will reject character values (numeric, alphabetic, grammatical, and/or special characters) that are not specified as allowable in the whole field or parts of a field.

Requirement 5.1.1-3 Reject non-numeric characters in a numeric field

The alpha-numeric verification check will reject values that are not numeric characters or user-specified characters, such as a decimal or a comma.

Requirement 5.1.1-4 Execute numeric checks on a numeric field

The alpha-numeric verification check will disallow entries with too many significant digits and/or entries that are out of the allowable range.

5.1.2 Algorithm Checks

Algorithm checks can utilize mathematical relations to verify data. These checks (some permanently stored, some temporarily stored) may be used to determine the validity of a data value using previously verified, stored data. Thus, a verification could be executed to determine if water-discharge values at a downstream site are greater than those for the same time period at an upstream site. Other checks might verify that the depth to water in a well does not exceed the depth of the well itself, while another check might verify that the milliequivalents of measured cations and anions of a water-quality sample are balanced.

Algorithm checks also can be simple threshold checks to verify whether a data value meets defined boundary conditions. Examples of threshold checks include:

- date
- time
- maximum value
- minimum value
- percent change in consecutive values
- rate of change
- QW constraint (e.g., pH)

Requirement 5.1.2-1 Provide the ability to verify data using mathematical relations

NWIS-II shall be capable of executing algorithm verification checks that incorporate mathematical relations.

Requirement 5.1.2-2 Provide the ability to verify data using threshold checks

NWIS-II shall be capable of executing algorithm-verification checks that incorporate threshold relations.

Requirement 5.1.2-3 Provide for system-wide and user-defined algorithms to verify data

Certain data-verification algorithms will be system-wide (approved by a designated authority) and maintained by the NWIS-II. Users also shall have the ability to create and store algorithms that they can use in the verification process.

5.1.2.1 Date And Time Checks

The verification of date and time fall into two categories. One category is the general date and time check. All discrete date and time data entered in NWIS-II will be checked for correctness. For example, dates must be logical; minute values cannot exceed 60, hourly values cannot exceed 24, and end dates cannot precede beginning dates.

The other date/time verification is used to verify and, if necessary, adjust time-series data collected with a field recorder. Beginning/end dates and times used in translating time-series data are verified. If there is a discrepancy between the number of data values recorded (data's end time) and the actual time when the data were removed from the recorder (watch time) the user is notified. If the two end times differ by more than 1 minute, the intermediate data can be automatically adjusted to reflect the expansion or compression of time increments to correct the discrepancy. However, this verification-of-time process does not involve time adjustments, so original data are stored unadjusted. The time-series data may or may not be at equal time increments after time adjustment is completed in a later process. Time corrections are applied by using the "standard time correction" as described in section 6.2.3, Time adjustments.

Requirement 5.1.2.1-1 Provide verification of all date and time data

An algorithm shall be used to verify the validity of dates and times entered into NWIS-II. Dates will not be allowed to exceed the present except for scheduling processes.

Requirement 5.1.2.1-2 Provide verification of field-recorder time-series data

Time-series data shall be verified in NWIS-II. Users shall be notified of time discrepancies.

5.1.3 Reference List Checks

Reference lists are online files composed of elements that identify data associated with different disciplines within WRD. Entry of certain data elements will be checked against a system list of acceptable values for that data element, and only items from that list will be allowed in the data base. Each list's elements are used to verify such data as names, technical terms, phrases, and pictures. This check can be executed interactively or as a batch

process. A variety of reference lists are part of NWIS-II and are used to verify data being input. Elements of the reference lists are listed in Appendix G. Reference lists include but are not limited to:

1) Site - A simple way to check whether or not a station exists would be to compare the new name or number to a list(s) of station ID's currently stored in the data base. Duplicates would be noted by the software and resolved by the user.

2) Dictionary (spelling) - A spell checker compares the entered name with all similarly spelled words. If there is no match, a list of elements from the reference list similar to the one entered are displayed as the closest match (e.g., user mistakenly enters Cipris and the software echoes back: 'Cipris: Cyprus, Cyprinus, and Cyprinidae'). The user then can select the correct match for substitution.

3) Scientific name of an organism- The U.S. Environmental Protection Agency (USEPA) and the National Oceanographic Data Center (NODC) have developed a taxonomic reference list. This EPA-NODC taxonomic reference list will be the primary list used to verify the correct identification and spelling of the scientific name of a biological organism and any taxonomic aliases (superseded names) of the scientific name. A WRD taxonomic reference list will be used to document WRD-identified species not listed on the EPA-NODC taxonomic reference list.

4) Geologic name - A geologic-names reference list will be used to verify the correct identification and spelling of a geologic unit name.

5) Aliases - Different names or numbering schemes are used by various agencies (and users). These other names are aliases for the USGS site-identification system. By having the ability to input a site by the standard USGS naming configuration as well as by an alias, the number of duplicated sites stored in NWIS-II would be kept to a minimum.

6) Constituent description system - Samples will be input, stored, and retrieved more efficiently with the proposed constituent description system. The description will replace the STORET parameter code and be maintained in a reference list. A user can have multiple samples collected at a site at the same time and easily verify if the samples were collected using similar criteria or methods.

7) Partial names

8) Common names

9) FIPS codes

Requirement 5.1.3-1 Provide the ability to verify data with reference lists

Input items for a specific data field shall be checked against an appropriate reference list. If the item is found on the reference list, it will be allowed into the data base. If the entered item is not found on the reference list, it will not be allowed in the data base and the user will be notified.

Requirement 5.1.3-2 Provide the ability to browse reference lists

Users shall have the ability to interactively inspect reference lists to search for selected items.

Requirement 5.1.3-3 Provide the ability to execute reference-list verification by batch operation

NWIS-II shall provide the capability to utilize a reference list(s) to verify data during a batch operation. Verification reports shall be provided to the user upon completion.

5.1.3.1 System-Wide Reference Lists

Some reference lists will be applicable for data verification throughout the NWIS-II network. These system-wide reference lists will not be modifiable by users at the district level. Modification of these lists will be a function of personnel located at headquarters.

Requirement 5.1.3.1-1 Provide system-wide reference lists

System-wide reference lists that have been identified and listed in Appendix G.

Requirement 5.1.3.1-2 Provide the ability to request updates to system-wide reference lists

Users shall be able to request that NWIS-II update existing items or add new items to system-wide reference lists. The request shall be automatically approved, if not rejected by an NWIS-II oversight committee in 30 working days.

Requirement 5.1.3.1-3 Provide the ability to modify and resubmit requests to update system-wide reference lists

If an oversight committee rejects a user's request to update a reference list, the user shall have the option to modify the update request and resubmit it or to delete the corresponding entries in the data base. A list of "not approved-not appending approval" entries can be generated for the user for such a purpose.

5.1.3.2 Taxonomic Data Checks

Taxonomic data verification is needed to correctly classify organisms and enter biological data into the NWIS-II data base. Users will utilize taxonomic reference lists to: (1) verify their initial classification of an organism with respect to the current classification and taxonomic aliases (synonyms or previous classifications) and (2) verify the taxonomic authority that originally classified an organism. An online EPA-NODC taxonomic reference list will contain the scientific name, taxonomic authority and date, common names, and taxonomic aliases approved by EPA-NODC taxonomic specialists. The common name and taxonomic aliases will be cross-referenced so that a user can verify or check the associated scientific name with the name that is input. An online WRD taxonomic list will contain taxonomic information for species that are not on the current EPA-NODC list but have been identified by WRD researchers. The logic of the taxonomic data-verification process is described below:

Data Verification

When the user enters the scientific name, it is checked against the EPA-NODC reference list. If the organism name is listed on the EPA-NODC reference list, the organism name is entered as **EPA-NODC-approved.** If the organism name is listed as a taxonomic alias on the EPA-NODC reference list, the system notifies the user that the name is a taxonomic alias and displays the corresponding EPA-NODC scientific name and taxonomic authority. The user then may choose to designate either the taxonomic alias or the EPA-NODC scientific name as the user-preferred name, and the data will be entered as **EPA-NODC-approved.** If an organism name is not listed as a scientific name or taxonomic alias on the EPA-NODC reference list, spell-checking diagnostics will list scientific names and aliases that are spelled similar to the entry, along with associated taxonomic authority and aliases (and scientific name, if a taxonomic alias). If one of the scientific names or aliases on the list is the correct spelling of the user's entry, the user could designate that name as user-preferred and enter the selection and corresponding data as **EPA-NODC-approved.**

If the user's organism name cannot be verified as a scientific name or taxonomic alias using the EPA-NODC reference list, the system will check the WRD taxonomic reference list in a similar series of steps. If the organism name cannot be verified using the WRD taxonomic reference list, the user may choose to enter the data and add the name and supporting information to the WRD taxonomic reference list. If the user wants to submit the organism name to EPA-NODC for approval, the data will be entered as **not EPA-NODC-approved, pending EPA-NODC approval.** If the user does not intend to submit the organism name for EPA-NODC approval, as in the case of an organism named "Tubificid Species A," the data will be entered as **not EPA-NODC-approved, not pending EPA-NODC approval.** In each case the user will enter the corresponding information about classification hierarchy (e.g., phylum, class, order, family).

When a user enters a new organism name to the WRD taxonomic reference list, the supporting taxonomic information also is added to the WRD taxonomic reference file. Those entries flagged **not EPA-NODC-approved, pending EPA-NODC approval** will be submitted to EPA-NODC via the headquarter's taxonomic administrator (EPA-NODC liaison person) to request that the names be officially recognized and subsequently added to the EPA-NODC reference list. This compilation should be checked for duplication (both the name and authority must be the same to constitute duplication), and entries should be combined when warranted. Once the organism name and classification have been EPA-NODC-approved, the appropriate entries in the data base will be reflagged as **EPA-NODC-approved** and associated EPA-NODC codes will be updated. In addition, corresponding entries in the WRD taxonomic list will be updated to **superseded by EPA-NODC.** Those entries flagged **not EPA-NODC-approved, not pending EPA-NODC approval** will be subject to the normal WRD approval process for requests to update a WRD reference list.

Once the organism's name is verified with the EPA-NODC reference list or the WRD taxonomic reference list, the verification of the taxonomic authority follows an analogous series of steps. Taxonomic authority entries may be flagged as **EPA-NODC-approved**; not **EPA-NODC-approved, not pending approval**; or **not EPA-NODC-approved, pending approval.**

Because the EPA-NODC list of scientific names is subject to updating, any data entered prior to an update of the reference list must be accessible under either the new scientific name or the originally entered scientific name. For example, the EPA-NODC scientific name of rainbow trout was updated from *Salmo gairdneri* to *Oncorhynchus mykiss* in 1988, and a user who entered data before that date may want to retrieve that data

using the originally entered scientific name, *Salmo gairdneri*. To provide this retrieval ability, the system will identify, i.e., flag, the originally entered scientific name.

Requirement 5.1.3.2-1 Provide verification of taxonomic data using the EPA-NODC taxonomic reference list and the WRD taxonomic reference list

Taxonomic names shall be verified by first cross-checking the EPA-NODC reference list of approved scientific names and aliases and then by cross-checking the WRD taxonomic reference list.

Requirement 5.1.3.2-2 Provide taxonomic reference lists

The taxonomic names and taxonomic authority lists shall be based primarily on the EPA-NODC reference list that includes aliases and common names. A WRD reference list will be provided for verification of names not listed on the EPA-NODC list. If a name is not on either list, the user may add the name and supporting data to the WRD taxonomic list.

Requirement 5.1.3.2-3 Provide the ability to enter scientific names under an alias

Users shall have the ability to enter previously published or historical data under the original classification. These data, if non-USGS, will be flagged as such.

Requirement 5.1.3.2-4 Provide the ability to identify the originally entered scientific name

NWIS-II will identify the originally entered scientific name. The name will be flagged in the data base, so that users may retrieve data under that name, even if the name has become a taxonomic alias because of updates to the EPA-NODC reference list.

Requirement 5.1.3.2-5 Provide the ability to request updates to the EPA-NODC reference list

Entries of organism names added to the WRD taxonomic reference list can be flagged as **pending EPA-NODC approval**. After review by a WRD oversight committee, these entries will be submitted to EPA-NODC for approval.

5.1.3.3 Aquifer Nomenclature Checks

Hydrogeologic units and geologic units verification checks are needed to help the geohydrologist correctly identify aquifer and confining unit names and formations to be entered into the NWIS-II data base. These checks will be done based upon data in the GEONAMES list of accepted geologic names and the GWSI list of accepted aquifer and confining unit names. The geohydrologist should be allowed to use new aquifer names not on the accepted list, but should be notified of the 'failure to match' a name on the reference list and guided through proper naming conventions, as defined in Open-File Report 86-534 (Laney and Davidson,1986). The process for using a new geologic name and having it considered for acceptance as an official name will be similar to that of taxonomic names.

Requirement 5.1.3.3-1 Provide verification of aquifer nomenclature

Aquifer and confining unit names shall be verified by cross-checking a reference list of approved names. Similarly, geologic units will be verified by a reference list.

Requirement 5.1.3.3-2 Provide aquifer nomenclature reference lists

The aquifer and confining unit names lists shall be generated from the National Ground-Water Atlas, whereas the geologic units (formations) names list will be obtained from the GWSI file.

5.1.4 Visual Checks

Visual checks of data allow users to view and verify correctness of discrete data points and scanned images. Verification of graphical data is covered in section 1.6. Users will be capable of displaying scanned images or visual representations of data that are available via CD-ROM or stored in the NWIS-II data base. Similarly, if electronic images of geophysical logs are available, the user will be able to display them for verification of the relative position of an aquifer in question. Pump diagrams and location sketches, if available, can be used in a likewise manner. An indexing scheme will be created to keep track of the various types of visualizations available, and to facilitate their use.

Requirement 5.1.4-1 Provide the ability to execute visual verification checks

NWIS-II shall be capable of executing verification checks that incorporate graphics and visual checks.

Requirement 5.1.4-2 Provide an index of scanned images used for verification checks

NWIS-II shall provide an index of images or visual representations that are available to verify data.

5.1.5 Geographic Information System Checks

GIS verification checks operate on spatially distributed data in the form of thematic and areal maps. NWIS-II will access a standard library of thematic maps. Districts also may have a set of separately maintained thematic maps that would supplement the standard library. The GIS shall display a series of thematic maps (e.g., State, county hydrologic unit, land surface datum, aquifer, stream reach) along with the location of the new and/or existing sites (highlighted on the display screen). Once all the maps are displayed, the location of the new sites are verified. The development of this functionality will require coordination between NWIS-II and DIS-II, as discussed in Software Supported by the Applications Assistance Unit of the Distributed Information System, section 2.3.5.

Coincident sites are identified by using a GIS to compare new site locations to existing site locations. Existing site locations can be reverified for accuracy using NWIS-II. If a discrepancy is found, the site can be moved, deleted, or left unchanged. The original site location is important information and would become an alias used to connect historical data to the verified site location. The new site location will be used wherever possible. For additional information using a GIS see Geographic Coordinates, section 6.2.7.

Requirement 5.1.5-1 Provide the ability to visually verify site location

Users shall have the ability to graphically display (on the screen) an existing site with relevant thematic maps in the background to perform a visual site verification. The accuracy of site location will depend on the method of determination and/or the map scale used. Users can select from a choice of the map scales available to plot sites.

Requirement 5.1.5-2 Provide the ability to identify coincident sites

Identification of coincident sites shall be provided by checking new site locations with existing site locations. Users will be notified when sites overlap or fall within a user-defined distance (this may be set by the implied accuracy of the method used to establish the location).

Requirement 5.1.5-3 Provide the ability to execute user-defined boundary checks

Users shall be able to verify the position of new sites against a user-defined boundary. Boundaries can be selected from thematic maps and/or can be defined on the screen using the mouse. This check would highlight (in a different color and symbol) any site(s) that falls outside of this boundary. Users shall be able to link together several boundary checks to be performed collectively. An example of this would be the ability to check if a new site was located in a particular basin and in a given county, where the basin extends across a portion of the county of interest and into an adjacent county.

5.1.6 Data Comparison

One type of data comparison occurs when users verify copies of data with the originals. For example, a user may decide to utilize a data base (sample data base) outside of NWIS-II, knowing that the data base is updated often. A function should be available to allow the user to verify whether an update to the original data base has affected entries in the sample data base. If changes have occurred, the user has the option to reload the sample data base or make updates where necessary.

A more complicated type of data comparison occurs when a user-defined verification is used to check a data value against characteristics of a select set of data. This type of data comparison is completed by creating a script that incorporates one or more of the other error-checking utilities and a selected set of data. The verification-acceptance criteria then are determined for the user automatically. For example, for water-use purposes, the number of wells in a municipal well field that are stored in the data base site group would be checked against the number reported in an annual state publication. Scripts also can be created and executed using statistical calculations with selected (current or historical) data in the NWIS-II data base. These calculations are in turn used to create verification checks that can be used with data newly entering NWIS-II or with data from outside of NWIS-II. For example, in water-use, current aggregated water-use data would be compared to historic aggregated water-use data where some limit (i.e., 10 percent) of change is established. If the limit of change is exceeded, the system would then notify the manager of the larger- or smaller-than-expected value.

Requirement 5.1.6-1 Provide the ability to verify a stored copy of data against current original data

Users shall be able to run a script that will compare a copy of a data subset that has been stored with the current original version of the data subset to verify if there have been changes.

Requirement 5.1.6-2 Provide the ability to verify input data using statistical values calculated on stored data

Users shall be able to create scripts that will execute a process to retrieve and compute statistics on historical data and use the results of the computations as threshold values to verify new data.

Requirement 5.1.6-3 Provide the ability to issue alerts based on the percent change in new data (aggregated or discrete) compared to statistical values calculated on stored data

Users shall be able to create scripts that will execute a process to retrieve and compute statistics on historical data and use the results to compare percent change in new data versus historical data. Should the new data exceed a threshold, an alert would be issued.

5.2 Data Review

One aspect of data verification is data review, which can occur throughout the data aging process. During data reviews, users have the capability to accept, modify, or delete verified data. Users' self-review processes can be halted at any point. Data can be recomputed or, if satisfactory, stored as data ready for project review. A project reviewer verifies whether the methods, algorithms, and utilities used to perform an operation are valid and the worked record is accurate. Support files that are both text files and intermediate-data computation files are used during data review to document and authenticate computational processes. Figure 17 shows the flow of data and verification information to and from the NWIS-II data base for user self-review and project-review processes.

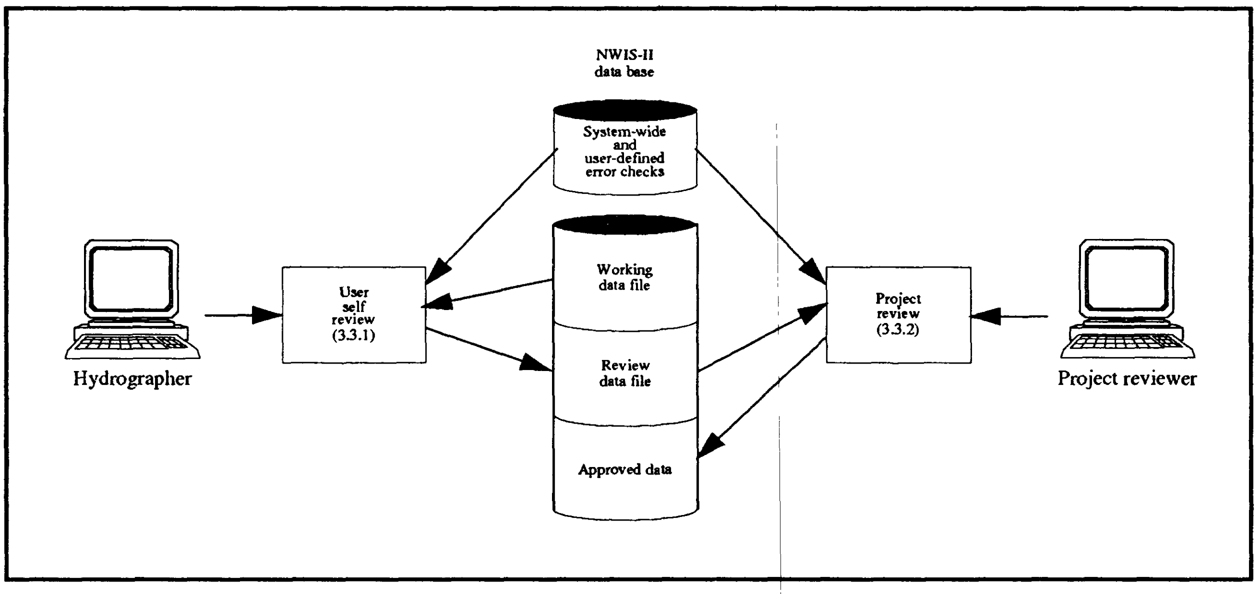

Figure 17. -- Data flow diagram for the data-review verification process.

When a data-review verification failure occurs, data may be: (1) deleted; (2) overwritten with recomputed data values; (3) flagged as a "working" data set and saved in a temporary file for comparison with other recomputed results; (4) flagged as a "review" data file saved in the NWIS-II data base in preparation for official review.

Requirement 5.2-1 Provide the ability to handle data-review verification failures

NWIS-II will have a protocol for handling data-review verification failures.

Requirement 5.2-2 Provide the ability to generate data-review verification reports

Users shall have the capability to request a diagnostic report for the data-review verification procedure.

Requirement 5.2-3 Provide for audit trails of the review process

Audit trails will track the history of data manipulations and reviews.

5.2.1 User Self-Review

When all the necessary data for primary computations are assembled and the computations have been completed, a process of interactive review will begin automatically. An interactive process of user self-review allows the hydrographer doing the computations to check and accept or reject his work. For example, the enhanced primary computations table will appear on-screen accompanied by the unit-values hydrograph of the data.

Users will have available all information needed to perform a cursory or in-depth review of the computations. For example, the following list are some of the stored data elements that could be reviewed:

- date and time
- unit values
- rating tables
- shifts
- datum corrections
- field measurements (e.g., discharge measurements)
- peak base information
- alert thresholds
- comment and explanations associated with the data
- information associated with data flags
- auxiliary data (e.g., temperature, precipitation, other gages)
- mean discharge for last day of previous water year
- statistics (maximum, minimum, mean, monthly totals)
- lab results - water quality and sediment lab
- level notes

As the review process proceeds, an option will be available to return to any point in the processing routine, make changes to input data, and recompute. Users also will have the option to "quit" the session and delete the primary computations created during the session. After a user self-review is completed, the user must accept or reject the primary computations. If upon review the user wants to accept the computations, a standard output of computed values will be produced. The data will be marked ready for review and the data protection will be set accordingly. If the user rejects the computations, there would be no output and the session would be deleted.

Requirement 5.2.1-1 Provide the ability for project worker to verify and review data

A project worker shall have the ability to execute any verification function within the NWIS-II to prepare a working record ready for project and higher-level reviews.

Requirement 5.2.1-2 Provide data required for user self-review

Users shall have immediate access to all of the ancillary information needed to review and make decisions about the accuracy of a working record.

Requirement 5.2.1-3 Provide displays required for user self review

The window environment will allow multiple screens, each with a different application to be executed concurrently. Similarly, several data files can be open simultaneously including such files as those for processing remarks and textual information and histories. The following displays will be required for the user-review function:

- tabular display of primary data
- graphical display of a time-series of primary data.

Requirement 5.2.1-4 Provide options for interactive review

User interaction needed to complete working-record review shall include the following capabilities:

- Scrolling forward and backward through displays
- Zooming in and out of graphics displays
- Adding text to REMARKS section
- Adding text to COMMENT FILE
- Adding “flags” to data
- Return to any part of the processing navigation path to make changes
- Accept processing and mark ready for review
- Reject computations and delete all processed data, remarks, and histories

5.2.2 Project-Level Data Review

Project managers and reviewers must have the ability to review pertinent hydrologic data processed by NWIS-II. The project manager or reviewer will be able to review data using any verification function available in NWIS-II. The type of review conducted will depend on the data type and the associated policies being approved for release. The project reviewer will need access to a variety of support files other than the actual data files (e.g., histories of the data collection, audit trails of data processing, editing and computational procedures that were performed on the data, and data used to perform quality-assurance checking). The project data reviewer will be notified of any independent records that have been reprocessed subsequent to the dependent record moving from working to review status. For example, the sediment discharge record is dependent on the surface-water discharge record. If the water-discharge record has been modified but the sediment record has not, the data reviewer will be notified.

Verification is complete when the project data and support information have been reviewed and certified as correct. The reviewer subsequently requests that the "review" status of the file be changed to "approved". If the data fail to be verified during the project-level review, the data are rejected and returned to the project worker for revision. A history of the review will be documented within an audit trail. The project-level data reviewer's name, office, date of review(s), status of review (accepted or rejected), and comments will be included.

Requirement 5.2.2-1 Provide the ability to review and verify project-level data

The project-level reviewer shall have the ability to execute any verification function in the NWIS-II to verify and certify that the correct method was used to process the data associated with a project.

Requirement 5.2.2-2 Provide notification of changes in dependent record(s)

The NWIS-II shall notify the user if a dependent record is not current with the status of associated independent records (i.e., where some data computations depend on the final computations of other data).

Requirement 5.2.2-3 Provide the ability to update the history of data review using an audit trail

The project-level reviewer shall have the ability to add comments to an audit trail during the review process. A history shall include the reviewer's name, office, date of review(s), status of review (accepted or rejected), and comments pertinent to the review.

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6. Computations

Computations are used to manipulate and analyze basic water-resources related data. The computational functions provided in NWIS-II can either be executed interactively or from a script and will include mathematical functions, statistical functions, graphical functions, and a transparent interface to use a geographical information system and spreadsheet package. The following sections describe the functionality of computational scripts, the computational tools available in NWIS-II, and WRD standard computational methods.

It is recognized that accuracy must be maintained during all processing routines. Rounding during calculations can corrupt data sightly as a result of the way computers and computer programs handle the significant digits. For more information on accuracy see Potential Problems Associated with Machine Computation, section 2.1.1 of chapter 7.

6.1 Computational Scripts

R.L. Moffatt, S.M. Trapanese, and J.D. Christman

A computational script contains a set of instructions for computing data. These scripts tell the computer how a set of successive computational operations should be completed. Normally, it is a set of instructions that requires little user interaction to proceed. The interaction might be a prompt for users to specify a site and the type of computation to be performed. The script also may direct the system to retrieve all the necessary data to perform the calculation and to save the output in the data base.

Computational scripts can be either system-defined or user-defined. System-defined scripts are used to automatically implement WRD discipline standard processes that include approved methods and algorithms transparent to the user. One to several system-defined computational scripts may be incorporated into one of several processes that are included in a navigation path, where the navigational path is a series of execution options available for the user to process WRD data using standard methods (see Navigation Paths, section 1.5).

User-defined scripts are created by the user to perform experimental computations using techniques that supplement or substitute discipline standard methods. A work space will be allocated for the user to compose and store user-defined scripts and to store preliminary computational results.

Requirement 6.1-1 Provide WRD approved and user-defined scripts

There shall be two types of computational scripts available: system-defined discipline scripts that use one or more of the WRD approved standard methods, and user-defined scripts that do not necessarily incorporate WRD standard methods. Some prototype scripts shall be available for the user to implement as is or to modify so calculations can be done for unique situations. The user-defined script may contain any combination of available computation subfunctions, from data specific to generalized math and statistical routines. User-defined scripts that are approved by PC&TS can subsequently be added to the WRD methods and algorithms subfunction during a software revision.

Requirement 6.1-2 Provide the ability to reuse user-defined scripts

It shall be possible to save user-defined computational scripts. One that is used frequently can be added to a menu selection so it could be available to everyone on the system at a node. These would include district or regional approved scripts.

6.2 Computational Tools

R.L. Moffatt, D.W. Stewart, and S.M. Trapanese

Computational tools are utilities that help users perform calculations. The tools available within the NWIS-II will consist of programs written by the USGS to perform calculations for unit conversions and for the manipulation of data for comparison, estimation, and statistical analyses. Third-party software will provide the means for users to do various mathematical computations, statistical analyses, graphical representations of data, and various functions related to the geographical characteristics of data.

6.2.1 Units Conversion

A unit conversion utility is needed to convert data collected in different units into a common unit for storage in the data base or to convert stored data for output in user-preferred units. This utility can be used in scripts that will be transparent to the user or used interactively. Unit conversion factors available from within the NWIS-II are listed in Appendix E: Unit Conversion Factors..

Requirement 6.2.1-1 Provide the ability to convert units of measure

A units conversion utility shall be provided that will allow conversion algorithms to be implemented in a forward or reverse direction.

Unit conversion will not be automatic for all data. Users shall have the ability to input, store, and output their data in any preferred units. Some unit conversions will be done automatically on data output to standard WRD reports.

6.2.2 Manipulation of Time-Series data

Time-series data often require some form of manipulation to compare data sets or make reasonable estimates during times when data are missing. Methods are needed to manipulate instantaneous, recorded time-series data and computed, time-series data to make comparisons or estimates, or create new time series. This generally is done using mathematical and statistical functions to interpolate, extrapolate, synchronize, and compute water-resources data over time. The time-series data may include parameter values measured or sampled at discrete time intervals, or they may include parameter values that are recorded as unit values where the unit is some interval of time that may be constant or variable and generally is less than a day.

Requirement 6.2.2-1 Provide the ability to extract selected intervals from a time series

Users shall be able to extract data for a selected interval of time from a time series recorded at a different interval, such as extracting 15-minute values from hourly or variable-time-step data. The algorithm used to extract data

must take proper account of the unit-values statistic code -- instantaneous values, average values over the recording interval, and values averaged over a short period around the instant at which the value was recorded. User shall have the option to use simple linear interpolation, log-linear interpolation, or spline interpolation.

Maximum and minimum observed values shall be considered when interpolating the series over peaks or through troughs.

Users shall be able to smooth values on the basis of a user-specified smoothing parameter.

Requirement 6.2.2-2 Provide the ability to create a new time-series data set

Users shall have the ability to create and store a new time-series data set using extracted values together with an original data set, where the data definition of the new set is the same as the old with information that identifies the operation that created the new set.

Requirement 6.2.2-3 Provide for synchronization of a group of concurrent time-series data

Additional unit values shall be interpolated into all data sets in a group as necessary to ensure that all data sets in the group contain unit values at the same times. User can specify time tolerance to be used to decide whether two values or groups of more than two values are synchronous.

This function also can be used to produce a group of synchronized data from an unsynchronized set of data. The data sets can be summed (+ or -), multiplied, or divided. Approximate derivative values of a set of data can be computed by taking the difference between each value and the one preceding it and divide by the corresponding time difference (du/dt).

Requirement 6.2.2-4 Provide the ability to transform extracted and synchronized data

Users shall be able to apply mathematical functions to a time series where each value in the resultant time series is the result of evaluating a function using the corresponding value in the input time series. The transforms will at least include log base 10, antilog base 10, power, square, square root, round off, and trigonometric transforms.

Requirement 6.2.2-5 Provide for tabular-defined relations of synchronized data

Users shall be able to use a table of descriptor points to create one set of data from another. The table lookup algorithm will provide for interpolation options, such as linear, log-log, semi-log in X, semi-log in Y, normal-probability (X or Y), and spline. It shall provide for extrapolation options, such as no extrapolation allowed, or extrapolate on the basis of the last two descriptor points as defined independently at either end of the relation.

6.2.3 Comparison and Estimation of Time-Series Data

Time-series data are often compared and estimated at similar time scales for the same and for different time periods. Users need the ability to align all time-dependent data occurring at various time scales. This can be done by proration as a straight-line interpolation of data values in time, such as distributing a quantity over a discrete time period (e.g., an annual total over 12 months or an hourly value over quarter hours). Also needed for

comparing and estimating time-series data is the ability to offset or lag one time series with others, so events at different time periods can be examined.

Requirement 6.2.3-1 Provide the ability to prorate data over time

A program shall be provided to interpolate data by prorating over time. Proration is the easiest, fastest, and often the most accurate technique available. This method is accurate where a parameter's values are increasing or decreasing at a steady rate and missing values are few. Datum corrections and coefficients can be prorated using the same technique Data Adjustments, section 6.3.3.

Requirement 6.2.3-2 Provide the ability to merge data sets with different recording times

It shall be possible to merge time-dependent data sets. Merging of data sets with different recording times via interpolation and time weighting of values is necessary for production of interpretative tools, such as the water/ sediment hydrograph. It also shall be possible to merge data recorded by different equipment to develop a more refined set of values over time (e.g., merging DCP and ADR recorded data).

Requirement 6.2.3-3 Provide the ability to control proration

Users shall have the ability to control how prorated data values are applied. Data can be prorated continuously or noncontinuously over time. The system also shall provide the option of entry of data to give intermediate control of the proration. Inserting these intermediate points would not only provide control, but also increase the accuracy of the proration. Such estimations shall be stored in nonpublishable interpretive files. For example, if 20 days of missing sediment record are to be estimated and the water discharge (or some other characteristic) changes within that period, it may be desirable to adjust the method of proration for the period of the change. For water-use estimates, proration techniques are applied to annual data to account for variations in water use that are known to occur during the year (e.g., seasonal pumpage patterns associated with irrigation and cooling requirements).

Requirement 6.2.3-4 Provide the ability to adjust for time lag

Correlations are often made between time-dependent data with different time periods. NWIS-II shall have the ability to adjust time-series data so that two or more discrete sets of time-dependent data with different start or ending times can be compared. Adjustments can therefore be made to the time period of one or more time-dependent sets of data to align them with other sets of time-dependent data by transposing them forward or backward by equal units of time (i.e., minutes, hours, days, or years).

6.2.4 Mathematics

Mathematical functions are available in third-party software for use in an interactive mode or batch processing mode. Users can incorporate mathematical functions into computational scripts for their own purposes or implement them as an online calculator. The NWIS-II plans to incorporate a commercially available mathematics software package to meet the following requirements. This package is not meant to replace the standard computational processes of the WRD; it is simply an analyst's tool.

Requirement 6.2.4-1 Provide a standard set of mathematics functions

The system shall provide a set of arithmetic functions that can be used in algebraic operations. Some standard functions to be included are:

- addition
- subtraction
- multiplication
- division
- exponentiation
- percentage
- logarithms - natural and base 10
- anti-logarithms

Requirement 6.2.4-2 Provide the ability to store and implement user-defined equations

The system shall allow users to define equations from a set of mathematical functions in script and store them for later use in batch or interactive processing. Users also shall be able to use the mathematical functions interactively in a calculator.

Requirement 6.2.4-3 Provide the ability to perform advanced mathematical manipulations

The analyst shall have the capability to perform advanced mathematical manipulations. For example, the surface-water and sediment users request the capability to define relationships, such as by correlation between two or more station records for the purpose of estimating missing record. Some examples of mathematical routines to be provided include:

- singular and multiple linear regression
- nonlinear regression
- quadratic equation solving
- matrix algebra (including computation of eigenvalues and eigenvectors)

Requirement 6.2.4-4 Provide the ability to interpolate between X-Y pairs

Users shall have the ability to interpolate between X-Y pairs. All nonlinear interpolations must be approved by PC&TS.

6.2.5 Statistics

Statistical routines are available in third-party software and can be available to users in an interactive mode or batch processing mode. Users can incorporate calls to statistical routines into scripts or export their data to a statistical package and import the statistical results into NWIS-II. The following is a list of some common routines that have been requested:

- range
- maximum
- minimum

- mode
- summation
- geometric mean
- arithmetic mean
- harmonic mean
- median
- standard deviation
- variance
- parametric & non-parametric analyses
- maintenance of variance extension
- sampling routines to include stratified or unstratified random sample selection
- redundancy analysis
- cluster analysis
- factor analysis
- ranking
- sorting
- percentile
- chi-square
- p-test, F-test, t-test

The system will also provide WRD approved statistical routines; see Water Resources Division Computational Methods, section 6.3 of chapter 7. Additional WRD statistical applications are listed in PC&TS Application Software, section 2.3.1 of chapter 7.

Requirement 6.2.5-1 Provide a set of standard statistical routines

The system shall provide a set of statistical routines in third-party software to be used as an interactive tool within NWIS-II. Users also shall have the capability to export data from the NWIS-II to a statistical package (see Export of Formatted Files, section 7.5) and import the results of statistical analysis from an external package into NWIS-II.

6.2.6 Interactive Graphics

Interactive graphics will provide NWIS-II users with another tool to manipulate, compute, and analyze data visually and recursively. To assist users adequately, the interactive graphics package must have the capability to recompute graphically displayed data, update the graphical display, and if desired, store the recomputed values. Discussion associated with graphical entry and editing of data can be found in Graphical Input and Editing, section 4.7. The following requirements do not apply to development of rating curves graphically. The type of graphical displays and the ability to manipulate data will depend on the software available to the NWIS-II.

Requirement 6.2.6-1 Provide curve-fitting techniques within interactive graphics package

Graphical curve-fitting techniques fit pairs of X-Y data to a mathematical expression(s) using a polynomial equation, spline, or another technique. The curve-fitting procedures may be provided in a graphics package on

the DIS-II or in a math or graphics package procured by the NWIS-II Mathematics, section 6.2.4. In this case, third-party software will be interfaced with the NWIS-II to meet any special requirements for data-set handling and data-value manipulation.

Requirement 6.2.6-2 Provide the ability to draw a curve (free-hand)

The ability to draw a curve on the screen using a mouse or other pointing device and modify the curve with the same pointing device shall be provided (see Graphical Input and Editing, section 4.7).

Requirement 6.2.6-3 Provide the ability to store curves

The representation of the curve shall be stored in the data base as a set of data points or mathematical expressions.

Requirement 6.2.6-4 Provide the ability to index curves

The representation of the curve shall be indexed. The index will be utilized to define: 1) the type of curve, 2) the family of curves, if any, to which the particular data set belongs, 3) whether the data set is associated with a specific site, and 4) whether the data set has a history or time dependency. This indexing system shall be available (not mandatory) for all time-series and multivariable data curves whether they are hand drawn, computed, or smoothed.

6.2.7 Geographic Coordinates

Geographic coordinates are used to locate NWIS-II sites and geographic features on the earth. These coordinates have an associated projection and coordinate system. A projection is a flat representation of a round surface, such as a map that depicts an area on the surface of the earth. To process the geographic coordinates of NWIS-II sites, they must be in a known projection and coordinate system. To accurately register a map into geographic space on a digitizer to input, edit, and retrieve NWIS-II information, it may be necessary to compute the positional coordinates. Users shall have an option to select from a reference list to specify the projection of the retrieved NWIS-II information. The projection of the thematic maps will be the default. For additional information on GIS see Geographic Information System Checks, section 5.1.5.

Requirement 6.2.7-1 Provide reference list of longitude and latitude values for standard maps

The longitude and latitude values of the corners of the standard USGS quadrangle series (1:24,000, 1:100,000 or a 1:250,000 scale) shall be obtained from a reference list to be used as registration points. These points shall be selected based on the quadrangle name and scale, to orient site locations for the input, edit, retrieval and output of NWIS-II information.

Requirement 6.2.7-2 Provide reference list of projection parameters

Projection parameters of the standard USGS 1:24,000, 1:100,000 or 1:250,000 scale topographic maps shall be obtained from a reference list based on the projection name. Users shall have the ability to enter, store and use

other projection parameters. The projection that parameters are based on are stored in the system and include but are not limited to:

- polyconic for 1:24,000 scale topographic quadrangles
- universal transverse mercator (UTM) for 1:100,000 and 1:250,000 scale topographic quadrangles
- albers equal area for 1:2,000,000 scale National Atlas series
- state plane

Requirement 6.2.7-3 Provide the ability to register a map or plot on a digitizer

Users shall register a map on a digitizer for the input, edit and retrieval of NWIS-II information. Users would: 1) mount a map on the digitizer table, 2) be prompted to enter a known longitude/latitude value from the keyboard, or for standard maps, use the reference list of maps and enter the map name, and 3) point on the map to the exact location of the registration point. To register the map correctly, this would be repeated perhaps four times.

Requirement 6.2.7-4 Provide the ability to project geographic coordinates

Users shall have the ability to project geographic coordinates into a variety of projections. To project a file of geographic coordinates, parameters describing the input and output projection characteristics are required. These parameters were used to compile the original map and must be duplicated to project. Different projections require different parameters.The projection parameters, for example, required to project an albers equal area data set would be the first and second standard parallels, the central meridian, the latitude of the projections origin, the false easting and false northing. The parameters will be obtained from a reference list if they are stored, or users shall be prompted for the parameters if they are not stored.

Requirement 6.2.7-5 Provide the ability to transform site location coordinates

Users shall have the ability to transform spatial coordinates. Transform is used to convert maps created in digitized units into real-world units represented on the map.

6.2.8 Spreadsheet

The spreadsheet tool will provide links between NWIS-II and a spreadsheet software package. It will be available for users to use interactively or in batch processing and may have the capability to use predefined scripts stored in NWIS-II but implemented in the spreadsheet. The water-use discipline utilizes a wide variety of computations to determine aggregated and site-specific water-use estimates. An alternative to providing a set of predefined computations within NWIS-II is to provide the ability to manipulate data in a spreadsheet to perform the desired calculation. The spreadsheet would provide much of the functionality needed for these types of computations that may not be provided for through the use of algorithms.

Requirement 6.2.8-1 Provide spreadsheet capabilities

Users shall have the ability to utilize a spreadsheet package. Users shall have the capability to export data from NWIS-II to a spreadsheet and import the results of spreadsheet calculations back into the data base.

6.3 Water Resources Division Computational Methods

R. L. Moffatt

Computational methods described herein are standard division approved methods used to process water-resources data and principally differ by discipline. Some computations such as data aggregation, time-adjusting unit values, data adjustments, and application of ratings are common to several water-resources disciplines.

Much of the data collected by the WRD is treated as continuous, time-series data. These data need to be processed over time, without regard for artificial boundaries, such as discrete water or calendar years.

Requirement 6.3-1 Provide the ability to compute time-series data across water-year boundaries

Computations on all time-series data shall be continuous for the period selected and can cross water-year boundaries.

6.3.1 Data Aggregation

Data aggregation is a statistical tool commonly used to analyze trends in water-resources data or describe impacts on the hydrological environment. This function will most likely be performed by a statistical package with the use of a predefined script and also may be done using a spreadsheet package as described above. Aggregations of data using this tool are for general, interdisciplinary use and not intended to be the only means by which water-use aggregations are done. Users are given the flexibility to do any kind of aggregation where they make the determination of whether or not it is meaningful. For additional information see Water-Use Computations, section 6.3.9.

Requirement 6.3.1-1 Provide the ability to aggregate data

Userss shall have the ability to aggregate data by the following attributes either singularly by a specified attribute or by concatenating two or more attributes. For example, an aggregation could be done by State and county where the data would be aggregated for each unique occurrence of State and county.

- State
- county
- district
- station or site
- set or group of sites
- hydrologic unit, region, subregion, accounting unit, or cataloging unit
- water-use category
- water source
- aquifer
- drainage basin
- time period
- any bounded area defined in a GIS

Requirement 6.3.1-2 Provide the ability to perform aggregations

Users shall have the ability to aggregate any subset of data by any statistical function provided for in the statistical package linked to the NWIS-II, or use a third-party spreadsheet package with user-defined equations.

6.3.2 Time adjustments of unit values

Recorder times of continuous, time-series data often vary from actual time as determined from the field inspector's actual watch time of instantaneous observations of the data being recorded. This discrepancy occurs as a result of recorder-clock stoppages and recorder malfunctions. For these instances, the time-series data must be distributed in time to correct or adjust recorded times with actual times.

Requirement 6.3.2-1 Provide for adjustments to recorded times of time-series data

The associated times of recorded unit values shall be corrected using the standard time-correction method in the NWIS-I. The difference between the watch time or actual time, and the recorded time is distributed equally over each time increment during the period defined by the beginning recorded time and ending watch time. Recorded unit values will not be deleted or added, only redistributed in time.

6.3.3 Data Adjustments

Most often raw data recorded or observed in situ, requires some kind of adjustment to account for changes in datum (vertical control of reference gage), recorder error, inability to sense the true physical or chemical characteristics of a water body, or changes to the hydraulic control of a stream (shifts). The adjustments are applied to recorded unit values of a parameter after they have been converted to engineering units, time corrected, and edited. The adjustments are distributed either as a constant correction, prorated uniformly by time; or distributed variably as a function of changing hydraulic conditions, on the basis of the hydrographers judgment of the adjustment cause.

Data adjustments are based on discrete observations made at a site as determined from: 1) surveyed levels of reference and auxiliary gages, 2) the field recorders ability to accurately sense or record the true physical or chemical characteristics of the water body being gaged, and 3) measurements of the physical and chemical characteristics of the water body being gaged.

Adjustments generally referred to as datum corrections include changes in vertical control of a reference gage (datum) and recorded differences from the reference gage (recorder corrections). Datum corrections are changes to the original recorded unit value but the changed value is filed separately and does not overwrite the original, recorded unit value. Adjustments referred to as shifts include changes to the hydraulic control of a stream. Shifts are used for computational purposes and do not change stored values of either the original, recorded unit value or the datum corrected unit value.

Requirement 6.3.3-1 Provide the ability to store and compute data obtained from surveys

Users shall have the ability to store data obtained from surveys made to determine elevations and dimensions of hydraulic features and gages. For the purpose of applying datum corrections for vertical control, users shall have the option to apply this type of correction to measured (gage readings) and observed unit values (instrument readings) made during station visits over a specified time period. The correction will be computed for any reference point selected from a level circuit and can be recomputed recursively based on any other reference point selected and applied to any and all gage readings.

Requirement 6.3.3-2 Provide the ability to store measurement data and compute shifts

Users shall have the ability to store discrete measurement data and use these data to compute optimum shifts and percent differences from a rating, percent differences from zero shift, and percent differences from any user-assigned shift.

Requirement 6.3.3-3 Provide the ability to distribute gage height corrections

Gage height corrections shall be distributed over the period of processed record either as a constant value, uniformly over time, or distributed variably as defined by the user on a data correction input form. The gage-height corrected value will alter the original, recorded unit value but shall be filed separately in the data base so as not to overwrite any original recorded unit values.

Requirement 6.3.3-4 Provide for the analysis of shifts to compute streamflow

The analysis will be done on the basis of the current or user-specified rating and last-used shift curve. Measurements to be evaluated by shift analysis shall be selected by users for specified time periods, by a value greater than or less than a specified parameter value, or by sequence of measurement numbers. Users shall be able to order the measurements by date, measurement number, or parameter value. The default selection of measurements will be done for a specified time period and will include two measurements made just previous to the time period used to evaluate shifts.

The process for shift analysis will be a combined procedure for users to implement interactive graphics to develop shift curves and review computational results on output tables and graphs such as unit values of gage height and unit values of shifts as they are distributed in time.

Computations for shift analysis of stage-discharge relationships include:

$$\text{Percent difference of measured discharge from rated discharge} = 100(Qm-Qr)/Qr \quad \text{(EQ 1)}$$

$$\text{Optimum shift of rating to measurement} = Gm-Gr \quad \text{(EQ 2)}$$

$$\text{Percent difference of } Qm \text{ from rating with optimum shift} = 100(Qm-Qr')/Qr' \quad \text{(EQ 3)}$$

$$\text{Shift from rating to shift curve} = Gs-Gr \quad \text{(EQ 4)}$$

Computations

Percent difference of measured discharge from shifted rating = 100(Qm-Qs)/Qs (EQ 5)

where: Qr = rated discharge

Qm = measured discharge

Qr' = rated discharge corresponding to the measured gage height plus optimum shift

Qs = discharge from shift curve corresponding to the Gm plus shift to curve used.

Gm = measured gage height

Gr = gage height from rating corresponding to the measured discharge

Gs = gage height from shift curve corresponding to the measured discharge

Shifts shall be rounded to the nearest 0.01 feet, and percent differences shall be rounded to the nearest 0.1%.

Requirement 6.3.3-5 Provide for graphical editing of shift curves

A shift curve, displayed graphically on the rating curve plot shall be used automatically to distribute corrections in lieu of corrections entered on a tabular input form.

In the case of stage-discharge relationships, if a gage height of zero flow was determined during a site visit and the rating goes to zero discharge, then the difference between the gage height of zero flow and the gage height corresponding to zero discharge from the rating will be computed and used to aid in graphical editing of the shift curve.

The graphical representation of the shift curves will provide for interpolation between input points on the basis of shifts rather than parameter value, and not allow extrapolation beyond the defined limits of the shift curves.

Shift curves shall be saved for ultimate archival and be numbered in the format xxx.yyy, where xxx is the number of the base rating to which the shift curve applies and yyy is a sequential number for the shift curve.

Requirement 6.3.3-6 Provide the ability to distribute shift corrections

Shift adjustments will be made after any datum corrections and shall be distributed over the period of processed record either as a constant, uniformly over time, or distributed variably by the user from results of a graphical procedure used to define shift curves. Shifts will be used in a temporary mode for computational purposes so as not to alter either the original, recorded unit values or the datum-corrected unit values.

6.3.4 Rating development

Ratings are developed from a mathematical relationship between two or more variables, but generally are displayed as a two-dimensional graph or table of point pairs. Common ratings used in the computation of water resources data include: standard ratings, where one variable is directly related to another variable; hysteresis

ratings (loop), where the state of a variable is related to its antecedent condition and another variable; and growth and decay ratings, where the state of a variable is a function of time. The development of ratings in the NWIS-II for any WRD discipline will be essentially an interactive graphical procedure where users can draw the rating and manipulate it based on a plot of the selected measured parameters. The graphical editor must display the correct identifications of the parameters used in the rating. Input of descriptor points also can be used to develop a rating to be graphically displayed. After a rating has been developed,information contained in subsequent measurements can be used to graphically edit the rating and to plot shift curves. Any number of ratings can be developed and saved for use in primary computation where output will be a function of input for any two parameters.

Requirement 6.3.4-1 Provide the ability to develop rating curves and tables

1) Users shall be able to graphically develop, update, and alter ratings curves or input descriptor points used to define a rating.

2) This function shall provide for developing new rating curves and tables, updating existing rating curves and tables, and altering an existing curve interactively and graphically by curve-shaping techniques.

3) Users also shall be able to quit rating analysis development or update at any time and to save or not save any work accomplished to that point.

4) Users shall be able to select printed output on either a pre-printed form or a computer generated curve sheet.

5) Measurements used to define a new or existing rating will be plotted and the appropriate parameters shall be identified.

Requirement 6.3.4-2 Provide for equation ratings

Users shall be able to plot linear or log-linear ratings as shown in TWRI Book 3, Chapter A10 (Kilpatrick and Schneider, 1983, figure 10). The general form of the equation is

$$Y = a+b(X-e)^c \qquad \text{(EQ 6)}$$

where Y = output value

X = input value

a = equation constant (zero by default)

b = multiplier (value of 1 by default)

e = scale offset (zero by default)

c = exponent (value of 1 by default)

Users shall supply scale information, such as initial values for both axes, interval between values, and scale offset (for logarithmic plots). Grid size for rectangular plots is recommended to be 1/8-1/4 inches.

6.3.5 Surface-Water Computations

R.L. Moffatt

Many of the gaging stations operated by the USGS are for the purpose of computing unit values of discharge from unit values of stage and stream velocity through the use of relationships between stage, velocity and discharge. Other information and statistics, such as daily mean discharge, maximum and minimum stage, velocity, and discharge are routinely computed for these stations. Some stream-gaging stations are only operated to collect unit values of stage. Surface-water gage-height data are collected at sites in estuaries and along tidal-affected rivers to provide information concerning the daily diurnal and semi-diurnal variations in surface-water levels in these areas. At these stations water levels are sensed on a continuous basis. Surface-water data also are collected at lake and reservoir sites to provide information concerning the volume of water stored and the amount of runoff captured or released from these water bodies. At these stations, gage-height or elevation are sensed or observed on either a continuous or periodic basis. These records are then related to an elevation-storage relation to produce a record of the contents of the reservoir or lake. Following is a description of the computations and methods that are used to process the water-level and velocity data that are stored in the NWIS data base. All computations shall be made with unrounded numbers and all unit values, daily values, and statistics will be stored unrounded. Rounding will be performed on output (see Data Output, section 7)..

6.3.5.1 Ratings Used in Primary Surface-Water Computations

Primary surface-water data computations use several types of rating curves to compute discharge where discharge is a function of other parameters that describe the hydraulic conditions at a streamflow gaging site.

Requirement 6.3.5.1-1 Provide for specific types of surface-water ratings

Users shall be able to graphically develop and edit surface-water ratings for:

- stage versus discharge
- slope, constant fall and variable fall
- index velocity
- rate-of-change in stage, Boyer method and storage-correction method

The following computations will provide for the ability to develop slope ratings:

- Measured fall Fm=base gage-height minus auxiliary gage-height
- Trial rating discharges $Qr_{1\text{-}n}=Qm/(Fm)^{1/2}$
- Ratio of measured discharge to rating discharge Qm/Qr
- Adjusted discharge Qadj=Qm/factor, factor comes from a fall factor curve
- Percent difference between Qadj and Qr

This function will provide for the following additional computations necessary to produce a variable-fall rating:

Computations

- Ratio of measured fall to rating fall Fm/Fr
- Adjusted fall Fadj=Fm/curve ratio of fall

This function will provide for the following computation necessary to produce a velocity index rating:

- Ratio of measured velocity to rating velocity Vm/Vr
- Adjusted velocity Vadj=Vm/Cr, Cr is stage coefficient from plot Vm/Vr vs. measured gage-heights
- Percent difference between measured and rated discharge as 100(Qr-Qm/Vr)/Qm/Cr

This function will provide for the following computations necessary to produce a rate-of-change in stage rating using the Boyer method:

- Rate of change in stage J=gage-height (ending time of measurement)-gage-height (starting time of measurement) converted to ft/hr.
- Adjustment variable $1/USc=(Qm^2-Qr^2)/J(Qr^2)$
- $Factor=[1+J(1/USc \text{ from curve})]^{1/2}$
- Adjusted discharge Qadj=Qm/Factor

This function will provide for the following additional computations necessary to produce a storage-correction rating:

- Storage correction Sc=Qm-Qr
- Computed variable Sc/J
- Measurement correction factor Mc=-(Sc/J from curve)J
- Adjusted discharge Qadj=Mc+Qm

Users also shall be able to develop and display a theoretical rating to be used as a tool for shaping user-developed ratings. For ratings of streams where section control exists, the equation to be used is:

$$Q=CLH^{3/2} \tag{EQ 7}$$

where Q=discharge (ft^3/sec)

C = a function of gage height and is computed using the section control cross-section and input of one or more points (gage height and discharge) on the rating. C is backed out using Q, L, and H from measurements.

L = width of cross-section control normal to the flow (ft) is a function of gage height

H = total energy head in feet near upstream side of control ($h+V^2/2g$)

h = gage height minus gage height at zero flow (ft)

V = approach velocity (ft/sec) is a function of gage height

g = gravitational force (ft/sec^2)

For a rating or section of a rating where channel control exist, the equation used is:

Computations

$$Q=(1.486/n)AR^{2/3}S^{1/2} \quad \text{(EQ 8)}$$

where n = Manning's roughness coefficient

A = cross-sectional area (ft^2) of channel near the gage and is a function of gage height

R = hydraulic radius (a function of gage height) is the ratio of cross-sectional area (A) to wetted perimeter of the cross section (ft)

S=slope as computed using the channel control equation, the channel cross section, and from one point on the curve, gage-height and discharge furnished by the user (ft/ft).

6.3.5.2 Stage-Discharge Computations

Stage-discharge computations are the most common type of streamflow computations. They require only unit values of stage, which are easily sensed and recorded, and a rating used to define the relationship between stage and discharge. The computations are done on the basis of discrete measurements of gage height and discharge and on continuous recorded values of gage height. The discrete measurements of gage height and discharge identify corrections to gage readings and shifts due to hydraulic conditions that need to be applied to the recorded unit values of gage height for accurate computations of unit values and daily values of discharge.

Requirement 6.3.5.2-1 Provide for the ability to apply corrections to unit values of gage height

Gage-height corrections for changes to datum and recorder corrections (including stilling-well flushing corrections) will be automatically computed from field observations input to the data base. Users shall have the ability to review, edit, and distribute the corrections in time to original recorded unit values of gage height. The gage-height corrected unit values are then saved in the data base in addition to the original (unedited) unit values of gage height.

Requirement 6.3.5.2-2 Provide the ability to alter corrections to unit values of gage height

Subsequent gage-height corrections to stored unit values of gage height shall not be cumulative and will allow users to overwrite the previously stored (corrected) unit values and previously saved corrections, but not overwrite the original unit values of gage height.

Requirement 6.3.5.2-3 Provide for gage-height corrections with stage-variable diagrams

Each individual variation diagram consists of linear segments between user-supplied correction pairs. All gage heights above the uppermost correction pair will assume a correction value equal to that for the pair. Likewise, corrections below the lowermost pair will equal that for the lowermost pair.

The stage variation diagram can be defined by up to five points or four segments that lie between the points. Each point is described by a pair of values consisting of a correction and corresponding gage height.

Computations

Proration of variation diagrams by time shall be done as an unweighted linear interpolation between equal values of stage on the time-adjacent variation diagrams so that the interpolations are done first by stage on the two diagrams preceding and following the time in question, and then interpolations by time are done second, between the results of the first two interpolations.

Zero diagrams shall be treated like any other diagram containing non-zero values. Once a diagram is started, it shall continue in effect until cancelled or changed. This applies to zero diagrams or variable diagrams.

Distribution of corrections shall be automatic and uniform across water-year boundaries unless there is no entry in the previous water-year file. Then corrections will start at the first entry in a given water year and proceed forward in time.

Requirement 6.3.5.2-4 Provide the ability to apply shifts to unit values

When shift curves are used directly (not time prorated) for a specified time period, the shift for a given unit value of gage height is determined by subtracting that gage height from the gage height of the base rating for the same discharge. The algebraic sign of this subtraction is retained as part of the shift. All shifts are rounded to the nearest 0.01 foot.

For time prorated shifts, only those shifts needed to adjust unit values of gage height should be determined, not those outside of the range of recorded unit values. Shifts are interpolated between the times assigned to each shift curve as an unweighted, linear interpolation with each new time step having a new interpolation.

When shifts are constant throughout the range of stages that define the shift curve, and that curve is prorated to another constant shift curve or to the base rating, the distribution of shifts will be equivalent to simple time shifting.

Computed shifts shall be rounded to the accuracy specified (default will be to the nearest 0.01 feet), and added to each of the edited unit values of gage height for the period of computation. Shift-adjusted unit values of gage height will not be stored in the data base.

The maximum and minimum shift for each day shall be determined, stored, and identified on output.

Requirement 6.3.5.2-5 Provide for primary computations of unit values of discharge

Unit values of discharge shall be determined by selecting the discharge that corresponds to each value of the shift adjusted unit value of gage height from the appropriate rating. Computed unit values of discharge are stored for subsequent computation of daily values and archival.

All shift-adjusted gage heights found to be greater than the highest gage height in a rating or less than the lowest gage height in a rating that is not defined to zero flow, shall cause a flag to be set for discharge in the given time slot indicating the rating was exceeded on either the high or low end, respectively. If the rating is defined to zero flow, discharge shall be set to zero for all shift-adjusted gage heights encountered below the

lowest value of the rating and will not be flagged. Shift-adjusted values of gage height that are less than the point of zero flow will be flagged.

Requirement 6.3.5.2-6 Provide for the computations of daily mean gage height

The trapezoidal method shall be used to compute daily mean gage heights from instantaneous unit values of gage height. The rectangular method shall be used for time-corrected mean gage heights, where the mean is over an incremental period of time. For the latter situation, a time correction will be applied to the unit values so that the effective time occurs at the midpoint of the unit values used to compute the mean. This time correction equals minus one-half of the recording interval. Figure 18 shows how the area under a curve is computed by integrating trapezoidal subareas under the curve. The general form of the equations are:

$$\text{Sub-area (n) : (n+1)} = [(v(n)+v(n+1))/2]dt(n) \quad \text{(EQ 9)}$$

where v = parameter value and n = data point number

$$\text{Total area (under curve)} = \sum_{1}^{n} subarea \quad \text{(EQ 10)}$$

$$\text{Daily mean value} = \text{Total area/86,400 seconds} \quad \text{(EQ 11)}$$

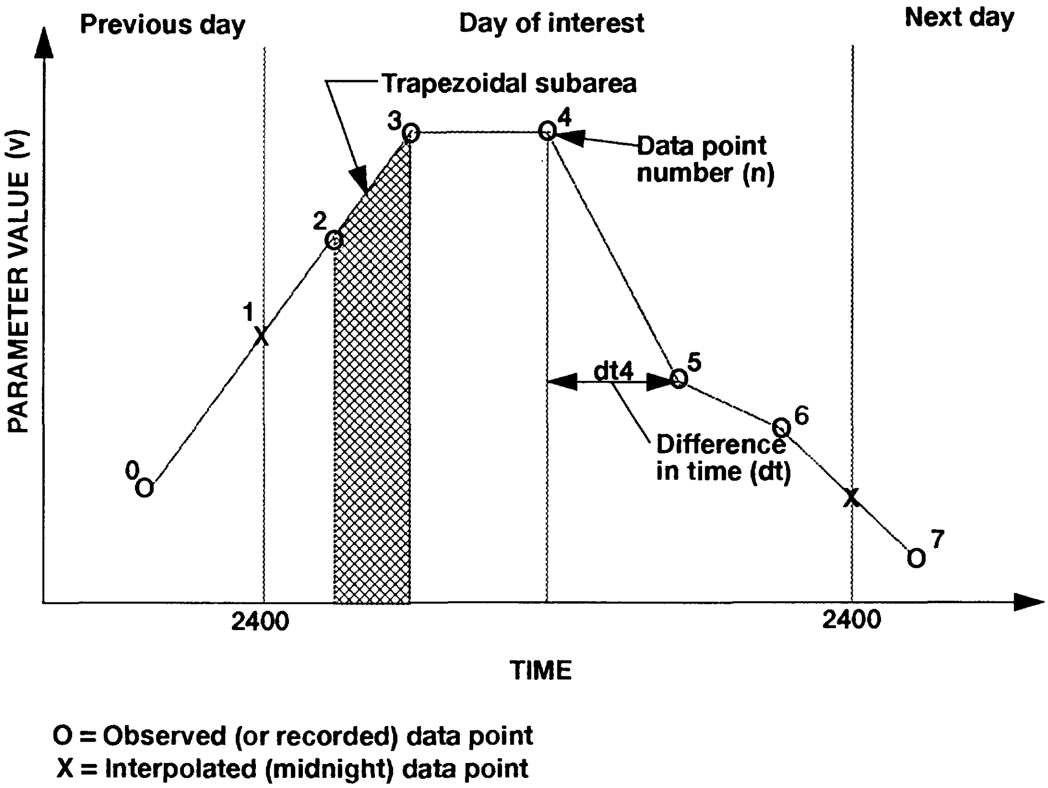


Figure 18. -- Trapezoidal computation method

The rectangular method is used to compute daily mean gage heights when the field recorder calculates and stores a mean unit value for an incremental period of time.

A time increment of 1 day has boundaries defined to be the 2400th hour of that day and the previous day. If values of gage height do not exist at the day boundaries, they will be interpolated from available data bracketing the boundary. This case shall require that the time between the adjacent values does not meet or exceed the daily-values abort interval. The interval is determined at the project or district level and is based on the recording device. If the daily-values abort interval is met or exceeded at either boundary but 1) the interval between the first or last recorded value for the day and the boundary does not meet or exceed the abort interval and 2) no other such interval occurs during that day, then the daily values computation shall proceed. Otherwise, should the abort limit be met or exceeded for any time during a day, the daily value will be flagged

as incomplete and a note shall be placed in the comment file to assist with the determination of the completeness of the record for the station analysis (see Surface-water Discipline Tables, section 7.4.6).

If a day is flagged as incomplete but subsequently is completed by supplemental data, the incomplete flag shall be removed and the daily mean gage height shall be recomputed.

Requirement 6.3.5.2-7 Provide for the computation of daily mean discharge

The trapezoidal method shall be used for computing all daily mean values of discharge from unit values of discharge and the rectangular method shall be used when recorded mean values are stored. The daily mean shall be stored as a real, unrounded value.

No daily mean value of discharge will be computed for days that include unit values containing flags indicating that the rating was exceeded.

The discharge for an incomplete day will be computed and output to the historical or standard primary (default is historical format) for review, but will not be stored in the data base unless specifically requested. These values will be flagged as an incomplete day.

If specified thresholds have been exceeded during a day, daily mean discharge will be computed, flagged for a threshold violation, stored, and output with a flag during the verification process.

Requirement 6.3.5.2-8 Provide for the computation of standard statistics

Standard statistics in addition to mean gage height and mean discharge shall be computed for each day there is a daily mean computed and for the period of computation to include:

- maximum and minimum gage height
- maximum and minimum discharge
- maximum and minimum shift

All unit values shall be used to determine maximum and minimum values, recorded (or interpolated) at the midnight times, 0000 and 2400. All statistics shall be stored as unrounded, real values.

In cases where unit values are incremental means, the maximum and minimum statistics should be appropriately flagged.

6.3.5.3 Computations of Discharge Affected by Variable Slope

Some discharge stations require more complex computations because of the presence of variable backwater. At these stations, two or three ratings will be necessary to compute discharge. This type of station, referred to as a slope station, requires two gages, a base (reference) gage, and an auxiliary gage some distance downstream or

upstream from the base gage. Both gages should be set at the same datum and the difference between the stage at the two gages is the water-surface fall, which provides a measure of the water-surface slope.

Gage-height corrections are applied, as described in Stage-Discharge Computations, section 6.3.5.2, except that corrections to both the base and auxiliary gage unit values, as needed, must be made before any computations.

Slope stations require 2 or 3 ratings to compute discharge from unit values of base gage height: 1) a stage-discharge rating, 2) a gage height versus fall rating (not needed for constant fall method), and 3) a factor rating of the relation between the ratio of measured discharge to rating discharge (Qm/Qr) versus the ratio of measured fall to rating fall (Fm/Fr). In the case of the constant fall method, the factor rating is a relation between Qm/Qr and Fm. The ratings can be developed using interactive graphics as provided for in sections 6.2.6 and 6.3.4.

Requirement 6.3.5.3-1 Provide for the computations of unit values of fall

Unit values of fall are computed by subtracting the auxiliary gage height from the base gage height, or vice-versa if the auxiliary gage is upstream from the base gage.

Unit values for simultaneous times shall be used for these computations; but if not available, time-interpolated unit values are used.

Requirement 6.3.5.3-2 Provide for the ability to apply shifts to unit values from the base gage

The process of applying shifts is the same as that for the stage-discharge process, except that shifts must be applied to the unit values of gage height for the base gage after the slope-adjustment factor, Qm/Qr, is computed. Then the corresponding rating discharge, Qr, for the shift-adjusted base gage height is multiplied by the adjustment factor, Qm/Qr, to obtain the slope-adjusted rating discharge.

Shifts should not be applied to the stage-fall rating or the factor rating.

The current rating curves (fall rating, stage-discharge rating, and factor rating) shall be displayed for user review.

Shifts and percent difference for each discharge measurement shall be computed using the three current ratings or user-selected ratings.

$$\text{Shift} = \text{Gm} - \text{Gadj} \qquad \text{(EQ 12)}$$

where: Gm = measured gage height

$$\text{Gadj} = \text{rating gage height corresponding to Qm} \qquad \text{(EQ 13)}$$

Computations

$$\text{Percent difference} = 100(Qm\text{-}Qadj)/Qadj \quad \text{(EQ 14)}$$

where: Qm = slope-adjusted measured discharge

$$Qadj = \text{slope-adjusted rating discharge} \quad \text{(EQ 15)}$$

Requirement 6.3.5.3-3 Provide for the computation of slope-adjusted rating discharge

The slope-adjusted rating discharge (true discharge) is computed as follows:

Unit values of gage height of base gage are used to enter gage height versus fall rating to determine rating fall (Fr) (not required for constant fall method).

The ratio of measured to rating fall, Fm/Fr, is computed and used to enter the factor rating to determine the ratio Qm/Qr. The factor rating is entered directly with Fm for the constant-fall method.

The stage-discharge rating is entered with the shift-adjusted base gage height to determine Qr.

The factor Qm/Qr is multiplied times the rating discharge, Qr, to determine the slope-adjusted rating discharge or actual flow in the stream.

Requirement 6.3.5.3-4 Provide for the computation of daily mean gage height

Computations of daily mean gage height for the base and auxiliary gages shall follow the same procedure as that for the stage-discharge process.

Requirement 6.3.5.3-5 Provide for the computation of daily mean discharge

Computations of daily mean discharge shall follow the same procedure as for the stage-discharge process.

Requirement 6.3.5.3-6 Provide for the computation of standard statistics

Standard statistics shall be computed by the same process as for the stage-discharge method but with the following additions:

- maximum and minimum daily gage height at the auxiliary gage
- maximum and minimum fall measured for each day
- discharge ratios associated with maximum and minimum discharges for each day
- times associated with each of the above
- daily mean auxiliary gage height

6.3.5.4 Computations of Discharge Affected by Rate-of-change in Stage

At some gaging station, the water-surface slope may at times be variable, and no simple relation may exist between stage and discharge. At such stations, rating loops may occur as a result of overbank flow or channel storage between the gage and the control. When this condition exists, the discharge for a given stage is greater when the stream is rising than when the stream is falling. Discharge measurements made on a rising stage plot

to the right of the base rating, while those made on a falling stage plot to the left. The rate-of-change in stage must be considered in computing discharge for these stations.

The two methods commonly used to compute discharge for stations where rate-of-change in stage is a factor are 1) the Boyer method, which relates the magnitude of the rating loop to the velocity of the flood waves and to the water-surface slope at constant discharge, and 2) the storage correction method, which treats the rating loop as a simple storage phenomenon. The two methods are similar in that each defines the correct discharge by applying an adjustment factor to the base rating discharge.

For the Boyer method, an adjustment factor (determined from a factor curve or table and the computed rate-of-change in stage) is multiplied by the rating-table discharge to obtain the corrected discharge.

Actual discharge for the storage-correction method is obtained by adding a storage correction to the rating-table discharge.

Requirement 6.3.5.4-1 Provide for the computations of rate-of-change in stage

For each unit value of stage, a rate-of-change in stage (dh/dt) value shall be computed by subtracting the previous recorded stage value from the one following the recorded value in time and converting to feet per hour. The sign of the value is carried with the value to indicate rising (positive values) and falling (negative values) stages.

If the rate of change is between default values of -.10 to +.10 ft/hr, this process shall stop and discharge shall be computed using the stage-versus-discharge method. The limits for this to occur shall be user-defined.

Requirement 6.3.5.4-2 Provide for the computation and distribution of shifts

The last used or specified rating shall include a factor curve (Boyer method), or storage curve (storage-correction method).

The optimum shift for each measurement will be computed as the shift required to bring the rating to the adjusted discharge rather than the measured discharge.

For each measurement, the adjusted discharge is computed as follows:

- Boyer method -- The adjusted discharge (Qadj) for each measurement is the measured discharge (Qm) divided by the square root of the term 1+(1/USc)(dh/dt), where 1/USc is obtained from the factor curve.
- Storage-correction method -- Qadj for each discharge measurement is computed by subtracting the discharge adjustment factor from the measured discharge. The discharge adjustment factor is determined by entering the storage curve or table with the mean gage height for the measurement to obtain a storage correction (delta Q/J) value and multiplying this value by J, where J is the rate-of-change in stage dh/dt, in ft/hr.

The gage heights used to enter the adjustment factor curves are unshifted.

Requirement 6.3.5.4-3 Provide for the computation of unit values of discharge

Unadjusted unit values of discharge will be determined by selecting the discharge from the rating-table file that corresponds to each value of the shift-adjusted unit value of gage height. The unadjusted discharges will then be adjusted by applying the discharge-adjustment factors by 1) multiplying each unit value of discharge by its adjustment factor (Boyer method), or 2) adding each unit value of discharge to its adjustment factor (storage correction method).

The adjusted unit values of discharge are true values and will be saved for further computation and archival. The unadjusted unit values of discharge shall be temporarily saved for user review.

Values of discharge that cannot be computed because they exceed the limits of the rating shall be appropriately flagged.

Requirement 6.3.5.4-4 Provide for the computation of daily mean gage heights

Computations of daily mean gage heights shall follow the same procedure as that for the stage-discharge process.

Requirement 6.3.5.4-5 Provide for the computation of daily mean discharge

Computations of daily mean discharge shall follow the same procedure as that for the stage-discharge process, except that daily mean discharge for days when the rate-of-change adjustment was used should be appropriately flagged.

Requirement 6.3.5.4-6 Provide for the computation of standard statistics

Standard statistics shall be computed by the same process as for the stage-discharge method but with the following additions:

- maximum and minimum rate-of-change in stage (dh/dt) values and associated times for each day
- maximum and minimum discharge-adjustment values and associated times for each day.

6.3.5.5 Computations of Discharge Associated with a Velocity Index

At some gaging stations, the use of a stage-discharge relationship to compute discharge from unit values of stage cannot be used because of variable backwater. At these stations, continuous sensing and recording of stream velocity at a point or along one or more lines across the stream, provides an index of the mean velocity of the stream. Ratings are required to relate stage to cross-sectional area, and to relate index velocity to mean velocity. An optional rating to relate stage to a velocity factor may also be used.

Requirement 6.3.5.5-1 Provide for computations of discharge at velocity index sites

Unit values of discharge shall be computed by use of the continuity equation,

$$Q = AV \tag{EQ 16}$$

where, Q = discharge

A = cross-sectional area, a function of stage

V = mean velocity of the stream, a function of index velocity, Vi, and the velocity factor, Fv. Fv also is a function of stage. If Fv is not used, V = Vr, where Vr is the velocity taken directly from the velocity rating. If Fv is used, the mean velocity is computed as:

$$V = Vr(Fv) \tag{EQ 17}$$

Special algorithms will be required for sites having multiple velocity sensors. The algorithms will allow the averaging of vertically spaced sensors and crosspath sensors, and the application of coefficients to account for missing data where one or more sensors are not functional.

Requirement 6.3.5.5-2 Provide for the computation and distribution of shifts

Shifts for stage-area and index-velocity ratings will be determined and applied in the same way as shifts for the stage-discharge process, stated above. Shift curves to either rating (velocity and/or stage-area) can be used directly or distributed by time. Shifts are not applicable to the velocity-factor rating.

Requirement 6.3.5.5-3 Provide for the computation of unit values

Unit values of mean stream velocity, cross-section area, and discharge shall be computed as follows:

Mean stream velocity, V, is computed by adding the shift to the index-velocity reading, determining the rating velocity, Vr, that corresponds to the shift-adjusted index-velocity reading, and multiplying the rating velocity times the velocity factor, Fv.

Cross-section area is computed by adding the appropriate shift to the gage height, and determining the area that corresponds to the shift-adjusted gage height from the stage-area rating.

Unit values of discharge are computed as the product of the mean stream velocity and the cross section area at simultaneous times. If unit values of V and A are not recorded at simultaneous times, or if time corrections cause them to be at different times, then the corresponding and simultaneous values for each unit value of velocity and area shall be interpolated.

If the site consists of multiple segments or channels, unit values of discharge are computed for each segment or channel. Unit values representing total stream discharge are computed by summation of the segment unit values for simultaneous time steps.

Requirement 6.3.5.5-4 Provide for computation of daily mean gage heights and index velocities

Computations of daily mean gage heights and daily mean index velocities shall follow the same procedure as that for the stage-discharge process.

Requirement 6.3.5.5-5 Provide for the computation of daily mean discharge

Computation of daily mean stream velocity, cross-section area, and discharge shall follow the same procedure as described for daily mean discharge in the stage-discharge computational procedure.

Requirement 6.3.5.5-6 Provide for the computation of standard statistics

Standard statistics shall be computed by the same process as for the stage-discharge method but with the following additions:

Unit values

- maximum and minimum gage height
- maximum and minimum index velocity
- maximum and minimum discharge
- maximum and minimum stream velocity
- maximum and minimum velocity factor
- maximum and minimum area
- maximum and minimum shift for stage-area rating
- maximum and minimum shift for velocity-index rating
- times associated with each of the above

Daily values

- daily mean gage height
- daily mean index velocity
- daily mean area
- daily mean-stream velocity
- daily mean discharge

6.3.5.6 Computations of Discharge at Control Structures

Some streamflow gaging stations are located near control structures, such as dams and pump stations, to take advantage of the control structure for rating purposes. Such sites can be simple setups involving only one or two gates or pumps, or they can be very complex setups including numerous gates, pumps, turbines, siphons, spillways, and locks. Five different flow controls may be present on a multipurpose structure. These are: 1) Tainter gates, 2) hydraulic turbines, 3) fixed spillways, 4) navigation locks, and 5) crest gates. The respective hydraulic equations for each of these control types are listed below. Although some of the ratings can utilize the NWIS-II rating-development features for stage-discharge stations, the ratings and calibration coefficients, for the most part, must be done external to the NWIS-II software and entered into the system manually.

Requirement 6.3.5.6-1 Provide for the computation of shifts from structure control ratings

This function will provide for the computation of shifts and percent differences in discharge from a structure rating to measurements of discharge made at a gaging site where the flow is controlled by a structure.

Requirement 6.3.5.6-2 Provide for computation of discharge

Primary computations of discharge at control structures will be similar to stage-discharge ratings, as described above, except that partial discharges will be computed for various components of the system and a summation will compute total daily discharge from unit values that have been interpolated to equal time intervals, as specified by users.

Where ratings of flow can be defined, compute discharge using the following hydraulic equations. Collins (1977) defines these symbols.

Flow control	Flow regimes	Hydraulic conditions	Equations for calibration & computation
Tainter gates	leakage	submergible gates, $h_g \approx 0$	$Q = (\Delta h/(\Delta h)_d)^{1/2}(q_{GL})$
	free orifice	$h_g<2/3h_1$ & $h_3<h_g$	$Q = Ch_gB(2gh_1)^{1/2}$
	submerged orifice	$h_g<2/3h_1$ & $h_3>=h_g$	$Q = C_{gs}h_3B(2g\Delta h)^{1/2}$
	free weir	$h_g>=2/3h_1$ & $h_3/h_1<0.6$	$Q = C_WBh_1^{3/2}$
	submerged weir	$h_g>=2/3h_1$ & $h_3/h_1>=0.6$	$Q = C_WC_{WS}Bh_1^{3/2}$
Turbines		$\Delta h>0$	$Q_t = K(\Delta p)^{1/2}$or
			$Q_t = K_1Q_{cm}$
Fixed spillway	free weir	$h_{3s}/h_{1s}<0.6$	$Q_s = C_{SW}B_sh_{1s}^{3/2}$
	submerged weir	$h_{3s}/h_{1s}>=0.6$	$Q_s = C_{SW}C_{SWS}B_sh_{1s}^{3/2}$
Locks		$\Delta h>0$	$Q_L = NA\Delta h/\Delta t$
	leakage	$\Delta h>0$	$Q_{LL} = (\Delta h/(\Delta h)_d)^{1/2}(q_{LL})$
Crest gates	free weir	$h_{1c}>0$	$Q_c = f(h_{1c},B_c)$
Flumes	free flow	$W_T>6.0$ ft.	$Q_0^{.645} = Y_0/1.345+Q_0^2/2.702Y_0^2(1+.4X_0)^2$
		$W_T<6.0$ ft.	$Q = Y_0g^{.5}/1.190W_T^{2.5}X_0^{.0494}$

where, Q = discharge, in cubic feet per second

Q_0 = nondimensional discharge, $Q/g^{1/2}W_T^{5/2}$

X_0 = nondimensional distance, LW_T

Y_0 = nondimensional depth, H_C/W_T

H_C = head at measuring section, in feet

W_T = channel width at throat of flume, in feet

g = acceleration of gravity, in feet per second squared

L = distance from throat crest to measuring section, feet

See TWRI Book 3, Chapter A14 (Kilpatrick and Schneider, 1983) for discharge correction coefficients to be applied when flumes are submerged.

6.3.5.7 Stage-Only Computations

The primary interest at some gaging stations is for stage data, useful for the design of structures affected by stream elevation and the planning of flood plane use. For these sites, the published records may consist of average daily stage, instantaneous "observed" stage at discreet times, or maximum and minimum stage for each day. Some site data that are input as gage height require a computation to convert gage height to elevation. However, these data are not used to convert gage height to discharge; therefore no rating and shift analysis and computations are required.

Requirement 6.3.5.7-1 Provide for the computation of unit values of gage height

Computations of unit values of gage height shall follow the same procedure as that for the stage-discharge process.

Requirement 6.3.5.7-2 Provide for datum adjustments

Datum adjustments (+ or -), will be added to recorded unit values of gage height to convert them to elevation.

Requirement 6.3.5.7-3 Provide for computation of daily mean gage heights and elevations

These computations will use the trapezoidal method and follow the same procedure as the stage-discharge process. Linear interpolation between observed unit values will be used to obtain unit values at midnight or at other times, as necessary.

Requirement 6.3.5.7-4 Provide for the computation of standard statistics

Standard statistics shall be computed by the same process as for the stage-discharge method but with the following exceptions and changes:

- Information concerning shifts will not be required.

- **Interpolated values will be used for any required value when instantaneous unit values are not available for a specific time. These values shall be flagged as interpolated and subject to abort limit tests described in Requirement 6.3.5.2-6.**

6.3.5.8 Computational Procedures Used on Stage Data Related to Tides

Tidal stations are usually located at or near the mouths of streams along coastal areas and estuaries. The primary interest at these sites is defining maximum and minimum tidal peaks and troughs for each day.

Requirement 6.3.5.8-1 Provide for the computation of unit values of gage height

Computations of unit values of gage height shall follow the same procedure as that for the stage-discharge process.

Requirement 6.3.5.8-2 Provide for datum adjustments

Datum adjustments (+ or -) will be added to recorded unit values of gage height to convert them to elevation.

Requirement 6.3.5.8-3 Provide for determination of tidal peaks and troughs

The corrected unit values of gage height shall be scanned continuously for successive peaks and troughs within periods of given length following the time of the previous extreme. After each extreme is found, the calendar day in which it occurred and time is determined. The method then proceeds to find the successive peak or trough, searching for an opposite extreme within the following 10.5 hours. Comparison of two peaks or two troughs found within the same calendar day are used to assign each as HIGH-HIGH, LOW-HIGH, HIGH-LOW, or LOW-LOW for the day. The daily values of HI-HI, LO-HI, HI-LO, and LO-LO will be stored in the data base.

If the next extreme occurs in the last hour of the 10.5 hour search period, it is assumed that this extreme is not a true tidal peak or trough in a semi-diurnal cycle, but is instead falling toward a trough or rising toward a peak in a diurnal tidal cycle. To find the real tidal peak or trough in this longer cycle, the search period is extended by another 12 hours and the new results are used as the next peak or trough. After finding the next opposite extreme using this search period (12 hours), the next search reverts again to the initial 10.5 hours so that a change back from a diurnal tide to a semi-diurnal tide is not missed.

Requirement 6.3.5.8-4 Provide for computations of daily mean gage heights and elevations

These computations will use the trapezoidal method and follow the same procedure as described for the stage-discharge process. Linear interpolation between observed unit values will be used to obtain unit values at midnight or at other times, as necessary.

Requirement 6.3.5.8-5 Provide for the computation of standard statistics

Standard statistics shall be computed by the same process as for the stage-discharge method but with the following exceptions and changes:

- Information concerning shifts will not be required.
- Interpolated values will be used for any required value when instantaneous unit values are not available for a specific time. These values shall be flagged as interpolated and subject to abort limit tests described in Requirement 6.3.5.2-6.

6.3.5.9 Computation of Lake and Reservoir Data

Many gaging stations are located on lakes and reservoirs for measuring the continuous or intermittent levels of the water bodies. The water levels are measurements of gage height above some arbitrary datum or are referenced to NGVD and converted to elevations. Where a relationship as been established between the level of a lake or reservoir and its contents, a rating can be developed and used to determine the contents for any given value of gage height or elevation.

Requirement 6.3.5.9-1 Provide for the computation of unit values of gage height

Computations of unit values of gage height shall follow the same procedure as that for the stage-discharge process.

Requirement 6.3.5.9-2 Provide for datum adjustments

Datum adjustments (+ or -) will be added to recorded unit values of gage height to convert them to elevation. Recorder adjustments shall be made when needed. In the case of a digital recorder, when recorded values decrease by more than 99.99 ft. between successive readings, the adjustment factor will be increased by 100.00 ft. When the recorded values increase by more than 99.99 ft. between successive readings, the datum adjustment factor will decrease by 100.00 ft.

Requirement 6.3.5.9-3 Provide for computations of unit values of contents

Datum adjustments will be applied to the gage-height data that have been time-corrected and to which gage-height corrections have been applied before contents (storage values) are computed from a rating table.

Linear interpolation between observed unit values will be used to obtain unit values at midnight or other times as necessary.

Requirement 6.3.5.9-4 Provide for computations of daily mean gage heights and elevations

These computations will use the trapezoidal method and follow the same procedure as described for the stage-discharge process.

Requirement 6.3.5.9-5 Provide for computations of daily mean contents

These computations will use the trapezoidal method and are the same as described for daily mean discharge in the stage-discharge process.

Requirement 6.3.5.9-6 Provide for the computation of standard statistics

Standard statistics shall be computed by the same process as for the stage-discharge method, but with the following exceptions and changes:

- Information concerning shifts will not be required.
- References to discharge apply to contents.
- Interpolated values will be used for any required value when instantaneous unit values are not available for a specific time. These values shall be flagged as interpolated and subject to abort limit tests described in Requirement 6.3.5.2-6.

6.3.5.10 Estimation and Comparison of Surface-Water Information

A complete set of daily discharge values are needed to complete the site records for the annual data report, compute runoff to reservoirs, calibrate models, or provide the discharge values for the computation of chemical or sediment loads. However, data are commonly missing because of failures of the sensing or recording device; or data may be invalid because of backwater from ice, debris choking the channel, sand waves passing in an alluvial channel, or other hydraulic conditions that invalidate the stage-discharge relationship. It is often necessary to estimate instantaneous values of stage or discharge, or extremes of stage or discharge for periods of missing record that may have lasted from a few minutes to many days. Computational procedures are provided to assist users in making reasonable estimates of missing discharge data.

Gage-height can only be reliably estimated for short periods of missing record, by subjective judgment and interpolation between periods of good record.

Requirement 6.3.5.10-1 Provide techniques to estimate missing data

Techniques shall be provided to compare time-series data for estimating discharge. The seven methods listed below, some of which are currently available, shall be provided:

- hydrographic and climatic comparison
- discharge ratio method Q = Qa(Qm/Qr),

where: Q = daily mean discharge to be estimated

Qa = discharge from the open-water rating curve corresponding to the daily mean gage height

Qm = measured discharge

Qr = discharge from the open-water rating corresponding to the gage height of Qm and interpolation is done by time between values of the ratio Qm/Qr

- semilogarithmic interpolation method
- ESTWAT or other regression-based techniques
- water budget method
- daily- or unit-values manipulation techniques
- flow routing

6.3.6 Climatological Data Computations

L.C. Trotta

The NWIS-II needs to provide for the storage and computation of various climatological data that may be recorded on a continuous basis or measured periodically at regular and irregular intervals. Recorded unit values of climatic parameters should be stored in the data base as original (unedited) unit values that may also require time adjustments and corrections for instrument error. The edited and corrected unit values can then be used to compute some standard daily statistics to be stored in the data base, and monthly and annual statistics for output.

Requirement 6.3.6-1 Provide for the following computations on measured climatic parameters

SNOW DENSITY (no units)

snow density = snow water equivalent (in inches)/ snow depth (in inches) (EQ 18)

WIND SPEED (mph)

$$\text{mean wind speed, } \bar{S} = \left(\sum_i^N S_i\right)/N\text{, as } i \text{ goes from 1 to } N \qquad \text{(EQ 19)}$$

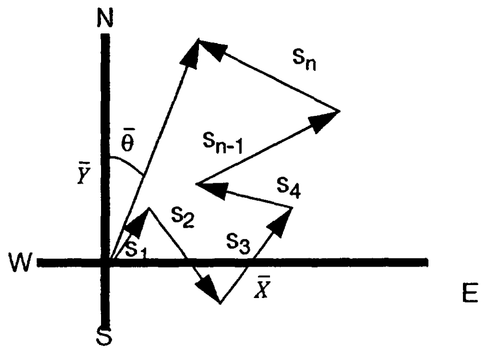
$$\text{resultant wind speed, } \bar{U} = \sqrt{\bar{X}^2 + \bar{Y}^2} \qquad \text{(EQ 20)}$$

$$\bar{X} = \left(\sum_i^N S_i \sin(\theta i)\right)/N \qquad \text{(EQ 21)}$$

$$\bar{Y} = \left(\sum_i^N S_i \cos(\theta i)\right)/N \qquad \text{(EQ 22)}$$

where N = number of observations, = T/t

T = output interval
t = sample interval
S_i = speed during *ith* interval
θ_i = direction during *ith* interval



WIND DIRECTION, DEGREES CLOCKWISE FROM TRUE NORTH

$$\text{resultant wind direction, } \bar{\theta} = \text{atan}\,(\bar{X} \div \bar{Y}) \qquad \text{(EQ 23)}$$

STANDARD DEVIATION OF WIND DIRECTION

$$\text{standard deviation of wind direction about } \delta\,(\theta) = 81\sqrt{1 - \bar{u}/\bar{S}} \qquad \text{(EQ 24)}$$

SATURATION VAPOR PRESSURE (millibars)

$$\text{saturation vapor pressure, } e_s = a_0+T(a_1+T(a_2+T(a_3+T(a_4+T(a_5+a_6T))))) \qquad \text{(EQ 25)}$$

where T = tempurature in degrees Celsius or Kelvin

a_i (i = 0,1,2,...,6) = numerical coefficients for the water reference formula

For temperature in degree Celsius	For temperature in degrees Kelvin
$a_0 = 6.107799961$	$a_0 = 6984.505294$
$a_1 = 4.436518521 \times 10^{-1}$	$a_1 = -188.9039310$
$a_2 = 1.428945805 \times 10^{-2}$	$a_2 = 2.133357675$
$a_3 = 2.650648471 \times 10^{-4}$	$a_3 = -1.288580973 \times 10^{-2}$
$a_4 = 3{,}031240396 \times 10^{-6}$	$a_4 = 4.393587233 \times 10^{-5}$
$a_5 = 2.034080948 \times 10^{-8}$	$a_5 = -8.023923082 \times 10^{-8}$
$a_6 = 6.136820929 \times 10^{-11}$	$a_6 = 6.136820929 \times 10^{-11}$

VAPOR PRESSURE (millibars)

$$\text{vapor pressure, } e_0 = (\text{relative humidity} \times e_s)/100 \qquad \text{(EQ 26)}$$

or

$$\text{vapor pressure, } e_0 = e_s - 0.00066p\,(T_a - T_w)(1 + 0.00115T_w) \qquad \text{(EQ 27)}$$

where e_s = saturation vapor pressure

p = atmospheric pressure measured, usually in inches of mercury
T_a = air temperature measured
T_w = wet bulb temperature measured with a sling psychrometer

All values of pressure may be stored in Pascal units.

Requirement 6.3.6-2 Provide for the adjustment to barometric pressure

Users shall be able to adjust observed values of barometric pressure to elevations different from which it was measured.

Requirement 6.3.6-3 Provide for the computation of standard statistics of climatic data

The following standard statistics shall be computed from stored unit values of climatic data that were recorded or input as periodic unit measurements.

- daily total precipitation
- maximum and minimum daily total precipitation for month and year having no missing daily values
- total precipitation for each month having no missing daily values
- precipitation intensity in inches per hour
- total precipitation per storm event
- daily minimum and maximum air temperature from recorded unit values
- daily mean temperature from recorded unit values

- daily mean temperature from once daily readings of maximum and minimum temperature

  where mean temperature = $(T_{max}-T_{min})/2$ (EQ 28)
- total daily snow-water equivalent from recorded unit values
- average areal snow depth from multiple samples taken at a site per date
- average areal density of snow from multiple samples taken at a site per date
- average areal water equivalent of snow from multiple samples taken at a site per date
- daily mean barometric pressure from recorded unit values
- daily minimum and maximum barometric pressure from recorded unit values
- daily mean vapor pressure from recorded unit values of temperature and pressure
- daily minimum and maximum vapor pressure from unit values of temperature and pressure
- daily mean wind speed from recorded unit values of wind speed and direction
- daily mean wind direction from recorded unit values of resultant wind direction
- wind run from unit values of resultant wind speed
- daily mean relative humidity
- daily minimum and maximum relative humidity
- daily mean dewpoint temperature
- daily minimum and maximum dewpoint temperature
- mean frostpoint temperature
- daily minimum and maximum frostpoint temperature
- daily mean saturation vapor pressure
- daily minimum and maximum saturation vapor pressure
- total evaporation
- total minutes of sunshine
- duration of sunshine as a percentage of total possible sunshine
- daily total direct solar radiation
- daily total sky radiation
- daily total global radiation
- daily total reflected solar radiation
- daily total net solar radiation
- daily total atmospheric radiation
- daily total terrestrial radiation
- daily total net longwave radiation
- daily total net radiation

6.3.7 Water-Quality Computations

D.W. Stewart, R.L. Moffatt, and M.C. Rowan

Computations of water-quality data include conversion of recorded unit values, computation of daily mean values or daily constituent loads from unit values, the computation by algorithms of unmeasured water-quality parameters from recorded data, and the computation of field parameters given input of raw data, such as the quantity of titrants used in field tests.

6.3.7.1 QW Monitor (unit value) computations

Quality of water data monitored in situ and recorded continuously generally require time adjustments and conversion from recorded unit values to engineering units. Conversions are done by application of an equation, after which adjustments of recorded time to real time are made. Corrections then can be made to adjust converted unit values to the true physical or chemical characteristics of the water body being measured.

Requirement 6.3.7.1-1 Provide for the computation of QW unit-values data

Computational procedures will be provided for processing recorded unit values of water-quality parameters similar to the computations of unit values of gage height. Conversion to engineering units will be done on recorded unit values and then stored as original-unedited or time-adjusted data. The unit values are then adjusted for time and edited for erroneous values. Corrections to adjust converted and time-adjusted unit values to the true physical or chemical characteristics of the water shall be performed by the user-defined methods listed below.

Requirement 6.3.7.1-2 Provide the ability to correct data using a variety of methods

Users shall have the ability to correct data for offsets, electronic drifts, and calibration problems--individually or in combination using the following methods:

- constant - apply constant value to data selection
- variable - corrections based on relationship defined by three or more points
- percent - corrections based on percentage of observed value
- equation - user-defined or standard equation
- constituent - based on input value of an associated constituents or a group of constituents
- coefficient - based on input-measurement-file data

6.3.7.2 Daily Load Computations

Daily constituent loads are calculated by user-selectable standard procedures using either direct computations or regression analysis. Direct computation is used when the independent variables are measured or recorded continuously. Regression analysis is used when one or more independent variables that accurately define a relationship to the variable of interest can be measured periodically and when stream discharge is a continuous record of unit values.

Requirement 6.3.7.2-1 Provide the ability to compute daily load

Users shall have the ability to compute daily load when discharge and constituent concentrations are measured continuously in time. The daily load will be computed by instantaneous readings, as shown below, or can be estimated from the instantaneous values available when the daily-value abort limit is equaled or exceeded Stage-Discharge Computations, section 6.3.5.2. If only daily mean data are available, the estimate of daily

load will be computed as the product of the daily mean discharge, daily mean constituent concentration, and K, and flagged as an estimate.

$$\text{Daily load} = \sum_{i=1}^{T} Q_i C_i K \qquad \text{(EQ 29)}$$

where: Daily load = the load of the constituent

Q_i = the instantaneous unit value of discharge

C_i = the instantaneous unit value of constituent concentration

K = a conversion factor (constant)

T = the total number of equal intervals of time in a day

Requirement 6.3.7.2-2 Provide the ability to compute constituent loads using regression equations or other computational tools

Other means shall be available to compute constituent loads using the math functions and statistical routines provided in Mathematics, section 6.2.4.

6.3.7.3 QW Computational Algorithms

Algorithms are used to compute certain water-quality parameters that are not measured in situ, but can be obtained from other parameters measured and stored within NWIS-II. Algorithms can be used to compute constituent values, chemical logic criteria, and laboratory precision. Algorithms also can be used to compute field-measured parameters for the analysis of samples done in the field or the computation of mean values of measured parameters in a cross section.

Requirement 6.3.7.3-1 Provide for water-quality parameter algorithms at the system level

A tentative list of the algorithms are provided for the computation of certain physical and chemical characteristics of water. (See Appendix F, Algorithms for Computed Parameters.).

Requirement 6.3.7.3-2 Provide for water-quality parameter algorithms to be user-defined

Users shall have the ability to define algorithms to be stored in their work area and used to compute certain physical and chemical characteristics of water when no algorithm is provided for at the system level.

6.3.8 Sediment Computations

L.C. Trotta and S.E. Hammond

There are several intermediate computations associated with the computation of suspended-sediment discharge. Computation of bedload, bed-material and total sediment discharge each has its own requirements. The NWIS-II

main focus lies in the storage and computation of suspended sediment discharge data. Although the other sediment computations are desirable in the NWIS-II, they will be needed less frequently.

Many sediment discharge computations are essentially the same as those required for chemical constituents. It is the purpose of the NWIS-II to integrate computational procedures across the limiting discipline boundaries. Removal of the somewhat arbitrary barriers in the current system will enable multidiscipline investigations relating sediment, water-quality, biological, and surface-water data.

6.3.8.1 Suspended Sediment Cross-Sectional Mean Concentration

A typical computation of suspended sediment cross-sectional mean concentration would include a user sorting/browsing through the results of laboratory analyses and selecting the appropriate samples needed to compute intermediate cross-sectional mean concentration. Once the selection of samples is completed the user is likely to: 1) retrieve the set of individual cross-section sediment concentration values into a temporary work space, 2) assess the quality of a given value and either (a) flag it in the data base as an unused part of the computation of cross-sectional mean concentration and drop it from further consideration or (b) use it as an input value to (EQ 30), and 3) save the computed cross-sectional mean concentration value.

Requirement 6.3.8.1-1 Provide the ability to compute cross-sectional mean concentration

The hydrographer shall be able to compute the cross-sectional mean sediment concentration. The mean concentration is determined from multiple suspended sediment samples taken at the cross section using the equal-discharge-increment (EDI) or the equal-width-increment (EWI) sampling method. This mean is used as a reference to determine the departure of the sediment concentration observed at a nearby, fixed sampling point where samples are collected more often.

The following conditions apply to the determination of the suspended-sediment cross-sectional mean concentration:

1. If the cross-section samples were collected using the EDI method, the concentration of the individual samples are averaged to determine the mean concentration.

$$C_c = \frac{\sum_{i=1}^{n} C_{v_i}}{n} \qquad \text{(EQ 30)}$$

where:

C_c = cross-sectional mean sediment concentration, in milligrams per liter;

C_{v_i} = sediment concentration in a vertical, in milligrams per liter;

i = the vertical number;

n = the total number of verticals.

2. If the cross-section samples were collected using the EWI method, the concentration for EWI will be computed by the laboratory and entered into the data base.

Requirement 6.3.8.1-2 Ability to save computed cross-sectional mean concentration values

The computed suspended sediment cross-sectional mean concentration values shall be saved (this value is the unit value in the present system), along with the net dry and sample weights.

Requirement 6.3.8.1-3 Ability to flag individual sediment concentration values used in computations

Analysts shall have the ability to discard (not use) the results of one or more of the individual cross-sectional concentration values if the values are not thought to be representative. The remaining concentration values must then be weighted accordingly to account for the discarded sample and shall be flagged as used in the computations.

6.3.8.2 Suspended-Sediment Concentration Coefficient

Suspended-sediment samples are routinely obtained at a fixed vertical or point in (or near) a cross section. The relation of the sediment concentration at a fixed location to the mean concentration in the cross section must be determined prior to computation of sediment discharge. A concentration coefficient is the ratio of the mean suspended-sediment concentration in the cross section to the concentration determined by samples at a fixed station (Porterfield, 1972, p.12).

Requirement 6.3.8.2-1 Compute suspended-sediment cross-sectional mean concentration coefficients

Users shall be able to compute a suspended sediment concentration coefficient using the following equation:

$$C_a = \frac{C_c}{\left(\frac{\sum_{i=1}^{n} C_{p_i}}{n}\right)} \qquad \text{(EQ 31)}$$

where:

C_a = suspended-sediment concentration coefficient, dimensionless;

C_c = cross-sectional mean sediment concentration, in milligrams per liter;

C_{p_i} = fixed point sediment concentration, in milligrams per liter.

C_p includes one or more values of sediment concentration for a sample(s) collected immediately before and after the cross-section samples. Individual concentration coefficients and the water-discharge hydrograph are then plotted using semilog and/or rectilinear graphs, allowing users to view the relationships and edit the

values. By close examination of the trends of the water discharge and the computed coefficients, interpolation between coefficients can be completed creating a continuous concentration coefficient time series. The editing is done using interactive graphics (see Graphical Input and Editing, section 4.7).

6.3.8.3 Suspended-Sediment Daily Mean Concentration

The NWIS-II will provide users with the ability to enter continuous suspended-sediment concentration data (see Graphical Input and Editing, section 4.7): (1) as discrete points sampled at a field location, then a graphics package is used to fit a continuous curve to the data points (see Interactive Graphics, section 6.2.6); or (2) as a digitized time series in which the data will have been plotted and a continuous concentration curve drawn by hand outside of the NWIS-II.

Concentration coefficients will be applied to the concentration curve after the suspended-sediment time-series data have been entered to the NWIS-II. This 'adjusted' suspended sediment concentration curve will be the product of the sediment concentration and concentration coefficient time series (see section 6.2.6). The adjusted sediment concentration curve is then used to compute the daily mean suspended-sediment concentration.

Requirement 6.3.8.3-1 Ability to integrate a suspended-sediment concentration curve

NWIS-II shall provide the ability to integrate a sediment concentration curve over a 24-hour period (midnight to midnight) to compute the daily mean suspended-sediment concentration.

6.3.8.4 Sediment Discharge

Computation of sediment discharge is made from: (1) suspended-sediment data, (2) bedload data, and (3) bed material data. Also, a variety of sediment computation programs currently exist to compute sediment discharge empirically.

6.3.8.4.1 Sediment Transport Curves (Ratings)

For periods where water discharge is fluctuating and prorating is not adequate, a transport curve can be used. To apply this procedure, the daily mean water discharge is determined and this value is used in conjunction with the transport curve to determine the daily mean sediment discharge or concentration. A major advantage of using a transport curve is that the estimated value can be easily reproduced.

Often by examining historical and current records for a station, general shape characteristics of its sediment concentration curves can be determined. If these characteristics are uniform and predictable, estimated concentration curves can be drawn with a fair degree of confidence. For periods of low flow and low sediment concentration, drawing an estimated concentration graph and estimating the concentration by proration is an excellent cross-checking technique. The following relationships can be reviewed and edited by means of interactive graphics (see Interactive Graphics, section 6.2.6).

- water discharge versus sediment discharge
- water discharge versus sediment concentration
- rate of contaminant discharge versus rate of transport medium discharge
- suspended-sediment concentration for fixed location versus cross-sectional mean

6.3.8.4.2 Suspended Sediment Discharge

For days when samples were not obtained, the suspended-sediment discharge is estimated (see Requirement 6.3.8.5-1).

Requirement 6.3.8.4.2-1 Provide the ability to compute suspended-sediment discharge

Suspended-sediment discharge shall be determined for days when samples were collected as a time-series of data using the same formula used for daily load Daily Load Computations, section 6.3.7.2.

6.3.8.4.3 Bedload Discharge

Instantaneous bedload discharge can be computed for a single vertical in the cross-section, the active zone of bedload transport, or for the entire cross-section. These computations can be made for each particle-size class or composited size classes. Present WRD policy states that bedload data will not be adjusted for the efficiency of the bedload sampler. Therefore, only unadjusted bedload data shall be allowed in the NWIS-II data base.

Requirement 6.3.8.4.3-1 Provide the ability to compute bedload discharge

Users shall have the ability to compute bedload discharge through a cross section using the single equal width increment method, the multiple equal width increment method, or the unequal width increment method. The equations used and definition of terms are found in Open-File Report 86-531 (Edwards and Glysson, 1988, pp. 103-107).

Requirement 6.3.8.4.3-2 Flag bedload discharge values

Computed values of bedload discharge shall be flagged as either (a) dry weight of sediment, or (b) submerged weight of sediment.

Computed values of bedload discharges for a cross section shall be flagged as either (a) total width of channel cross section, (b) active zone of bedload transport, or (c) a subsection of the active zone of bedload transport.

6.3.8.4.4 Total Sediment Discharge

Ordinarily suspended-sediment discharge incorporates 100 percent of the water discharge through a cross section. However, to compute total sediment discharge analytically the value of suspended-sediment

discharge Q_s is adjusted. This is accomplished by decreasing the total water discharge Q_i in (EQ 29) by the discharge passing through a zone near the streambed having the height of the bedload nozzle above the streambed. The adjusted suspended sediment discharge Q_{s_a} is then used to compute the total sediment discharge Q_t.

The bedload discharge and the suspended sediment discharge should both be in terms of dry weight to complete the total sediment-discharge computation.

Requirement 6.3.8.4.4-1 Provide the ability to compute total sediment discharge

Total sediment discharge is generally computed analytically as follows.

$$Q_t = Q_{s_a} + Q_b \qquad \text{(EQ 32)}$$

where:

Q_t = total sediment discharge, in tons per day;

Q_{s_a} = suspended-sediment discharge (adjusted), in tons per day;

Q_b = bedload discharge, in tons per day.

6.3.8.4.5 Empirical Sediment Discharge

Discharge from bed material, bedload, and total sediment can be computed using a variety of empirical equations. Bed material data, suspended sediment data, and hydraulics data are generally required input to many of these functions.

Requirement 6.3.8.4.5-1 Provide the ability to export data to an application program that computes sediment discharge empirically

NWIS-II shall have the ability to export data out of the program in the appropriate format for input to application programs (e.g., sediment computations programs).

6.3.8.5 Estimated Sediment Parameters

There is a necessity to compute sediment concentration or sediment discharge when no sediment samples have been collected. Record estimation can be accomplished in a variety of ways that include: 1) proration, 2) transport curves, 3) estimated sediment concentration graphs, 4) hydrographic comparison, 5) rating curve/ flow duration.

Requirement 6.3.8.5-1 Provide several methods to estimate missing sediment record

NWIS-II will provide several methods to estimate missing sediment record. The estimation methods are:

(1) Prorate sediment discharge from one known date to the following known date.

(2) Transport curves are used to provide information about the trend of an unknown parameter when related to another known parameter (e.g., sediment discharge related to water discharge) Interactive Graphics, section 6.2.6).

(3) Estimated concentration graphs can be drawn, as discussed in section 6.2.6.

(4) Hydrographic comparison shall allow two or more stations' sediment records to be compared to estimate missing record, usually by comparing trends in sediment discharge or sediment concentration.

(5) Rating curve/flow duration estimation is used when only a load for a storm or event is desired.

6.3.8.6 Sediment-Related Statistics

Requirement 6.3.8.6-1 Store computed statistics necessary for sediment calculations

NWIS-II or PC&TS shall provide algorithms to compute statistics associated with suspended-sediment, bedload, and bed-material data. The system also shall store the computed statistics necessary for sediment calculations (e.g., sample weight, percentage of material in each size class, and particle size for specified percentiles). Some of these components will be provided by the sediment lab [in paper form, but electronic form should be encouraged]. Bed-material data also may enter NWIS-II through field notes where the analysis was conducted.

Statistical analysis of suspended-sediment data shall include the mean size, geometric-mean size (Requirement 6.2.5-1), and measures of symmetry to describe the particle-size distribution determined from the lab. Statistical analysis of bed material would be similar to that for suspended sediment, but would also include such statistical descriptions as pebble geology and location, density, and specific weight.

One measure of symmetry for a particle-size distribution curve is known as the "percent finer." Laboratory size analysis determines the percent of the total sample in each size class. When entered into a file system they will be expressed as percent finer than the indicated size class, based on the weight of the sample.

6.3.9 Water-Use Computations

S.E. Hammond, T.W. Augenstein, and R.L. Moffatt

The nonstandard nature of water-use data requires that data manipulation and computation capabilities be flexible. Data formats and units vary according to data availability and cooperator needs, and frequently ancillary data are collected and used with a coefficient to calculate an estimate of water use. As with many of the other disciplines that will use the NWIS-II, the water-use user must have a set of basic tools for computing and manipulating site-specific and aggregated data. The water-use computations described below are derived from (1) the water-use user group, (2) "Estimated Use of Water in the United States in 1990: Guidelines for Preparation of State Water-Use Estimates" (Solley and others, written commun., 1990) , and (3) the manual provided at the NTC course on water use (Solley and others, written commun. 1990). The requirements are generally organized to provide for computations to produce site-specific data, computations using site-specific

data to produce other values, and aggregation of data. Calculations on aggregated data for accumulating amounts of water by source, use, and disposition are listed in Appendix F: Algorithms for Computed Parameters.

Requirement 6.3.9-1 Provide the ability to make computations interactively

The NWIS-II shall provide the ability to do interactive calculations using data retrieved from the data base and user-specified input from the keyboard.

6.3.9.1 Site-Specific Computations

Water-source and water-use data compilations depend on site-specific data that may be measured by the USGS, collected from alternate sources such as publications, or reported by industries or cooperating agencies. The site of water source or water use may be very unique, such as a diversion point at a well head or stream, or a delivery point like a thermoelectric plant; or the site may be more encompassing to include many points of diversion that come together, or many points of use that draw from the same source. The following requirements for the computation of site-specific data include single- and multiple-point site data.

Water-use flow measurements determine the volume of water passed through an aqueduct. Users can make direct-flow measurements by timing the flow for a specific volume of water discharged into a calibrated container, make discharge measurements with a velocity meter, use a rated control structure, or measure the attributes of flow through a pipe (e.g., how full the pipe is, the angle of discharge). Indirect pipe-flow measurements can be made from electrical, power-consumption records on a metered electric pump.

Requirement 6.3.9.1-1 Provide the ability to compute pipe-flow directly

Users shall have the ability to compute the volume of flow in a pipe using measured data.

$$V_t = t \times F \qquad \text{(EQ 33)}$$

Where: V_t = total volume of water discharge for a specified time period t, in gallons per minute;

$$F = A \times K\text{, flow for a filled pipe}$$
$$F = A \times K \times C_f\text{, flow for a partially filled pipe}$$

F = volume of pipe discharge, in gallons per minute;

A = measurement from the pipe outlet, in inches;

K = constant used to determine discharge;

C_f = correction factor for partially filled pipe.

Tables for K and C_f are located in the revised Handbook of Recommended Methods for Water-Data Acquisition (Herbert and others, 1990, chap. 11, p. 70).

Requirement 6.3.9.1-2 Provide the ability to compute pumping time

Users shall have the ability to compute pumping time using an electrical equivalent of pipe flow (Hurr and Litke, 1989). Additional information is contained in the section on irrigation in the NTC water-use concepts training manual (Solley and others, written commun., 1990).

$$t = \frac{E}{P} \quad \text{(EQ 34)}$$

Where: t = time, in minutes or hours (substitute into (EQ 33) above);

$$E = (R_2 - R_1) \times f_{CT} \times f_{PT} \quad \text{(EQ 35)}$$

E = energy consumption during measurement period, in Kilowatt hours;

R_i = beginning and ending power meter reading, in Kilowatt hours;

f_{CT} = current transformer factor;

f_{PT} = potential transformer factor;

$$P = 3.6 \times M_{dr} \times Kh \times f_{CT} \times f_{PT} \quad \text{(EQ 36)}$$

P = power demand, in Kilowatt hours;

M_{dr} = measured meter disk revolution rate, in revolutions per second;

Kh = power meter factor, in watt-hours per revolution.

6.3.9.1.1 Water Conveyance Systems

A conveyance is the means by which water is transferred from one point to another, generally through man-made structures. During the transfer of water from one point to another, there may be losses and gains in the amount of water. Conveyance systems may extend across artificial boundaries, such as political or project; or physical boundaries, such as hydrologic units or aquifers. To account for the volume of water transferred through a conveyance system, it is important to be able to track and measure (or estimate) the quantity of water at specific sites on the conveyance. Users need the ability to assess data on inflow and outflow to a reach of conveyance where inflow is steady over the period of time when measurements are made at endpoints of a reach.

Requirement 6.3.9.1.1-1 Provide the ability to compute conveyance losses and gains

NWIS-II shall have the ability to compute losses and gains from measurements or estimates of the quantity of water at points along a conveyance by conservation of mass, where inflow minus outflow equals the change in storage. If values for both endpoints are known, the conveyance loss does not need to be stored. If

the conveyance loss or consumptive use is calculated with a coefficient and one set of measurements, the resulting values should be stored in the data base.

Gains and losses can be aggregated where a series of measurements are made at different points on the conveyance system.

The computations are based on selected end points of a reach of the conveyance, regardless of dissecting political or physical boundaries.

6.3.9.1.2 Wastewater

Wastewater can be either returned to the environment after use or reclaimed for reuse. Reclaimed wastewater (also known as reclaimed sewage) is water that is released for reuse after being processed in a sewage treatment facility. Wastewater returns can be estimated from public-supply deliveries plus distribution gains, minus estimated distribution losses and consumptive uses, plus self-supplied user discharges. If returns are known, the net of distribution losses and gains could be calculated by taking the difference between deliveries and returns.

Requirement 6.3.9.1.2-1 Provide the ability to compute wastewater returns

Known or reported values of wastewater returns and reclaimed wastewater shall be input and stored in the NWIS-II data base. If watewater return values are not known, users shall be able to calculate them by creating and storing a user-defined script that will access and operate on site-specific data stored in the data base (Guidelines for Preparation of State Water-Use Estimated, Solley and others, written commun., 1990, p. 88). Since conditions are not the same for every water supply and sewage treatment system, the user-defined script shall be tied to the data. Several prototype scripts shall be available for users to either implement or modify. The following are examples of calculations that will be available in prototype scripts.

(1) Calculations to total known transfers of water to the water-treatment facility.

(2) Calculations to estimate water entering a water-treatment facility based on deliveries of water from a public supply and consumptive-use information for specific users.

(3) Calculations to estimate water entering a water-treatment facility based on withdrawals and consumptive use information for self-supplied users.

(4) Calculations to estimate values of gains or losses in the distribution system or sewage lines.

(5) Calculations to estimate return flow from a sewage treatment facility.

6.3.9.2 Aggregation of Site-Specific data

Water-use data are summarized by county, hydrologic unit (region, subregion, accounting, and cataloging), or aquifer. Aggregations also need to be done on smaller areal scales by water source, water-user category, and

standard industries code (SIC). Aggregate computations can include site-specific information, estimates for incomplete data in a water-use category, or a combination of the two to arrive at summary totals.

It should be possible to aggregate site-specific data to all possible aggregate data types described in Solley and others (1988, pp. 8-9). The calculations involve retrieving site-specific data values with appropriate descriptive information; then, depending on the type of data to aggregate, the calculation may involve a variety of mathematical functions. NWIS currently has this functionality; however, users also need the ability to aggregate user-defined data types.

Requirement 6.3.9.2-1 Provide the ability to aggregate site-specific water-use data

The NWIS-II shall provide the ability to aggregate site-specific water-use data. Users shall have the options to store the aggregate values directly in the NWIS-II data base or be written to a fixed-format file in formats that can be easily read by programs, such as spreadsheets or data base management systems, or have the aggregate values loaded directly into a spreadsheet.

6.3.9.3 Extrapolation of Site-Specific Data

The extrapolation of site-specific data to aggregated values may take one of several forms depending on the geographic entity and water-use category being summarized. For example, the industrial use for a particular aquifer may be known to be restricted to certain types of industries requiring its specific water-quality characteristics. Use at a few known sites can be extrapolated to other sites indicated in a directory of manufacturers. In another case, the commercial use for a county may be well known for a portion of the county but must be extrapolated based on road density, market area statistics, or areal percentage for the rest of the county. These extrapolation methods will provide acceptable results if the category and facility characteristics are similar. Extrapolation of a partial inventory of site-specific data can be accomplished by:

(A) Extrapolating demographic information into desired water-use units

(1) correlating demographic information with the actual water-use information
(2) calculating a coefficient
(3) prorating the site-specific data to the entire unit size

(B) Weighting or prorating the known quantity for sites over the total number of sites

$$T_a = m \times \left(\frac{\sum_{i=1}^{n} a_i}{n} \right) \qquad \text{(EQ 37)}$$

Where:

T_a = total aggregated water use for a given category, in gallons per unit
m = total number of sites for a given water-use category
a_i = value for a specific water-use site with a given water use, in gallons per unit
n = number of sites sampled for a specific water-use category

Requirement 6.3.9.3-1 Ability to aggregate through extrapolation of site-specific data

NWIS-II shall provide the ability to extrapolate partial inventory of site-specific data into an entire aggregated unit.

Requirement 6.3.9.3-2 Provide for additional calculations on site-specific data

Users shall be able to calculate any set of measurements from a known set using coefficients that are also stored in the data base and associated with the data values.

Users will be able to calculate monthly and annual water-use values from ancillary data stored in the data base. Ancillary data that could be used include: population served, acres irrigated, employees, previous year's water use, pumping time, production amounts, and power generated.

Users shall be able to distribute an aggregated measurement such as master meter readings to the sites that contribute to the flow, using stored contribution percents or a default of equal distribution. The values can be stored in the data base, and require users to flag either the distributed values or the aggregate value so that this water will not be double-counted during a larger-scale aggregation. The same can be done for return flows to be distributed among several discharge pipes, and for measurements from a single well to be distributed to several contributing aquifers.

Distribute water sales by a water supplier to the relevant customers and customer groups, using coefficients entered into the data base by users. The coefficients will be accessed by programs or scripts used to perform calculations for different facilities.

Calculate the consumptive use in a facility from measurements of all water entering the facility and all water leaving the facility.

Requirement 6.3.9.3-3 Provide the ability to compute per capita water use

NWIS-II shall provide the ability to compute per capita water use from site-specific and aggregated data.

The following equation incorporates census data and requires the ability to use an external data base or reference file of census data to compute per capita water use.

$$U_{pc} = \frac{A}{B} \qquad \text{(EQ 38)}$$

Where:

U_{pc} = per capita water use, in gallons per day per person

A = water-use volume, in gallons per day

B = population data, in number of persons

6.3.9.4 Reaggregation of Data

Some aggregated water-use data may exist in units not directly usable in a report. These data can be transformed or reaggregated into desirable units required for analysis and/or publication. Data received in an aggregated format may have to be divided into subunits for particular geographic areas of interest and then reaggregated into the desired areal units.

Requirement 6.3.9.4-1 Provide the ability to reaggregate data into new units

Users shall have the ability to reaggregate data when the stored aggregate was computed using: 1) only one of the desired units, such as county, and 2) a unit entirely different than the required ones. This is most easily accomplished by:

- overlaying maps of the acquired units and the desired units,
- estimate the proportion of the acquired unit that lies in the desired unit,
- multiply the water-use amount for the acquired unit by the proportion of the acquired and save the value as a subtotal for the desired unit, and
- after proportioning all the data for the acquired unit sum the subtotals for the desired unit.

Users shall be able to split reaggregated data by applying a coefficient of other-than-geographic proportions, such as by relative population in two geographic areas.

6.3.9.5 Estimated Aggregates

The basic estimated aggregate is the calculation of water withdrawals for an area based on an ancillary data item and a coefficient. For example, the number of cattle in each county may be stored and water use by these cattle calculated with a coefficient of water use per head. In a more complex case, the total population in each county might be stored, and the total population served by public suppliers would need to be subtracted from the total population to arrive at the self-supplied population. Then a per capita use coefficient could be applied to estimate water withdrawals.

The more complex cases are best handled in a spreadsheet, and the results moved into the data base. Some of the values needed to complete a computation will reside in the NWIS-II data base. However, other input values will be located in user-defined lists or supplied by the user as a result of an intermediate or external computation. This section is broken down by the type of water-use estimate, not by water-use category. Calculations generic enough to cover several water-use categories are given first with references. Category-specific calculations follow the more generic calculations.

6.3.9.5.1 Water Withdrawals

Water withdrawals include water removed from the ground or diverted from a surface-water source for use (e.g., industrial, commercial). Commonly, water is withdrawn from more than one aquifer. These withdrawals must be by site or by aggregated totals.

Computations

The estimate of aggregated ground-water withdrawal could involve one or several aquifers. This type of computation could be done by executing a user-defined script with mathematical functions from within NWIS-II or externally, using a spreadsheet package.

Water withdrawal for several water-use categories will be estimated through the use of some count estimate of the number of users, SIC codes, and coefficients implementing a user-defined script (Solley and others, written commun., 1990, p. 34 commercial, p. 40 industrial, p. 48 mining, p. 54 fossil-fuel power, p. 61 nuclear power, p. 67 hydroelectric power, p. 72 stock, p. 77 animal specialties).

Water deliveries are the amounts of water received by various users from water suppliers (Solley and others, written commun., p. 25 domestic, p. 35 commercial, p. 41 industrial, p. 55 fossil-fuel power, p. 61 nuclear power). Water deliveries are normally estimated by user-defined script.

6.3.9.5.2 Consumptive Water Use from an Aggregated Total Withdrawal

Consumptive-use estimates are most frequently derived by applying a percentage against withdrawn and delivered data (EUOWITUS, p. 26 domestic, p. 35 commercial, p. 41 industrial, p. 48 mining, p. 55 fossil-fuel power, p. 62 nuclear power).

In NWIS-II, these percentages or coefficients most likely will vary from State to State. The coefficient may exist as a part of a user-defined list, or the equation used for a specific State may exist with the coefficient in place. For accuracy, this computation should be done on the smallest level possible (preferably site by site).

$$C_u = k_{cu} \times (X_{ww} + X_{wd}) \qquad \text{(EQ 39)}$$

Where:

C_u = consumptive use, in millions of gallons

k_{cu} = percentage or coefficient used to estimate consumptive use

X_{ww} = water withdrawal, in millions of gallons

X_{wd} = water deliveries, in millions of gallons

The largest amount of domestic consumptive use probably occurs from lawn watering (EUOWITUS, p. 26). Therefore, lawn-watering estimates may be useful for estimating domestic consumptive use. The following equation will be used to estimate domestic consumptive use from lawn watering:

$$Q_s = 0.6 \times c \times a \times L_s (E_{pot} - P_{eff}) \qquad \text{(EQ 40)}$$

Where:

Q_s = total sprinkling use for "a" dwelling units, in gallons per day ($Q_s = 0$, when precipitation occurs)

c = constant to adjust for units (27,2000 gallons per acre-inch)

a = number of dwelling units

L_s = average lawn area, in acres

E_{pot} = average potential evapotranspiration, in inches per day (highly variable)

P_{eff} = effective precipitation, in inches per day (highly variable)

Requirement 6.3.9.5.2-1 Provide the ability to estimate aggregates

NWIS-II shall provide a means by which calculations can be meaningful estimates of aggregated water-use data to be stored and flagged as estimated.

6.3.9.5.3 Octopus Diagrams

Water-use specialists have developed a diagram that graphically summarizes the source and disposition of water in a geographic area for one or more categories of water use. The amounts of water are shown with proportionally sized boxes and the boxes are connected with proportional- or uniform-width flow lines, thus the name "octopus diagram." An example of this type of diagram is shown in Figure 19. All of the data used to produce an octopus diagram should reside in aggregated form in the NWIS-II data base. The statistics for octopus diagrams consist of percentages for withdrawals from different sources, public-supply deliveries to each category, water uses, and water dispositions. The water volumes totaled from sources, uses, and dispositions must be equal, and percentages for each subtotal must equal 100 percent.

Although the SOURCE and USE categories themselves may vary slightly, all octopus diagrams follow the same general format.

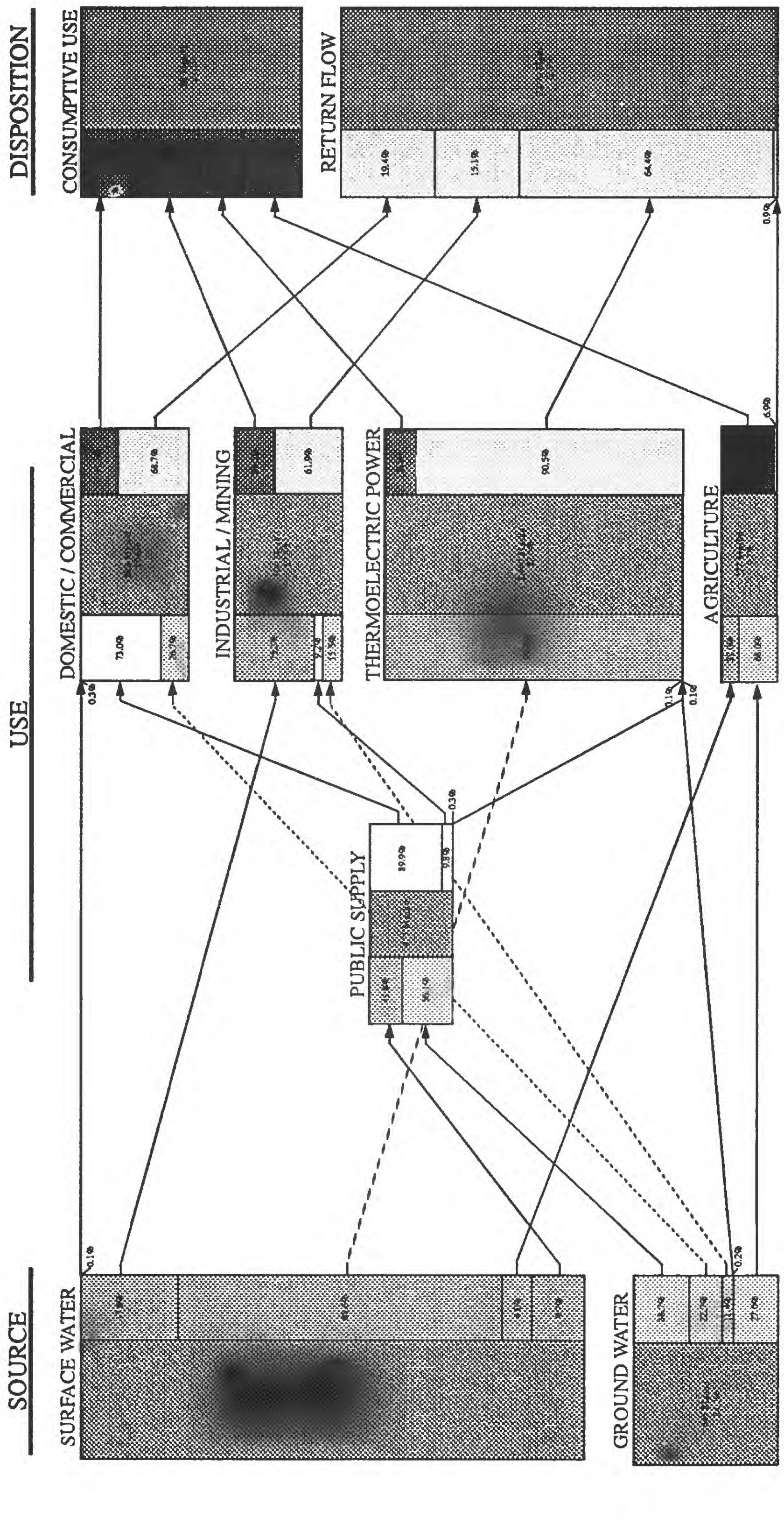


Figure 19. - Example of water-use octopus diagram from the National Water Summary 1987, Minnesota (U.S. Geological Survey, 1990).

Requirement 6.3.9.5.3-1 Provide the ability to compute percentages for octopus diagrams

The following percentages shall be calculated:

- percent surface water withdrawn of total water withdrawn
- percent ground water withdrawn of total water withdrawn
- percent of total surface water withdrawn by each category, including public supply
- percent of total ground water withdrawn by each category, including public supply
- percent of water used by each category supplied from ground water, surface water, and public supply
- percent of water used for each use of total water used
- percent of water used by each category that was consumed, and percent returned
- percent of total consumptive use by each category
- percent of total return flow returned by each category
- percent of total water disposed of represented by consumptive use
- percent of total water disposed of represented by return flow

Requirement 6.3.9.5.3-2 Provide accurate totals for octopus diagram statistics

The water volumes totaled from sources, uses (other than public supply), and dispositions in the example above should be equal. The values shall be compared and discrepancies reported to the user. Percentages for the various subcategories and the percentages for the SOURCE, USE, and DISPOSITION categories should equal 100 percent. The percentages shall be verified and discrepancies reported to the user.

6.3.9.6 Quality Assurance of Water-Use Data

A few quality codes and statistics associated with water use are desired to help qualify and compare data collected over various periods of time. The statistics include annual averages, percent change in volumes of water source or water use from one time period to another, and percentages of water source, use, and disposition used in octopus diagrams.

Besides the specific requirements for statistics as stated below, users will be able to use any math function or statistical routine available in third-party software (see Mathematics, section 6.2.4 and Statistics, section 6.2.5).

Requirement 6.3.9.6-1 Provide the ability to denote certain water-use data

The new system shall allow users to identify site-specific data in output as questionable, estimated, or reported.

Requirement 6.3.9.6-2 Provide the ability to compute monthly and annual averages

Users shall have the ability to compute monthly averages from daily averages and annual averages from monthly averages for any site-specific data.

Annual averages can also be input to the data base and compared to computed annual averages.

Requirement 6.3.9.6-3 Provide the ability to compare total aggregated data

Statewide totals of each water-use data type, aggregated by county, HUC, and aquifer shall be compared with one another for quality control.

Requirement 6.3.9.6-4 Provide the ability to compute a percentage change between values

NWIS-II shall provide the ability to compare the current water-use values with previous values by computing a percentage change statistic for specified water-use sources or categories.

$$\text{Percent change} = 100(A-B)/B \qquad \text{(EQ 41)}$$

Where: A = present value for source or category

B = previous value for source or category

6.3.10 Biological Computations

C.L. Qualls, S.M. Trapanese, and M.C. Rowan

Based upon constituent or parameter identification of the sample on which the biological user is working, only the relevant categories, methods, and equations will be displayed as computational options. However, the biological user also shall have the ability to use the math tool box to define new equations (see Computational Tools, section 6.2).

If the identification of the sample and method is unknown, the system shall display groups of selected biological computations presented in the above reference. Biological Computations are based on Britton and Greeson (1989).

Requirement 6.3.10-1 Provide for the computations of biological and associated parameters

Computations described within the following subsections shall be provided for. The available computational categories are:

- bacteria counts
- phytoplankton
- zooplankton
- seston
- periphyton
- macrophytes
- benthic invertebrates
- aquatic vertebrates
- cellular contents
- primary productivity
- bioassay algal growth potential

Requirement 6.3.10-2 Archival of laboratory and field data needed for computation

Certain data values are needed as input to computational schema and shall be stored for use at the local node but will not be viewable. These data values shall be archived near online and shall not be part of the national system data base. The resulting values from computations also shall be stored and will be available to anyone having adequate viewing rights. These data will be part of the national system's data base.

Requirement 6.3.10-3 Rounding of intermediate computed or derived values

The NWIS-II computations shall round intermediate computed or derived values to the proper number of significant figures prior to the intermediate values subsequent use in the next computation.

6.3.10.1 Bacteria Count

Determinations that estimate a bacteria count for a water sample are made using one of the following methods: (1) Membrane Filter, (2) Most-probable-number, and (3) Epifluorescence.

6.3.10.1.1 Membrane Filter Method

The membrane filter method determines the number of bacterial colonies per milliliter from the filtrations of water samples. The volume and dilution factor of each water sample is recorded. The membrane filters are placed in petri dishes with growth medium and incubated. After incubation, the number of bacterial colonies are counted for each filter. The applicable tests or applications of the membrane filter method and method numbers are:

- Standard Plate Count (31751): B-0001-85
- Total Coliform (immediate incubation): B-0025-85
- Total Coliform (delayed incubation): B-0030-85
- Fecal Coliform (immediate incubation): B-0050-85
- Fecal Streptococci (immediate incubation): B-0055-85
- Pseudomonas aeruginosa: B-0105-85
- E.coli

Users will select the appropriate application of the Membrane Filter method and enter:

(1) Colony count

(2) Volume of water (mL)

The computational system shall allow users to enter interactively, or from an external file, one or more values for colony count and volume. The system shall scan the colony count values per the computational boundary conditions to determine the proper handling of the calculation. If a user enters more than one value for the colony count that is ideal based upon the boundary conditions, the system will add or perform a summation to determine the Colony Count Sum. The Volume Sum shall be performed in the same manner. The system then determines the bacterial count of colonies per mL by (EQ 42) or colonies per 100 mL by (EQ 43) and stores the value in the NWIS-II data base.

Computations

The individual colony counts and volumes used as input shall be stored or archived by the system in a near online format.

The system will use (EQ 42) to compute colonies/mL for the Standard Plate Count application:

$$\text{Colonies per mL} = \frac{\Sigma \text{ colonies counted}}{\Sigma \text{ volume (mL)}} \qquad \text{(EQ 42)}$$

The system will use (EQ 43) to compute colonies/100 mL for all other applications:

$$\text{Colonies per 100 mL} = \frac{\Sigma \text{ colonies counted X 100}}{\Sigma \text{ volume (mL)}} \qquad \text{(EQ 43)}$$

The system will perform certain computational boundary condition, logic checks and reporting precision depending on the application used. The conditions are listed below. Application dependent values for the **Ideal Colony Count Range** and the **Maximum Threshold** colony count are listed by test in Table 7.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) The number of sample colony count entries must equal the number of volume entries. In other words, every colony count has a corresponding value for volume of water filtered.

(2) The summations are for those filters that fall within the **Ideal Colony Count Range** for the application. There may be only one filter sample that meets this criteria.

(3) If all filters fall outside the application **Ideal Colony Count Range**, use (EQ 42) or (EQ 43) for all filters that have at least one colony but do not have colonies too numerous to count (TNTC). Store the value for the colonies/ml or colonies/100 mL but qualify the data with "Estimated count based on non-ideal colony count."

(4) If there are no colonies on the filters, report a result of less than (<) with an estimated count of 1 for the largest volume filtered.

(5) If all filters have colonies too numerous to count (TNTC), assume a count equal to the application **Maximum Threshold** colony count for the smallest volume sampled and compute using (EQ 42) or (EQ 43). Report the result as greater than (>) the calculated value.

(6) Report the resultant number of colonies per milliliter to two significant figures for values 10 and greater. Values less than 10 are reported as non-zero integer or whole numbers.

Table 7. -- Conditions for Tests of the Membrane Filter Method.

Test Name	Ideal Colony Count Range	Maximum Threshold	Equation Number	Units	EPA Parameter Code
Standard Plate Count	20 to 150	150	(EQ 42)	col./mL	31751
Total Coliform -immediate	20 to 80	80	(EQ 43)	col./100 mL	31501
Total Coliform-delayed	20 to 80	80	(EQ 43)	col/100 mL	31503
Fecal Coliform-immediate	20 to 60	60	(EQ 43)	col./100 mL	31625
Fecal Streptococci-immediate	20 to 100	100	(EQ 43)	col./100 mL	31673
Pseudomonas aeruginosa	20 to 80	80	(EQ 43)	col./100 mL	71220

6.3.10.1.2 Most-Probable-Number Method

The most-probable-number (MPN) method is used to estimate the size of a bacterial population without actually counting cells or colonies. Several dilutions are made of a sample. A portion of each dilution is used to inject culture media that is selective for the growth of certain bacteria. Based on positive and negative culture growth responses, the MPN of the original water sample is calculated. The calculation of MPN is facilitated in NWIS-II by storing the various MPN Index Data Tables found in Britton and Greeson (1989).

The MPN method is not used prevalently with the WRD and is most likely to be a low priority computation.

The tests or applications that make up the MPN method and method numbers are:

- Total Coliform (presumptive): B-0035-85
- Total Coliform (presumptive on site): B-0040-85
- Fecal Coliform (presumptive): B-0051-85
- Fecal Streptococci (presumptive): B-0065-85
- Nitrifying Bacteria: B-0420-85
- Denitrifying and Nitrate Reducing Bacteria: B-0430-85

Users will select the appropriate application of the MPN method and enter the number of positive culture tubes for each of the three dilutions that define the volume series. Depending on the test, anywhere from three to five tubes are inoculated with each dilution of the volume series; therefore, the system should check that the user has not entered a positive number of culture tubes greater than the original number of tubes inoculated, usually three or five, for each dilution of the volume series. The user also enters the dilution factor, if any, of the first tube in the volume series (the tube having the largest concentration of sample). If the volume series used dilutions other than 1, 0.1, and 0.01 mL, the MPN Index Data Table values need to be corrected for the dilutions actually used. If no correction is needed, the user enters a one. If a user attempts to enter data for anything other than a three- or five-tube volume series, the computational system shall handle the request per the computational boundary conditions.

Depending on the test method and the number of tubes in the volume series (three or five), an appropriate MPN Index Data Table is selected by the system. The user's input of the set of positive culture tube responses is used by the system to look up the MPN and the 95 percent confidence limits in the MPN Index

Data Table. The values for MPN and the confidence limits are then divided by the dilution factor to achieve the sample's representative MPN and confidence limits for the test. The final MPN and confidence limits are then stored in the data base along with the appropriate codes for the sample identification and test method.

The input values for the number of tubes (one, three, or five) in the volume series, the dilution factor, and the individual positive counts from the volume series shall be stored or archived in a near online media.

Table 8. -- Conditions for Tests of the MPN Method.

Test Name	TWRI Table Page	Optimum Number of Tubes	Units	EPA Parameter Code
Total Coliform-presumptive	24-25	5	MPN Total Coli./100 mL	31507
Total Coliform-presumptive onsite	24-25	5	MPN Total Coli./100 mL	31507
Fecal Coliform-presumptive	24-25	5	MPN Fecal Coli./100 mL	31615
Fecal Streptococci-presumptive/ confirmation	24-25	5	MPN Fecal Strep/100 mL	31677
Nitrifying Bacteria	64	3	MPN Organism/100 mL H20 or /100 g soil (wet or dry)	31854
Denitrifying and Nitrate Reducing Bacteria	71	3 or 5	MPN/mL or MPN/g soil (wet or dry)	31856

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) The **Number of Tubes** indicated in the above table (Table 8) are the suggested optimum number of tubes for a volume series for a particular **Test.** Any of the **Tests** could use a three- or a five-tube series. The system shall store the MPN Index Data Tables from the TWRI (Britton and Greeson, 1989) for a three- and a five-tube series that report a 100mL sample (pages 24-25 and 64, respectively).The computational system can use these same tables for reporting the results of the one mL Denitrifying and Nitrate Reducing Bacteria samples by simply dividing the MPN and CL table lookup values by 100.

(2) According to Trae Bradfield (oral commun. with S. Trapanese, 1990), a user could conceivably enter any number of tubes (between 1 and 10) for a volume series. The system should initially provide the tables for three- and five-tube series only. The tables in the TWRI seem to be incorrect for the three- and five-tube series.

(3) According to Ted Ehlke (oral commun. with S. Trapanese, 1990), if a user enters data for only one tube, the value is entered as presence or absence ONLY. If the user used one tube for each dilution in the volume series, then user enters the value as < the inverse of the dilution factor. NWIS-II shall NOT provide a computation for one tube or a one-tube series. The value or descriptive qualifier will be stored in the data base

(4) All test results for bacteria concentrations are reported as follows: values less than 10, whole numbers; values 10 or greater, two significant figures.

(5) **All total coliform positive presumptive tests must be verified by a confirmation test (EPA parameter code 31505). A user shall simply answer a prompt during computations and before data base storage that a confirmation test was positive for the presence of coliforms. This shall be a requirement for storage of the computed values for MPN Total coliform (31507) but will be optional for the storage of Membrane Filter Total Coliform (31501 and 31503).** The storage of the information stating that a positive total coliform confirmation test was performed may be part of the original entry of data into the system during project or sample entry and identification.

6.3.10.1.3 Epifluorescence Method

Method: B-0005-85

Parameter and code:

Bacteria, total count, epifluorescence (number/mL): 81803

The Epifluorescence Method is used to determine the bacteria density in water using a microscope to count the number of cells in a sample volume.

The user is prompted by the system to enter the following data as input:

(1) a = average bacteria count per field

(2) b = effective filter area (square millimeters)

(3) c = field area of microscope (square millimeters)

(4) d = sample volume filtered (milliliters)

(5) e = preservative added (milliliters)

The system then calculates:

$$\textit{Dilution Factor}\ (F) = \frac{d}{d+e} \qquad \text{(EQ 44)}$$

The system uses the results for F to calculate the bacteria density or **bacteria** per milliliter:

$$\text{Bacteria per mL} = \frac{a\left(\frac{b}{c}\right)}{dF} \qquad \text{(EQ 45)}$$

The input data (a-e) shall be archived or stored in a near online manner at the local DIS node. The intermediate value, the *Dilution Factor* shall not be stored. The value for **Bacteria/mL** shall be stored in the local and national data base (EPA parameter code 81803).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) F must be less than or equal to 1

(2) a through e are positive numbers

(3) Report **Bacteria/mL** to three significant figures.

6.3.10.2 Phytoplankton

Methods: B-1505-85 (counting-cell method) and B-1520-85 (inverted microscope method)

Parameter and code:

Phytoplankton, total (cells/mL): 60050

Plankton is the community of suspended or floating organisms drifting passively with water currents. The plant component of plankton is called phytoplankton.The determination of the density of phytoplankton by the counting-cell and inverted-microscope methods depends on the type of sample collection (net or bottle) and the type of counting cell used for enumeration (ruled or unruled). First, the sample volume is corrected for any added preservatives. Then the sample concentration is determined. The concentration determination depends on how the sample was retrieved. There is one equation for a net sample and another for a bottle sample. The sample concentration value is used to determine the total volume of phytoplankton observed in the sample. There is one equation for total volume determination using the unruled counting cell and another for the ruled counting cell. Once the total volume of plankton is determined, the result is then used to compute the population density of plankton.

The NWIS-II system shall prompt users to begin data entry after selecting the option to compute a total plankton count.

6.3.10.2.1 Volume Correction for Preservative

The user is prompted to supply input values for:

(1) a = volume of water collected

(2) b = volume of preservative added

The system then calculates the factor to correct for volume of preservative added (X):

$$X = \frac{a+b}{a} \qquad \text{(EQ 46)}$$

Computational Boundary Conditions and Checks:

(1) X must be equal to or greater than one.

(2) All input values must be positive non-zero real numbers.

6.3.10.2.2 Determination of the Sample Concentration

The system shall ask the user to select the type of sample collection, either net or bottle. The system then prompts for the appropriate input as pertinent to the selected type of collection and determines the sample concentration.

6.3.10.2.2.1 Net Sample

For a sample retrieved from a net, the system shall prompt for:

(1) c = volume of water passed through net

(2) d = volume of preserved sample (net sample)

The system then calculates the factor for sample concentration (Y) using the input and the previous value for X.

$$Y = X\left(\frac{c}{d}\right) \qquad \text{(EQ 47)}$$

Checks:

(1) All input values must be positive, non-zero real numbers.

6.3.10.2.2.2 Bottle Sample

For a sample retrieved from a bottle, the system shall prompt for:

(1) a = volume of water collected

(2) e = final volume of concentrated or diluted sample

The system then calculates the factor for sample concentration (Y) using the input and the previous value for X.

$$Y = X\left(\frac{a}{e}\right) \qquad \text{(EQ 48)}$$

Checks:

(1) All input values must be positive, non-zero real numbers.

6.3.10.2.3 Total Volume of Phytoplankton

The system then asks for the type of counting cell used, unruled or ruled. Based the type of counting cell used, the system prompts for the pertinent input data and computes the total volume of plankton.

6.3.10.2.3.1 Unruled

The system prompts for input values:

(1) f = area of one microscopic field on ruled counting-cell or whipple disk (square millimeters)

(2) g = area that the sample covers on an unruled counting-cell (square millimeters)

(3) i = number of microscopic fields used for tally

(4) j = volume of preserved sample on counting cell

The system uses the input values and the previous calculation of Y to determine the total volume (Z).

$$Z = \frac{Yif}{gj} \tag{EQ 49}$$

Checks:

(1) All input values must be positive, non-zero real numbers

6.3.10.2.3.2 Ruled

The user is asked to provide input values for:

(1) i = number of microscopic fields used for tally

(2) k = volume of sample in one square of the counting cell (ruled cell)

The system uses the input values and the previous calculation of Y to determine the total volume (Z)

$$Z = Y \times i \times k \tag{EQ 50}$$

Checks:

(1) All input values must be positive, non-zero real numbers.

6.3.10.2.4 Population Density

Finally, the system prompts for input to complete the calculation for the plankton density.

(1) h = total number of units (cells, colonies, filaments times number of cells per colony or filament) tallied in "i" microscopic fields

The system uses the input and the previous value for Z to calculate the **total phytoplankton cells per mL**. The user can also set default or district values for the input variables, a-e.

$$\textbf{Phytoplankton, total} = \frac{h}{Z} \tag{EQ 51}$$

The input values (a-e) shall be archived near online at the local DIS node only. Output data, **total phytoplankton cells per mL**, will be stored in the local and national data base (EPA parameter code 60050). The intermediate values X, Y, and **Z** shall not be stored by NWIS-II.

Checks and Reporting Precision:

(1) All input values must be positive, zero or greater real numbers.

(2) Plankton total is reported to two significant figures.

6.3.10.3 Zooplankton

Zooplankton are the animal part of the plankton. In general, they predominantly are composed of free-living, nonphotosynthetic protozoa, rotatoria, and crustacea. They are found in a variety of aquatic habitats, although usually they are absent or occur in small numbers in rapid streams. Zooplankton are important contributors to aquatic ecosystem metabolism because they are grazers of phytoplankton and bacteria and are important predators. Fish and certain invertebrate groups also use zooplankton as a food source. Samples of the zooplankton community are collected, preserved, and examined microscopically to count and identify types of zooplankton per unit volume of water sampled. They are also analyzed for dry weight, ash weight, and ash-free weight, which are used to estimate the organic weight of the organisms per unit volume of water sampled (Britton and Greeson, 1989, p. 117).

The counting-cell method is used to count and identify zooplankton. There are two ways of using this method: 1) by using the Sedgwick-Rafter (closed) counting-cell method, and 2) by using the open counting-cell method. Percent taxon may be counted after performing either of these methods. Biomass of zooplankton is analyzed independently and consists of measuring the dry weight of the sample, the ash weight of the sample, and from those results, the ash-free, or organic, weight of the zooplankton.

6.3.10.3.1 Counting-cell Method

Method: B-2501-85

Parameter and code:

Zooplankton, total (organisms / m^3): 70946

In the counting-cell method, the laboratory analysis is performed using a counting cell. The organisms are counted for each taxon and for the total number of organisms in the water sample. There are two types of counting cells used to analyze zooplankton--the closed cell and the open cell. For the closed-cell method, the best for micro-zooplankton and smaller rotatoria, a Sedgwick-Rafter counting cell is used to hold a small, known volume of the sample, which is then covered with a lens cover. The open counting-cell method, generally a better method for counting larger rotatoria and crustacea, uses a Sedgwick-Rafter counting cell, or any similarly marked cell, in which the sample is analyzed uncovered.

To enter data for **total zooplankton**, users will enter the type of counting-cell method used: Sedgwick-Rafter (closed) counting-cell method *or* the open counting-cell method.

6.3.10.3.1.1 Sedgwick-Rafter (Closed) Counting-cell Method

Total zooplankton per cubic meter:

Computations

After selecting this type of analysis, the user will enter the following items:

(1) b = average number of organisms per cell

(2) c = volume of the analysis sample (milliliters)

(3) d = volume of water sampled (liters)

The system then calculates:

$$\text{Total Zooplankton} / \text{m}^3 = \left(\frac{bc}{d}\right) 1000 \text{ L} / \text{m}^3 \qquad \text{(EQ 52)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **total zooplankton**, will be stored in the local and national data base (EPA parameter code 70946).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **total zooplankton** to two significant figures.

6.3.10.3.1.2 Open Counting-cell Method

Total zooplankton per cubic meter:

The user will enter:

(1) c = volume of analysis sample (milliliters)

(2) d = volume of water sampled (liters)

(3) e = average count per section

(4) f = number of sections

(5) g = volume of counting cell (milliliters)

The system then calculates:

$$\text{Total Zooplankton} / \text{m}^3 = \left(\frac{efc}{gd}\right) 1000 \text{ L} / \text{m}^3 \qquad \text{(EQ 53)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **total zooplankton,** will be stored in the local and national data base (EPA parameter code 70946).
Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **total zooplankton** to two significant figures.

6.3.10.3.1.3 Computing Percent Taxon per Unit Volume

Computing the percentages of observed taxa in the water sample allows an estimation of the number of organisms in each taxon per cubic meter of water and permits an estimation of total organic material per cubic meter of water contributed by each taxon.For computation of **percent taxon**, the total zooplankton value from (EQ 52) or (EQ 53) will be accessed. For each taxon the user will enter an organism count.

The system then calculates composition in sample as:

Percent taxon = 100[(Number of zooplankton of a particular taxa) / (total zooplankton of all taxa)] (EQ 54)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **percent taxon**, will be archived or stored in a near online manner at the local DIS node. The value for **percent taxon** is not currently stored in WATSTORE or QWDATA. The user group requests the value be included in the NWIS-II data dictionary.

Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive, whole numbers.

Percent taxon will be stored with two significant figures and must be between the values 0 and 100.

6.3.10.3.2 Gravimetric Method for Biomass

Method: B-2520-85

Parameters and Codes:

Zooplankton, dry weight (g/m^3): 70947
Zooplankton, ash weight (g/m^3): 70948

Samples of the zooplankton community are collected from known volumes of water. The dry weight and ash weight of the organisms are determined analytically, and the weight of ash-free matter, an estimate of organic weight per unit volume of the water, is calculated using those values (Britton and Greeson, 1989, p. 125).

Data entry: sampling date, sampling method, sampling location, and other pertinent information required by the system for each analysis will need to be entered only once for multiple computations. Similarly, for succeeding computations, such as wet weight, dry weight, ash weight, and ash-free weight; and constants, such as crucible tare weights, will need to be entered only once. However, each of these computations may be used discretely.

6.3.10.3.2.1 Dry Weight of Zooplankton

The **dry weight of zooplankton** may be computed using either the entire sample or a smaller subsample. If a subsample is used, the dry weight may be calculated for the entire sample using simple mathematics.

6.3.10.3.2.1.1 Entire Sample Used

This method of calculating the **dry weight of zooplankton** is used for analyses that used the entire water sample for testing.

The user will enter:

(1) d = volume of water sample (liters)

(2) j = dry weight of residue and crucible (grams)

(3) k = tare weight of crucible (grams)

$$\text{Dry Weight of Zooplankton (g/m}^3\text{)} = \left(\frac{j-k}{d}\right) 1000\ \text{L} / \text{m}^3 \qquad \text{(EQ 55)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **dry weight zooplankton,** will be stored in the local and national data base (EPA parameter code 70947).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **dry weight of zooplankton** to two significant figures.

6.3.10.3.2.1.2 Subsample Used

This method of calculating **dry weight of zooplankton** is used when a small subsample of the sample is used for analysis.

The user will enter:

(1) J = dry weight of residue and crucible (grams)

(2) m = volume of suspension (liters)

(3) n = volume of subsample (liters)

$$\text{Dry Weight of Zooplankton (g/m}^3\text{)} = \left(\frac{J-k}{d}\right)\left(\frac{m}{n}\right) 1000\ \text{L} / \text{m}^3 \qquad \text{(EQ 56)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **dry weight of zooplankton,** will be stored in the local and national data base (EPA parameter code 70947).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **dry weight of zooplankton** to two significant figures.

6.3.10.3.2.2 Ash Weight of Zooplankton

After the dry weight has been determined, the sample is then placed in a muffle furnace and the organic matter is reduced to ash. After cooling, rinsing, and thorough drying, the sample is weighed again.

The user will enter:

(1) d = volume of water sampled (liters)

(2) k = tare weight of crucible (grams)

(3) r = weight of ash and crucible (grams)

The system will calculate:

$$\text{Ash weight of Zooplankton (g/m}^3\text{)} = \frac{r-k}{d} \qquad \text{(EQ 57)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash weight of zooplankton,** will be stored in the local and national data base (EPA parameter code 70948).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **ash weight of zooplankton** to two significant figures.

6.3.10.3.2.3 Ash-free Weight of Zooplankton

A request for **ash-free weight of zooplankton** to be calculated will be input. The system will then calculate:

$$\text{Ash-free (organic) weight (g/m}^3\text{)} = \text{Dry weight (g/m}^3\text{)} - \text{Ash weight (g/m}^3\text{)} \qquad \text{(EQ 58)}$$

Input data for this parameter have been archived or stored in a near online manner at the local DIS node as the result of previous computations. Output data, **ash-free weight of zooplankton,** will be stored in a near online manner at the local DIS node. The value for **ash-free weight** is not currently stored in WATSTORE or QWDATA. The user group requests the value be included in the NWIS-II data dictionary .

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Weights, numbers, and volumes must be positive numbers.

(2) Report **ash-free weight of zooplankton** to two significant figures.

6.3.10.4 Seston

Seston, or total suspended matter in water, is an important measurement in environmental studies. for example, this value has been shown to correlate with optical properties and with temporal and spatial changes in aquatic environments (Britton and Greeson, 1989, p. 127). Users analyze the water samples by filtering the suspended matter from the water through glass-fiber filters. The filters are thoroughly dried and weighed. The tare of the filter and the blank correction values are subtracted from the weight of residue and filter to yield the dry weight of seston. The filters are then placed in a muffle filter and heated to 500 °C. When the "burn" is finished and the filters have cooled, the filters are reweighed. The ash weight is subtracted from the dry weight to estimate ash-free or organic weight of the seston per unit volume.

Data entry: sampling date, sampling method, sampling location, and other pertinent information required by the system for each analysis will need to be entered only once for multiple computations. Similarly, for succeeding computations, such as wet weight, dry weight, ash weight, and ash-free weight; and constants, such as crucible tare weights, will need to be entered only once. However, each of these computations may be used discretely.

6.3.10.4.1 Glass-fiber Method

Method: B-3401-85

Parameters and codes:

Seston, dry weight (mg/L): 71100
Seston, ash weight (mf/L): 71101

A volume of water is filtered through pretared glass-fiber filters and dried at 105 °C. The weight after drying is a measure of the particulate matter in the sample. The sample is then ashed at 500 °C and reweighed. This value, the ash weight, is then subtracted from the dry weight; the result is a measure of organic matter in the sample.

Data entry: sampling date, sampling method, sampling location, and other pertinent information required by the system for each analysis will need to be entered only once for multiple computations. Similarly, for succeeding computations, such as wet weight, dry weight, ash weight, and ash-free weight; and constants, such as crucible tare weights, will need to be entered only once. However, each of these computations may be used discretely, if the user desires.

6.3.10.4.1.1 Calculation of Blank Correction

A blank correction must be calculated to compensate for changes in mass of the filters during processing. Blank filters are included in each run, as specified in the TWRI (Britton and Greeson, 1989), and are used to calculate the change in weight of each blank after being processed. The user then either calculates the change of weight for each filter and enters those results or enters the before and after weights of the

control filters and lets the system compute the differences; either way, the blank correction for the run is then calculated. The user selects the blank correction computation and, for each filter, enters either:

(1) b = control-filter weight before run (milligrams)

(2) a = control-filter weight after run (milligrams)

or, if the user has already calculated the difference:

(1) q = change in control-filter weight (milligrams)

In the first case, the system notes how many pairs of before and after weights (t) were entered and calculates the control filter differences:

$$\text{q (mg)} = b - a \tag{EQ 59}$$

The system then proceeds to (EQ 60), below. Or, in the second case, the system notes how many changes of control-filter weight were entered and then calculates the average blank correction:

$$\text{Average blank correction} = \frac{\Sigma q}{t} \tag{EQ 60}$$

Where t = total number control filters

6.3.10.4.1.2 Dry Weight of Seston

In this method, the sample is carefully filtered through glass-fiber filters. The filters and seston are thoroughly dried and the user carefully reweighs each filter. The user will enter:

(1) a = dry weight of filter and residue (milligrams)

(2) b = tare weight of filter (milligrams)

(3) d = volume of water sample (liters)

(4) e = blank correction (milligrams)

$$\text{Dry Weight of Seston (mg/L)} = \frac{a - b - e}{d} \tag{EQ 61}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **dry weight of seston,** will be stored in the local and national data base (EPA parameter code 71100).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **dry weight of seston** to two significant figures.

6.3.10.4.1.3 Ash Weight of Seston

The filters are then placed in the muffle furnace and organic material is reduced to ash. The analyst then reweighs the cooled sample.

The user will enter:

(1) b = tare weight of filter (milligrams)

(2) d = volume of water sample (liters)

(3) e = blank correction (milligrams)

(4) f = weight of filter and residue (milligrams)

$$\text{Ash Weight of Seston (mg/L)} = \frac{f - b - e}{d} \qquad \text{(EQ 62)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash weight of seston,** will be stored in the local and national data base (EPA parameter code 71101).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) input data must be positive numbers

(2) report **ash weight of seston** to two significant figures

6.3.10.4.1.4 Ash-free Weight of Seston

The ash weight of seston is subtracted from the dry weight and results in the ash-free or organic weight of the organisms. If this value is sought subsequent to the dry weight and ash weight analyses, the system will access the results of those analyses upon request and compute the ash-free weight. If the request is *not* immediately subsequent to these analyses, the user will enter:

(1) Dry weight of seston (milligrams per liter)

(2) Ash weight of seston (milligrams per liter)

The system will then calculate:

$$\text{Ash-free weight (mg/L)} = \text{Dry weight (mg/L)} - \text{Ash weight (mg/L)} \qquad \text{(EQ 63)}$$

Input data (a through e) will be archived or stored in a near online manner at the local DIS node. Output data, **ash-free weight of seston,** will be stored in a near online manner at the local DIS node. The value for **ash-free weight** is not currently stored in WATSTORE or QWDATA. The user group requests this value be included in the data dictionary for NWIS-II.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **ash-free weight of seston** to two significant figures.

6.3.10.5 Periphyton

Periphyton is a term that has evolved to include virtually every aquatic organism that live attached to or upon solid submerged surfaces. Periphyton include aquatic plants (original definition), algae, fungi, bacteria, protozoans, rotifers, and other small organisms. The group includes heterotrophs as well as autotrophs, mainly because of collection techniques, because some of the taxa included in the grouping usually are associated with benthic environments but are invariably sampled along with more traditional periphyton. Samples of periphyton can be collected from any solid submerged substrate, but artificial substrates are also used (Britton and Greeson, 1989, p. 131). Analysis of periphyton currently being supported in the Water Resources Division are limited to identification, enumeration, and quantification of periphytic plants (algae) and periphytic diatoms.

Periphytic diatoms are identified under high magnification. There are various methods of preparing slides for such analysis. The Inverted-Microscope Method presents one method of preparing a permanent slide and details identification and enumeration of the various taxa in the sample and quantification using a counting cell.

6.3.10.5.1 Periphytic Plants (Algae)

Biologic analysis of the algae include identification and enumeration of the various species, counts of total cells per square millimeter, and dry and ash weights. Counts of algae using the Sedgwick-Rafter counting-cell method, the dimensions of the sample area, and the area of the Whipple grid at 200X magnification are needed to complete these computations. Dry weights and ash weights are measured by drying and then reducing the organisms to ash in a crucible of a known weight.

6.3.10.5.1.1 Sedgwick-Rafter Method

Method: B-3501-85

Parameter and code:

Periphyton, total (cells/mm^2): 70945

Samples of the periphyton community are collected, preserved, and examined microscopically for types and numbers of algae. The periphyton samples may be from natural or artificial substrates, but the dimensions of the sample area must be known. This method quantifies the plant (autotrophic) part of the

periphyton. The sample is placed in a Sedgwick-Rafter counting cell, the taxa identified and counted, and an estimate of total periphyton per square millimeter is performed.

This computation is accomplished in three steps:

(1) calculation of a calibration factor--(EQ 64)

(2) calculation of periphyton cells per milliliter of suspended scraping--(EQ 65)

(3) calculation of **total periphyton** cells per square millimeter of surface--(EQ 66)

Step 1--Calibration Factor:

This step creates a calibration factor to adjust the cell count and the results are used in (EQ 65). The user will enter:

(1) A = area of the Whipple grid at 200X magnification (square millimeters)

The system then calculates:

$$F = \frac{1000\ \mathrm{mm}^2}{A} \qquad \text{(EQ 64)}$$

F = Calibration factor

Step 2--Periphyton cells per milliliter suspended scraping:

This is an intermediate step and the results are used in (EQ 66). The calibration factor (F) is used from (EQ 64) and the user will enter:

(1) T = total cell count

(2) N = number of random fields used

The system calculates:

$$C = \frac{FT}{\mathrm{N \times 1\ ml}} \qquad \text{(EQ 65)}$$

C = Periphyton cells per milliliter of suspended scraping

Step 3--**Total periphyton** cells per square millimeter of surface:

This is the final step of this computation. The calculated amount of periphyton per milliliter of suspended scraping (C), from (EQ 64), is used to calculate the total number of cells per square millimeter of the substrate from which the sample was scraped. The user will enter:

(1) V = total volume of scraping (milliliters)

(2) S = area of the scraped surface (square millimeters)

Computations

The system calculates:

$$\text{Total periphyton} / \text{mm}^2 = \frac{CV}{S} \qquad \text{(EQ 66)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **total periphyton,** will be stored in the local and national data base (EPA parameter code 70945). No provisions are made in WATSTORE and QWDATA to store identified taxa and number of organisms per taxa. The user group requests they be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Count and record total number of cells in each of 20 random fields.

(3) When 10x eyepiece and 20x objective are used, assume total of Whipple grid to be 0.5mm on a side.

(4) Report **total periphyton** to two significant figures.

(5) Report taxa and number of organisms per taxa.

(6) Report taxa to a whole number.

6.3.10.5.1.2 Gravimetric Method for Biomass

Method: B-3520-85

Parameters and Codes:

Periphyton, biomass, dry weight, total (g/m^2) (00573)
Periphyton, biomass, ash weight (g/m^2) (00572)

Samples of the periphyton community are collected from scraping a known area of substrate, either artificial or natural. The dry weight and ash weight of the organisms are determined by drying and ashing the organisms and weighing the results.

Data entry: sampling date, sampling method, sampling location, and other pertinent information required by the system for each analysis will need to be entered only once for multiple computations. Similarly, for succeeding computations, such as wet weight, dry weight, ash weight, and ash-free weight; and constants, such as crucible tare weights, will need to be entered only once. However, each of these computations may be used discretely.

6.3.10.5.1.2.1 Dry Weight of Periphyton

In this method, the sample of periphyton is carefully filtered through glass-fiber filters. The filters and periphyton are thoroughly dried and the user carefully re-weighs each filter. The user will enter:

Computations

(1) d = area of scraped surface (square meters)

(2) j = dry weight of residue and crucible (grams)

(3) k = tare weight of crucible (grams)

$$\text{Dry weight of Periphyton (g/m}^2\text{)} = \frac{j-k}{d} \qquad \text{(EQ 67)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **dry weight of periphyton,** will be stored in the local and national data base (EPA parameter code 00573).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **dry weight of periphyton** to two significant figures.

6.3.10.5.1.2.2 Ash Weight of Periphyton

Once the dry weight has been measured, the sample is placed in a muffle furnace and the organic matter is reduced to ash. After cooling, rinsing, and thorough drying, the sample is reweighed.

The user will enter:

(1) r = weight of ash and crucible (grams)

(2) d = area of scraped surface (square meters)

(3) k = tare weight of crucible (grams)

The system will calculate:

$$\text{Ash weight of Periphyton (g/m}^2\text{)} = \frac{r-k}{d} \qquad \text{(EQ 68)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash weight of periphyton,** will be stored in the local and national data base (EPA parameter code 00572).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **ash weight of periphyton** to two significant figure.

6.3.10.5.2 Periphytic Diatoms

Periphytic diatoms are that portion of the complex community of periphytons that are algae yet have siliceous cell walls.

6.3.10.5.2.1 Inverted Microscope Method

Parameter and code:

Diatoms, total, (number/mm^2): 81804

Periphytic diatoms are collected by scraping them from their substrate. Organic components, including gelatinous stalks and matrices and cellular components in the diatoms, are decomposed by oxidation. The diatoms in a sample are concentrated and a permanent mount is prepared. The mount is examined microscopically for the purpose of identification. The cleared diatoms are placed in a counting cell for enumeration (Britton and Greeson, 1989, p. 143). When identification and enumeration are complete, the total number of diatoms are calculated for later use in determining percent taxon.

Conditions:

- The count is usually done using a 100X objective lens. Count and identify all diatom taxa found in several lateral strips the width of the Whipple disc. Identify and tabulate 200 to 300 diatom cells; normally at least 100 individuals of the most common species should be counted.

Computation of **total diatoms** begins with an intermediate computation of the number of diatoms per milliliter of suspended scraping:

The user will enter:

(1) C = total count of diatoms

(2) N = number of microscopic fields used

(3) D = chamber depth (centimeters)

(4) A = the field area (square centimeters)

The system then calculates:

$$S = \frac{C}{NDA} \qquad \text{(EQ 69)}$$

S = Diatoms per milliliter of suspended scraping

Total diatoms per square millimeter of surface:

The result of (EQ 69), diatoms per milliliter suspended scraping (S), is used to complete the following calculations. The user will enter:

(1) V = total volume of scraping (milliliters)

(2) B = area of scraped surface (square millimeters)

The system then computes:

Computations

$$\text{Total diatoms per square millimeter surface} = \frac{SV}{B} \qquad \text{(EQ 70)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **total diatoms,** will be stored in the local and national data base (EPA parameter code 81804).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **total diatoms** to two significant figures.

6.3.10.5.2.2 Percent Occurrence of Each Species

The percent occurrence, or percent taxon, is calculated by the system accessing the total diatom count, C, entered for (EQ 69), and uses it to calculate percents for each taxon. The user will enter:

(1) number of different taxa observed

This cues the system to the number of iterations necessary to compute all the percent taxon. The user then enters:

(1) I = individual taxon counts

The system then computes the percentages:

$$\text{Percent taxon} = \left(\frac{I}{C}\right) 100 \qquad \text{(EQ 71)}$$

Input data will be archived or stored in a near online manner at the local DIS node. The values for **percent taxon** will be stored in a near online manner at the local DIS node.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **percent taxon** to two significant figures and the values must range between 0 and 100.

(3) Report taxa and number of organisms per taxon.

(4) Report taxa to a whole number.

6.3.10.6 Macrophytes

Macrophytes include vascular plants, bryophytes, and algae that can be seen without magnification. Included are the non-woody macrophytes found in wetlands or deep-water habitats. The vascular plants include aquatic varieties with emergent roots, floating-leaved rooted aquatics, submerged rooted aquatics, and free-floating

aquatics. The bryophytes include aquatic mosses and liverworts. The algae are the aquatic varieties, from the smallest visible to the naked eye to the mammoth marine species (Britton and Greeson, 1989, p. 145).

Specimens from each habitat are collected and identified using appropriate references and taxonomic keys. Specimens are preserved or pressed and mounted for herbarium collection or further study. Collection methods are varied and depend largely on the type of analysis planned.

Data entry: sampling date, sampling method, sampling location, and other pertinent information required by the system for each analysis will need to be entered only once for multiple computations. Similarly, for succeeding computations, such as wet weight, dry weight, ash weight, and ash-free weight; and constants, such as crucible tare weights, will need to be entered onlyonce. However, each of these computations may be used discretely.

6.3.10.6.1 Distribution and Abundance (Quantitative Method)

Method: B-4520-85

Parameter and code:

Macrophytes, total (number/m^2): 70944

The distribution of macrophytes is determined onsite and plotted on a map of the study area. The size of the subareas inhabited by different kings of macrophytes or the size of the vegetated area can be determined by a geographic information system, planimeter, or dot grid. Transect, grid, or quadrat sampling schemes are developed, and floral composition and relative abundance (percent cover, density, frequency of occurrence) are established (Britton and Greeson, 1989, p. 149).

6.3.10.6.1.1 Percent Cover

The **percent cover** quantifies the area covered by each species. The user enters:

(1) C = area covered by community, association, or homogenous stand (square meters or kilometers)

(2) T = total area of study area (square meters or kilometers)

The system then calculates:

$$\text{Percent cover} = \left(\frac{C}{T}\right) 100 \qquad \text{(EQ 72)}$$

Input data will be archived or stored in a near online manner at the local DIS node. The values for **percent cover** are not currently stored in WATSTORE or QWDAT. The user group requests this parameter and parameters listed in Boundary Conditions be included in the NWIS II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

Computations

(1) Input data must be positive numbers.

(2) List the taxa of macrophytes identified.

(3) Report distribution on map.

(4) Report the **percent cover, density**, or **frequency** of occurrence for each community, association or homogeneous stand.

(5) Report **percent cover** to two significant figures and values must be between 1 and 100.

6.3.10.6.1.2 Density

Density is a measure of quantity of plants in the community, association, or homogeneous stand, per unit area. The user will enter:

(1) P = number of individual plants

(2) A = area sampled (square meters)

The system then calculates:

$$\text{Density (plants per square meter)} = \frac{P}{A} \qquad \text{(EQ 73)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **density,** will be stored in the local and national data base (EPA parameter code 70944).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report density to two significant figures.

6.3.10.6.1.3 Frequency of Occurrence

The **frequency** of occurrence describes the distribution of the species over the study area. The user will enter:

(1) Pl = number of plots where species occurs

(2) N = total number of plots sampled

$$\text{Frequency} = \frac{\text{Pl}}{N} \qquad \text{(EQ 74)}$$

Input data will be archived or stored in a near online manner at the local DIS node. The values for **Frequency** are not currently stored in WATSTORE or QWDAT. The user group requests these values be included in the NWIS II data dictionary.

<u>Computations</u>

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **frequency** to two significant figures.

6.3.10.7 Benthic Invertebrates

The invertebrate animals inhabiting the bottoms of lakes, streams, and other water bodies perform essential consumer functions in the aquatic ecosystem. They are the most frequently used indicators of environmental quality (Britton and Greeson, 1989, p. 273). Calculations for classifying, enumerating, and quantifying are numerous and have been divided into four main methods:

(1) Faunal surveys (qualitative method)

(2) Numerical assessment (relative or semiquantitative method)

(3) Distribution and abundance (quantitative method)

(4) Invertebrate drift (quantity sampled over time)

6.3.10.7.1 Faunal Survey (Qualitative)

Method: B-5001-85

Parameters and codes:

Not applicable

The benthic invertebrates are sorted from the extraneous materials included in the sample, then identified and counted. Results are reported as numbers of different kinds of benthic invertebrates, or taxa, and the relative abundance of each taxon at different sites or times (Britton and Greeson, 1989, p. 171).

6.3.10.7.1.1 Total Number of Invertebrates per Taxon

A subsample is taken from the main sample, the various taxon are identified and individual members of each taxon are segregated, counted, and preserved. Total number of members of each taxon in the main sample are derived from the subsample. The user will enter:

(1) T = total number taxa observed (controls iteration of calculation with (EQ 75))

Then, for each taxon identified and counted the user will enter:

(2) I = number of benthic invertebrates in each taxon in the subsample

(3) F = fraction of total sample in the subsample

For each subsample, the system then calculates:

$$K = \frac{I}{F} \qquad \text{(EQ 75)}$$

<u>Computations</u>

K = **total number invertebrates per taxon** in sample

For use in later computations, the system then calculates:

$$N = \sum_{i}^{T} K_i \qquad \text{(EQ 76)}$$

Where N = total number invertebrates

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **total number of invertebrates,** are not currently stored in WATSTORE or QWDAT. The user group requests these data be included in the NWIS II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input datamust be positive numbers.

(2) Report **total number of invertebrates** to two significant figures.

6.3.10.7.1.2 Percent Composition

Once the total of invertebrates in each taxon has been determined, the **percent composition of taxon** in the sample can be calculated. The user will have the option of entering new data, or having these values calculated automatically from data in the previous computations.

For new data entry, the user will provide:

(1) K = total number of organisms in taxa

(2) N = total number of organisms

For automatic computations, the system accesses the total number of organisms for each taxon (K) and each taxon's identification from (EQ 75), and the total number of invertebrates (N) from (EQ 76). The system then calculates (for each taxon):

$$\text{Percent composition (each taxon)} = \left(\frac{K}{N}\right) \times 100 \qquad \text{(EQ 77)}$$

Input data will be archived or stored in a near online manner at the local DIS node. The values for **percent composition** are not currently stored in WATSTORE or QWDAT. The user group requests this value and the values in item (3), below, be included in the NWIS II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **percent composition** to two significant figures.

(3) **Report the number of taxa present, the percent composition of each taxon, and type of sampling method used.**

(4) no numerical precision data are available.

6.3.10.7.2 Numerical Assessment

Method: B-5020-85

Parameters and codes:

Invertebrates, benthic, wet weight (g/m^2): 70940
Invertebrates, benthic, dry weight (g/m^2): 70941
Invertebrates, benthic, ash weight (g/m^2): 70942
Invertebrates, benthic, total ($organisms/m^2$): 70943

This method assumes that the objective is to compare the kinds and relative abundances of taxa in samples from several sites or on different sampling dates. The differences between samples are assumed to be directly proportional to differences between the sites or dates.

Benthic invertebrates are collected using uniform procedures throughout a wide area or collected from small, homogeneous areas at sites that are to be compared. Unsorted samples, usually containing varying quantities of sand, gravel, and plant detritus, are preserved on site. In the laboratory, the benthic invertebrates are sorted from extraneous material, identified, and counted. Biomass is determined if appropriate to study objectives. Although generally determined from a total sample, the biomass may be determined for an individual taxon.

Data entry: sampling date, sampling method, sampling location, and other pertinent information required by the system for each analysis will only need to be entered once for multiple computations. Similarly, for succeeding computations, such as wet weight, dry weight, ash weight, and ash-free weight, constants, such as crucible tare weights, will only need to be entered once. However, each of these computations may be used discretely, if the user desires.

6.3.10.7.2.1 Total Number Invertebrates per Taxon in Sample

A subsample is taken from the main sample, the various taxon are identified and individual members of each taxon are segregated, counted, and preserved. Total number of members of each taxon in the main sample are derived from the subsample. The user enters:

(1) T = total number taxa observed (controls iteration of calculation with (EQ 78))

Then, for each taxon identified and counted, the user enters:

(2) A_s = area of sampler (square meters)

(3) I = number of benthic invertebrates in each taxon in subsample

(4) F = fraction of total sample in subsample

(5) N_s = number of samples

For each subsample, the system then calculates:

$$K = \frac{I}{F} \qquad \text{(EQ 78)}$$

K = **number invertebrates per taxon** in sample

For use in later computations, the system then calculates:

$$N = \sum_{i}^{T} K_i \qquad \text{(EQ 79)}$$

Where N = total number invertebrates

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **number of invertebrates per taxon,** are not currently stored in WATSTORE or QWDAT. The user group requests these data be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **number of invertebrates per taxon**--under 100 individual per square meter as a whole number, over 100 individuals report to two significant figures.

(3) Report identity of taxon, the number of taxa present, and type of sampling method used.

6.3.10.7.2.2 Percent Composition in Sample

Once the total of invertebrates in each taxon has been determined, the **percent composition of taxon** in the sample can be calculated. The user will have the option of entering new data, or having these values calculated automatically from data in the previous computations.

For new data entry, the user will provide:

(1) K = total number of organisms in taxa

(2) N = total number of organisms

For automatic computations, the system accesses the total number of organisms for each taxon (K) and each taxon's identification from (EQ 78), and the total number of invertebrates (N) from (EQ 79). The system then calculates (for each taxon):

$$\text{Percent composition (each taxon)} = \left(\frac{K}{N}\right) \times 100 \qquad \text{(EQ 80)}$$

Input data will be archived or stored in a near online manner at the local DIS node. The values for **percent composition** is not currently stored in WATSTORE or QWDAT. The user group requests this value, and the values in item (3), below, be included in the NWIS II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **percent composition** to two significant figures and each value must range between 0 and 100.

(3) Report identity of taxon, number of taxa present, percent composition of each taxon, and type of sampling method used.

(4) No numerical precision data are available.

6.3.10.7.2.3 Wet Weight of Benthic Invertebrates

After collection of the sample and separation of invertebrates from sample detritus, the sample organisms are prepared for weighing by blotting off any external water. The sample invertebrates may be subdivided by taxonomic group and weighed by taxon, if desired. The sample is placed in a tared crucible and is weighed. The user will enter:

(1) A_s = area of sampler (square meters)

(2) N_s = number of samples

(3) T = tare weight of crucible (grams)

(4) W = wet weight of invertebrates and crucible (grams)

The system then calculates:

$$K = \frac{W - T}{A_s N_s} \qquad \text{(EQ 81)}$$

Where K = **wet weight of benthic invertebrates** (g/m^2)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 82)}$$

Where N = **wet weight benthic invertebrates** (g/m^2)

Computations

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **wet weight,** will be stored in the local and national data base (EPA parameter code 70940).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report to two significant figures.

6.3.10.7.2.4 Dry Weight of Benthic Invertebrates

After making the wet-weight determination, or as an initial computation, the **dry weight** of the sample is determined. The sample remains in or is placed in a tared crucible and is dried. The sample and crucible are then re-weighed and the dry weight computed. If this computation is in sequence with the wet-weight computation, previously entered data will be accessed by the system and re-used. Otherwise, the user will enter:

(1) A_s = area of sampler

(2) D = **dry weight** of sample and crucible (grams)

(3) N_s = number of samples

(4) T = tare weight of crucible (grams)

The system calculates:

$$K = \frac{D-T}{A_s N_s} \qquad \text{(EQ 83)}$$

Where K = **dry weight of benthic invertebrates** (g/m^2)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 84)}$$

Where N = **dry weight benthic invertebrates** (g/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **dry weight,** will be stored in the local and national data base (EPA parameter code 70941).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report to two significant figures.

6.3.10.7.2.5 Ash Weight of Benthic Invertebrates

After completing the dry-weight determination, the analysis continues by determining the ash weight of the sample. The sample remains in or is placed in a tared crucible and is reduced to ash at high temperature in a muffle furnace. The sample and crucible are then cooled, rinsed, re-dried, and re-weighed. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and re-used. Otherwise, the user will enter:

(1) A_s = area of sampler

(2) A = ash weight of sample and crucible (grams)

(3) N_s = number of samples

(4) T = tare weight of crucible (grams)

The system calculates:

$$K = \frac{A - T}{A_s N_s} \qquad \text{(EQ 85)}$$

Where K = **ash weight of benthic invertebrates** (g/m^2)

If the user has been processing taxon-specific data, upon completion of the taxon-specific data the system will calculate the total weight:

$$N = \sum_i^{N_s} K_i \qquad \text{(EQ 86)}$$

Where N = **ash weight benthic invertebrates** (g/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash weight,** will be stored in the local and national data base (EPA parameter code 70942).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report to two significant figures.

6.3.10.7.2.6 Ash-Free Weight of Benthic Invertebrates

After completing ash weight computations, the ash-free weight of the sample is computed. The computation is the result of subtracting the ash weight from the dry weight, and is considered a representation of the organic material weight of the organisms. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and re-used. Otherwise, the user will enter:

Computations

(1) A = ash weight of sample (grams/square meter)

(2) D = dry weight of sample (grams/square meter)

The system then calculates:

$$K = D - A \qquad \text{(EQ 87)}$$

Where K = **Ash-free weight of benthic invertebrates** (g/m^2)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 88)}$$

Where N = **Ash-free weight of benthic invertebrates** (g/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash-free weight,** will be stored in a near online manner at the local DIS node. The value for **ash-free weight** is not currently stored in WATSTORE or QWDATA. The user group requests this value be included in the data dictionary for NWIS-II.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report to two significant figures.

6.3.10.7.2.7 Benthic Invertebrates per Square Meter of Projected Area of Rock

Results of sampling from individual rocks are expressed as benthic invertebrates per projected area (aspect) of rock (Britton and Greeson, 1989, p. 175). To report the number of benthic invertebrates per square meter of projected rock surface, the estimated or actual population figure for individuals is extended over a known surface area. The user will enter:

(1) N = number of benthic invertebrates collected from rock

(2) L_1 = length of longest axis of the rock surface area sampled (millimeters)

(3) L_2 = length of intermediate axis of rock surface area sampled (millimeters)

The system then calculates:

$$I = \left(\frac{N}{L_1 L_2}\right) \times 10^6 \qquad \text{(EQ 89)}$$

Where I = invertebrates per square meter

projected rock surface

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **benthic invertebrates per square meter** of projected rock surface, will be stored in the local and national data base (EPA parameter code 70943).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **benthic invertebrates per square meter** counts of under 100 as a whole number and over 100 to two significant figures.

(3) type of sampling method used.

6.3.10.7.2.8 Benthic Invertebrates per Square Meter of Total Rock Surface

Another method of reporting numbers of benthic invertebrates is to report results from sampling individual rocks expressed as benthic invertebrates per total rock surface (Britton and Greeson, 1989, p. 175). To do so, the user will enter:

(1) N = number of benthic invertebrates collected from rock

(2) L_2 = length of intermediate axis of rock (millimeters)

The system then calculates:

$$\text{Invertebrates per square meter total rock surface} = \left(\frac{N}{\pi L_2^2}\right) \times 10^6 \qquad \text{(EQ 90)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **benthic invertebrates per square meter of total rock surface,** will be stored in the local and national data base (EPA parameter code 70943, per Biological User Group; see below).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report benthic invertebrates per square meter counts of under 100 as a whole number and over 100 to two significant figures.

(3) Type of sampling method used.

(4) No numerical precision data are available.

6.3.10.7.3 Distribution and Abundance

Method: B-5040-85

Parameters and codes:

Invertebrates, benthic, wet weight (g/m^2): 70940
Invertebrates, benthic, dry weight (g/m^2): 70941
Invertebrates, benthic, ash weight (g/m^2): 70942
Invertebrates, benthic, total (organisms/m^2): 70943

This method is used in studies of biological productivity of benthic-invertebrate populations of communities. It is applicable to all natural waters (Britton and Greeson, 1989, p. 177).

6.3.10.7.3.1 Total Number of Invertebrates per Taxon in Sample

A subsample is taken from the main sample, the various taxon are identified, and individual members of each taxon are segregated, counted, and preserved. Total number of members of each taxon in the main sample are derived from the subsample. For each taxon identified and counted, the user will enter:

(1) I = number of benthic invertebrates in each taxon in subsample

(2) F = fraction of total sample in subsample

The system then calculates:

$$K = \frac{I}{F} \quad \text{(EQ 91)}$$

K = **total number invertebrates per taxon** in sample

Upon completion of the taxon-specific data entry, the system will calculate the total:

$$N = \sum_{i}^{N_s} K_i \quad \text{(EQ 92)}$$

Where N = **total number of benthic invertebrates** (grams/sample)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **total number invertebrates per taxon**, will be archived or stored in a near online manner at the local DIS node.The values for **total number of invertebrates per taxon** is not currently stored in WATSTORE or QWDAT. The user group requests inclusion in data dictionary for NWIS II.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **total number of invertebrates per taxon** counts of under 100 as whole numbers and over 100 to two significant figures.

(3) Report results in terms of a unit area of the habitat sampled.

(4) Report sampling method used.

6.3.10.7.3.2 Number of Benthic Invertebrates per Square Meter

Once the total of benthic invertebrates has been determined, the areal distribution of the organisms can be determined. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and reused. Otherwise, the user will enter:

(1) B = total number benthic invertebrates in all samples

(2) A_s = area of the sampler (square meters)

(3) N_s = number of samples

The system then calculates:

$$\text{Benthic invertebrates per square meter} = \frac{B}{A_s N_s} \quad \text{(EQ 93)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **benthic invertebrates per square meter,** will be stored in the local and national data base (EPA parameter code 70943).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **benthic invertebrates per square meter** counts under 100 as whole number and over 100 to two significant figures.

(3) Report results in terms of a unit area of the habitat sampled.

(4) No numerical precision data are available.

6.3.10.7.3.3 Wet Weight of Benthic Invertebrates

After collection of the sample and separation of invertebrates from sample detritus, the sample organisms are prepared for weighing by blotting off any external water. The sample may be subdivided by taxon, if desired. The sample is placed in a tared crucible and weighed. The user will enter:

(1) A_s = area of the sampler (square meters)

(2) N_s = number of sample

(3) T = tare weight of crucible (grams)

(4) W = wet weight of the invertebrates in all samples and crucible (grams)

The system then calculates:

$$\text{Wet weight benthic invertebrates (grams per square meter)} = \frac{W - T}{A_s N_s} \quad \text{(EQ 94)}$$

Computations

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 95)}$$

Where N = **wet weight of benthic invertebrates** (grams/square meter)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **wet weight,** will be stored in the local and national data base (EPA parameter code 70940).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report to two significant figures.

(3) Report sampling method used.

(4) Report results in terms of a unit area of the habitat sampled.

6.3.10.7.3.4 Dry Weight of Benthic Invertebrates

After determining the wet weight of the sample, the organisms are dried thoroughly in an oven to stable weight, cooled in a desiccator jar, and weighed to determine the dry weight. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and reused. Otherwise, the user will enter:

(1) A_S = area of the sampler (square meters)

(2) D = dry weight of the invertebrates including crucible weight (grams)

(3) N_S = number of sample

(4) T = tare weight of crucible (grams)

The system then calculates:

$$K = \frac{D - T}{A_S N_S} \qquad \text{(EQ 96)}$$

Where K = **dry weight of benthic invertebrates** (grams /square meter)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

Computations

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 97)}$$

Where N = **dry weight of benthic invertebrates** (grams/square meter)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **dry weight,** will be stored in the local and national data base (EPA parameter code 70941).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers

(2) Report to two significant figures.

(3) Report results in terms of a unit area of the habitat sampled.

(4) Report sampling method used.

(5) No numerical precision data are available.

6.3.10.7.3.5 Ash Weight of Benthic Invertebrates

After completing the dry-weight determination, the analysis continues by determining the ash weight of the sample. The sample remains or is placed in a tared crucible(s) and reduced to ash at high temperature, as described in the TWRI (Britton and Greeson, 1989). The sample and crucible are then cooled, rinsed, redried, and reweighed. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and reused. Otherwise, the user will enter:

(1) A_s = area of the sampler (square meters)

(2) N_s = number of samples

(3) T = tare weight of crucible (grams)

(4) A = **Ash weight** of benthic invertebrates including crucible weight (grams)

$$K = \frac{A - T}{A_s N_s} \qquad \text{(EQ 98)}$$

Where K = **ash weight of benthic invertebrates** (grams/square meter)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

Computations

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 99)}$$

Where N = **ash weight of benthic invertebrates** (grams/square meter)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash weight,** will be stored in the local and national data base (EPA parameter code 70942).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report to two significant figures.

6.3.10.7.3.6 Ash-free Weight of Benthic Invertebrates per Square Meter

After completing the dry-weight and ash-weight determinations, the computations are completed by determining the ash-free weight of the sample. This computation calculates the organic weight of biological material in the invertebrates. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and reused. Otherwise, the user will enter:

(1) Dry weight of benthic invertebrates (grams per square meter)

(2) Ash weight of benthic invertebrates (grams per square meter)

The system then calculates:

$$K = D - A \qquad \text{(EQ 100)}$$

Where K = **ash-free weight of benthic invertebrates** (g/m^2)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 101)}$$

Where N = **ash-free weight of benthic invertebrates** (g/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash-free weight,** will be stored in a near online manner at the local DIS node. The user group requests these data be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report to two significant figures.

(2) Input data must be positive numbers.

(3) Report results in terms of a unit area of the habitat sampled.

(4) Report sampling method used.

6.3.10.7.4 Invertebrate Drift

Method: B-5050-85

Parameters and codes:

Not applicable.

This method is used to quantify drifting invertebrates in streams with a flow of at least 0.01 m/s. Benthic invertebrates respond to stresses of pollution, flood, drought, or insecticides by increased drifting; therefore, drift may be a useful measure of water quality. Organisms are trapped in drift nets and the organisms analyzed for taxonomic distribution, wet weight, dry weight, ash weight, and ash-free weight. In addition, because the sample caught increases over time as more water filters through the net, samples are also quantified as density, drift rate, or as the total daily drift rate.

Drift invertebrates are enumerated according to taxonomic categories. Biomass is generally determined for the entire sample, although the biomass may be determined by individual taxon.

6.3.10.7.4.1 Number of Drift Invertebrates of a Particular Taxon

Identify and count the benthic invertebrates in the sample. The degree of identification required varies with objectives of the study. The sample may be analyzed for identification and enumeration using a subsample. The total number of individuals per taxon will be calculated by extending the subsample data mathematically. The user will enter:

(1) F = fraction of total sample in subsample

(2) S = number of individuals in taxon in subsample.

The system then calculates:

$$K = \frac{S}{F} \qquad \text{(EQ 102)}$$

Where K = **total number of drift** invertebrates of a particular taxon

Upon completion of the taxon-specific data entry, the system will calculate the total number in individual organisms for later use:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 103)}$$

Where N = **total number of drift invertebrates**

Input data will be archived or stored in a near online manner at the local DIS node. Output data will be stored in a near online manner at the local DIS node. The values for **total drift invertebrates by taxon** and **total drift invertebrates** are not currently stored in WATSTORE or QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **number of drift invertebrates** to two significant figures and each value must range between 0 and 100.

(3) Report identity of taxon, number of taxa present, percent composition of each taxon, and type of sampling method used.

6.3.10.7.4.2 Percent Composition in Sample

Once the total of invertebrates in each taxon has been determined, the **percent composition by taxon** in the sample can be calculated. The user will have the option of entering new data, or having these values calculated automatically from data in the previous computations.

For new data entry, the user will provide:

(1) K = total number of organisms in taxa

(2) N = total number of organisms

For automatic computations, the system accesses the total number of organisms for each taxon (K) and each taxon's identification from (EQ 103), and the total number of individuals (N) from (EQ 103). The system then calculates (for each taxon):

$$\text{percent composition} = \left(\frac{S}{N}\right) 100 \qquad \text{(EQ 104)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **percent composition,** will be stored in a near online manner at the local DIS node. Values for **percent**

composition are not currently stored in WATSTORE or QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **percent composition** to two significant figures and each value must range between 0 and 100

(3) Report identity of taxon, the number of taxa present, the percent composition of each taxon, and type of sampling method used.

6.3.10.7.4.3 Wet Weight of Drift Invertebrates

Weight calculations may be on a sample basis or a daily (24-hour) basis. After collection of the sample and separation of invertebrates from sample detritus, the sample organisms are prepared for weighing by blotting off any external water. The sample may be subdivided by taxon, if desired. The sample is placed in a tared crucible and weighed. The user will enter:

(1) T = tare weight of crucible (grams)

(2) W = wet weight of the invertebrates in all samples and crucible (grams)

The system then calculates:

Wet weight of drift invertebrates (grams) = W - T (EQ 105)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 106)}$$

Where N = **wet weight of drift invertebrates**

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **wet weight**, will be stored in a near online manner at the local DIS node. The values for **wet weight** are not currently stored in WATSTORE or QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report sampling method used.

(3) no numerical precision data are available.

6.3.10.7.4.4 Dry weight of drift invertebrates

After determining the wet weight of the sample, the organisms are dried thoroughly in an oven to stable weight, cooled in a desiccator jar, and weighed to determine the dry weight. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and re-used. Otherwise, the user will enter:

(1) T = Tare weight of crucible (grams)

(2) D = **dry weight** of drift invertebrates including crucible weight (grams)

The system then calculates:

$$K = D - T \qquad \text{(EQ 107)}$$

Where K= **dry weight of drift invertebrates** (grams)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 108)}$$

Where N = **dry weight of drift invertebrates** (grams)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **dry weight**, will be stored in a near online manner at the local DIS node. The values for **dry weight** are not currently stored in WATSTORE or QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report sampling method used.

(3) No numerical precision data are available.

6.3.10.7.4.5 Ash Weight of Drift Invertebrates

After completing the dry-weight determination, the analysis continues by determining the **ash weight** of the sample. The sample remains in or is placed in a tared crucible and is reduced to ash at high temperature in a muffle furnace. The sample and crucible are then cooled, rinsed, re-dried, and re-weighted. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and reused. Otherwise, the user will enter:

(1) A = **ash weight** of drift invertebrates including crucible weight (grams)

(2) T = tare weight of crucible (grams)

The system then calculates:

$$K = A - T \qquad \text{(EQ 109)}$$

Where K= **ash weight of drift invertebrates** (grams)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 110)}$$

Where N= **ash weight of drift invertebrates** (grams)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash weight**, will be stored in a near online manner at the local DIS node. The values for **ash weight** are not currently stored in WATSTORE or QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report sampling method used.

(3) no numerical precision data are available.

6.3.10.7.4.6 Ash-free Weight of Drift Invertebrates

After completing the dry-weight and ash-weight determinations, the computations are completed by determining the **ash-free** weight of the sample. This computation determines the organic weight of biological material in the invertebrates. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and re-used. Otherwise, the user will enter:

(1) dry weight of drift invertebrates (grams)

(2) ash weight of drift invertebrates (grams)

The system then calculates:

$$K = D - A \qquad \text{(EQ 111)}$$

Where K = **ash-free weight of drift invertebrates** (g/m^2)

If the user has been processing taxon-specific data, when completed the system will calculate the total weight:

Computations

$$N = \sum_{i}^{N_s} K_i \qquad \text{(EQ 112)}$$

Where N = **ash-free weight of drift invertebrates** (g/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **ash-free weight,** will be stored in a near online manner at the local DIS node. The value for **ash-free weight of drift invertebrates** is not currently stored in WATSTORE or QWDATA. The user group requests this value be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report to two significant figures.

6.3.10.7.4.7 Drift Density of Benthic Invertebrates

Drift densities are calculated because the organisms are trapped in a net. The catch increases as the volume of water passing through the net increases. Invertebrate drift density may be expressed on a sample basis or a daily (24-hour) basis, depending on the study objectives. The user must decide whether to calculate the density as a function of the number of organisms in the sample or as a function of mass. The system will produce results regardless of units used. The user will enter:

(1) L = quantity of drift organisms (number or grams)

(2) V = volume of water sampled (cubic meters)

The system then calculates:

$$\textbf{Drift density} \text{ (number or grams per cubic meter)} = \frac{L}{V} \qquad \text{(EQ 113)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **drift density**, will be stored in a near online manner at the local DIS node. The value for **drift density** is not currently stored in WATSTORE or QWDATA. The user group requests this value be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Weight calculations, invertebrate drift density, and rate may be expressed either on a sample basis or a daily (24-hour) basis, depending on the study objectives.

(2) Report drift quantity, taxa, and methods of collections for daylight samples. If sampling was done for 24 hours, report drift quantity and taxa per unit volume and time to indicate any periodicity that occurred.

(3) Describe methods of collection.

(4) Assume reporting information to two significant digits.

6.3.10.7.4.8 Drift Rates of Benthic Invertebrates

Drift rate of benthic invertebrates refer to the number of invertebrates or biomass passing a sampling point in a given time. The system calculates the drift rate as either number per time unit or as grams per time unit, depending on the needs of the researcher. The user will enter:

(1) L = quantity of drift invertebrates (number or grams).

(2) V = volume of water sampled (cubic meters)

(3) Q = stream discharge (cubic meters per time unit)

The system then calculates:

$$R = \frac{L}{VQ} \qquad \text{(EQ 114)}$$

Where R = **drift rate** (number/time or grams/time)

Input data will be archived or stored in a near online manner at a local DIS node. Output data, **drift rate,** will be stored in a near online manner at the local DIS node. The values for **drift rate** are not currently stored in WATSTORE or QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Weight calculations, invertebrates drift density, and rate may be expressed either on a sample basis or a daily (24-hour) basis, depending on the study objectives.

(2) Report drift quantity, taxa, and methods of collections for daylight samples. If sampling was done for 24 hours, report drift quantity and taxa per unit volume and time to indicate any periodicity that occurred.

(3) Describe methods of collection.

(4) Assume reporting information to two significant digits.

6.3.10.7.4.9 Total Daily Drift Rate of Benthic Invertebrates

Total daily drift rate of drift invertebrates refers to the number of invertebrates or biomass passing a sampling point *per day.* The system will calculate the drift rate as *per day* upon election of the user. The user will enter:

Computations

(1) L_d = quantity of drift invertebrates (numbers or grams)

(2) Q_d = total stream discharge in 24 hours (cubic meters per 24 hours)

(3) V = volume of water sampled (cubic meters)

$$R = \frac{L_d}{VQ_d} \qquad \text{(EQ 115)}$$

Where R = **total daily drift rate**
(number or grams per 24 hours)

Input data will be archived or stored in a near online manner at the local DIS node. Output data, total daily drift rate, will be stored in a near on line manner at the local DIS node. The values for **total daily drift rate** is not currently stored in WATSTORE or QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Conditions:

(1) Weight calculations, invertebrate drift density, and rate may be expressed either on a sample basis or a daily (24-hour) basis, depending on the study objectives.

(2) Report drift quantity, taxa, and methods of collections for daylight samples. If sampling was done for 24 hours, report drift quantity and taxa per unit volume and time to indicate any periodicity that occurred.

(3) Describe methods of collection.

(4) Assume reporting information to two significant digits.

6.3.10.8 Aquatic Vertebrates

Fish are the most common vertebrates in most ecosystems. The health of the local fish population is usually used as an index to the quality of water in a habitat and to the health of other organisms because fish depend on these organisms as food. Many methods exist to examine fish. Length-weight relationships can be used to compare fish from several streams. Changes in species composition with time can reveal water-quality trends, such as temperature changes or increased enrichment in an aquatic environment.

Many methods of collection, sample processing, and analyses exist and are beyond the scope of this document. These methods reveal much information about the fish--their speciation, population, and environment. Population data are collected and computations made to inform the researcher about the environment in which the species live. Included in population computations are percent composition of various species collected, population density estimates, and variance estimates from data obtained using the mark and recapture method.

6.3.10.8.1 Life History

Method: B-6020-85

Computations

Parameter and code:

Not applicable.

Fish and other aquatic invertebrates are collected and identified. Fish studies commonly include the number of specimens captured per unit area or unit time. The fish also may be measured, weighed, sexed, and aged to provide comparative information between populations in the same environment or between populations in different environments.

6.3.10.8.1.1 Percent Composition of Species of Aquatic Vertebrates

Fish sample populations are examined and identified using methods outlined in the technical manuals devoted to these processes. Once the samples have been identified and enumerated, percent composition of the various species is performed. The user will enter:

(1) S = the number of individuals of a particular species

(2) T = the total number of all fish collected

The system then calculates:

$$\text{Percent composition} = \left(\frac{S}{T}\right) 100 \qquad \text{(EQ 116)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **percent composition**, will be archived or stored in a near online manner at the local DIS node. The value for **percent composition** is not currently stored in WATSTORE or QWDATA. The user group requests this value, and the values in item (3), below, be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **percent composition** to the nearest whole number and each value must range between 0 and 100.

(3) Report identity of taxon, number of taxa present, percent composition of each taxon, and type of sampling method used.

6.3.10.8.1.2 Population-Density Estimate from Area-Density Data

The area-density method of counting the number of fish in a series of random or stratified plots or in areas that are representative of the total area whose population is to be estimated. The sample count is expanded to an estimate of the population by multiplying the aggregate sample count by the fraction: total area (or time) divided by the sum of sample areas. The user will enter:

(1) A= the number of equal units of area (or time) occupied by the total population

(2) a = number of units sampled

(3) N_i = the number counted in the i[th] sample area

The system then calculates:

$$N = \frac{A}{a}\sum_{i=1}^{a} N_i \qquad \text{(EQ 117)}$$

Where N = the estimate of **population** size

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **population**, will be archived or stored in a near online manner at the local DIS node. The value for **population** is not currently stored in WATSTORE or QWDATA. The user group requests this value, and the values in item (3), below, be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **population density** to nearest whole number.

(3) Report sampling method used.

6.3.10.8.1.3 Estimate of Variance of Population

The user will then indicate whether to calculate the population variance. The estimated variance is then calculated by:

$$v(N) = \frac{A^2 - aA}{a} \times \frac{a\sum_{i=1}^{a} N_i^2 - \left(\sum_{i=1}^{a} N_i\right)^2}{a(a-1)} \qquad \text{(EQ 118)}$$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **variance**, will be archived or stored in a near online manner at the local DIS node. The values for **variance** are not currently stored in WATSTORE and QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **variance** to two significant figures.

(3) Report sampling method used.

6.3.10.8.1.4 Population-Density Estimate from Mark and Recapture Data

The mark and recapture method of population involves, first, the capture and release of a number of marked individuals into the population; and second, the subsequent recapture of marked individuals and the capture of unmarked individuals from the population. The user will enter:

(1) C = the recapture sample size that includes both marked and unmarked individuals

(2) M = the number of individuals marked and released into the population

(3) R = the number of marked individuals that are recaptured

The system then calculates:

$$N = \frac{MC}{R} \quad \text{(EQ 119)}$$

Where N = **population density** estimate

If population density is large enough for multiple marking and recapture periods, use Schnable's equation by entering the same variables as in (EQ 119) and indicating a choice of this computation:

$$N = \frac{\sum_{t=1}^{n} M_t C_t}{\sum_{t=1}^{n} R_t} \quad \text{(EQ 120)}$$

Where N = **population density** estimate

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **population density**, will be archived or stored in a near online manner at the local DIS node. The values for **population density** are not currently stored WATSTORE and QWDATA. The user group requests these values be included in the NWIS-II data dictionary.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Input data must be positive numbers.

(2) Report **population density** in sample to the nearest whole number.

(3) Report sampling method.

6.3.10.9 Cellular Contents

Chlorophyll *a* is the primary photosynthetic pigment of all oxygen-producing photosynthetic organisms and is present in all algae (phytoplankton and periphyton). Thus, measurement of this pigment can indicate the quantity of algae present and provide an estimate of the primary productivity. Certain other algae contain

chlorophyll *c* and *d*. Ratios between the different types of chlorophyll may indicate the taxonomic composition of the algal community.

An estimate of the quantity of living micro-organisms (biomass) in an aquatic environment can be useful when assessing water quality. The universal occurrence and central function of adenosine triphosphate (ATP) in living cells and its chemical stability make it an excellent indicator for the presence of living material. The quantity of ATP therefore can be used to estimate total living biomass.

6.3.10.9.1 Chlorophyll in Phytoplankton by Spectroscopy

Method: B-6501-85

Parameters codes:

Chlorophyll *a*, phytoplankton, spectrometric, uncorrected (μg/L): 32230
Chlorophyll *b*, phytoplankton, spectrometric (μg/L): 32231
Chlorophyll *c*, phytoplankton, spectrometric (μg/L): 32232
Chlorophyll, total, phytoplankton, spectrometric, uncorrected (μg/L): 32234

Chlorophyll pigments are determined simultaneously without detailed separation. A water sample is filtered, and the phytoplankton cells retained on the filter are ruptured mechanically, using 90-percent acetone, to facilitate extraction of pigments. Concentrations of chlorophyll are calculated from measurements of absorbance by spectroscope of the extract at four wavelengths, corrected for a 90-percent acetone blank.

Absorbances of properly prepared samples are read at 750 nm, 664 nm, 647 nm, and 630 nm and compared to a 90-percent acetone blank. The absorbance at 750 nm is subtracted from the absorbances at each of the other wavelengths and each result is divided by the measurement of the light path of the spectrometer cell, in centimeters. The user will prompt the system to compute the chlorophyll in phytoplankton by spectroscopy calculations and begin by entering:

(1) A_{750} = absorbance at 750 nm

(2) A_{664} = absorbance at 664 nm

(3) A_{647} = absorbance at 647 nm

(4) A_{630} = absorbance at 630 nm

(5) f = measurement of spectrometer cell light path (centimeters)

The system will calculate:

$$e_{664} = \frac{A_{664} - A_{750}}{f} \quad \text{(EQ 121)}$$

where e_{664} = absorption for chlorophyll *a*

Computations

$$e_{647} = \frac{A_{647} - A_{750}}{f} \quad \text{(EQ 122)}$$

where e_{647} = absorption for chlorophyll *b*

$$e_{630} = \frac{A_{630} - A_{750}}{f} \quad \text{(EQ 123)}$$

where e_{630} = absorption for chlorophyll *c*

The values calculated above are then converted to the concentrations of chlorophyll in the extract, in micrograms per milliliter, by using equations (EQ 124) through (EQ 126), below. The system calculates:

$$D_{av} = 11.85e_{664} - 1.54e_{647} - 0.08e_{630} \quad \text{(EQ 124)}$$

Where D_{av} = concentration of chlorophyll *a* (μg/mL)

$$D_{bv} = -5.43e_{664} + 21.03e_{647} - 2.66e_{630} \quad \text{(EQ 125)}$$

Where D_{bv} = concentration of chlorophyll *b* (μg/mL)

$$D_{cv} = -1.67e_{664} - 7.60e_{647} + 24.52e_{630} \quad \text{(EQ 126)}$$

Where D_{cv} = concentration of chlorophyll *c* (μg/mL)

Finally, the concentrations of the chlorophyll in the sample are computed, in micrograms per liter. The results computed above are accessed by the system and input below. The user will enter:

(1) V_e = volume extracted for spectroscopic analysis (milliliters)

(2) V_s = volume of sample (liters)

For each chlorophyll, the system calculates:

$$C_a = \frac{D_{av}V_e}{V_s} \quad \text{(EQ 127)}$$

Where C_a = concentration of **chlorophyll *a* in phytoplankton** (μg/L)

$$C_b = \frac{D_{bv}V_e}{V_s} \quad \text{(EQ 128)}$$

Where C_b = concentration of **chlorophyll *b* in phytoplankton** (μg/L)

$$C_c = \frac{D_{cv}V_e}{V_s} \quad \text{(EQ 129)}$$

Where C_c = concentration of **chlorophyll *c* in phytoplankton** (μg/L)

Computations

Input data will be archived or stored in a near online manner at the local DIS node. The values for **chlorophyll *a*, chlorophyll *b*,** and **chlorophyll *c*,** will be stored on the local node and the national data base (EPA parameters 32230, 32231, 32232, respectively).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a, b, c* or total chlorophyll in micrograms per liter to 1 decimal if less than 1 microgram per liter, and 2 significant figures for over 1 microgram per liter.

(2) The precision of chlorophyll determinations is affected by the volume of water filtered, the range of chlorophyll values calculated, the volume of extraction solvent, and the light path of the spectrometer cells.

(3) The following precision estimates were reported by Britton and Greeson (1989, p. 220):

Chlorophyll *a* precision at the 5 µg level. The correct value is in the range: Mean of n determinations $\pm 0.26/n\ \ 1/2$ µg chlorophyll *a*.

Chlorophyll *b* precision at the 5 µg level. The correct value is in the range: Mean of n determinations $\pm 0.21/n\ \ 1/2$ µg chlorophyll *b*.

(4) The precision of chlorophyll *c* determinations is variable and very poor, anywhere between ±10 and ±30 percent of the quantity being measured; results are not accurate.

6.3.10.9.2 Chlorophyll in Phytoplankton by Chromatography and Spectroscopy

Method: B-6520-85

Parameters and codes:

Chlorophyll *a*, phytoplankton, chromatographic/spectrometric (µg/L): 70951
Chlorophyll *b*, phytoplankton, chromatographic/spectrometric (µg/L): 70952

A plankton sampled is filtered, and the chlorophyll are extracted from the algae cells. The chlorophyll are separated from each other and from chlorophyll degradation products by thin-layer chromatography. Chlorophyll are eluted and measured using a spectrometer.

Absorbances of properly prepared samples are read at 664 nm for chlorophyll *a* and at 647 nm for chlorophyll *b*. If the absorbance is less than 0.01, use the fluorescence technique. If the absorbance is greater than 0.01, determine concentrations using the specific absorptivities of 0.0877 L/mg x cm for chlorophyll *a* and 0.0514 L/mg x cm for chlorophyll *b* using the following equation. The user will enter:

(1) A_{664} = Absorbance for chlorophyll *a* at 664 nm

(2) A_{647} = absorbance for chlorophyll *b* at 647 nm

(3) α_a = specific absorptivity of chlorophyll *a*

(4) α_b = specific absorptivity of chlorophyll *b*

(5) f = measurement of spectrometer cell light path (centimeters)

The system will calculate:

$$C_a = \frac{A_{664}}{\alpha_a f} \qquad \text{(EQ 130)}$$

Where C_a = concentration for chlorophyll *a* (mg/L)

$$C_b = \frac{A_{647}}{\alpha_b f} \qquad \text{(EQ 131)}$$

Where C_b = concentration for chlorophyll *b* (mg/L)

To begin final calculation of the chlorophyll in micrograms per liter, the user will enter:

(1) C_{sa} = concentration of sample chlorophyll *a* (micrograms per milliliter)

(2) C_{sb} = concentration of sample chlorophyll *b* (micrograms per milliliter)

(3) V_C = volume of sample concentrate (microliters)

(4) V_S = volume streaked (microliters)

(5) V = sample volume (liters)

The system will then perform the final calculations:

$$C_A = \frac{(3mL)\, C_{sa}\left(\frac{V_C}{V_S}\right)}{V} \qquad \text{(EQ 132)}$$

Where C_A = **chlorophyll *a* in phytoplankton** (μg/L)

$$C_B = \frac{(3mL)\, C_{sb}\left(\frac{V_C}{V_S}\right)}{V} \qquad \text{(EQ 133)}$$

Where C_B = **chlorophyll *b* in phytoplankton** (μg/L)

Input data will be archived or stored in a near online manner at the local DIS node. The values for **chlorophyll *a*** and **chlorophyll *b*** will be stored on the local node and the national data base (EPA parameters 70951 and 70952, respectively).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll in micrograms per liter to 1 decimal if less than 1 microgram per liter, and 2 significant figures for over 1 microgram per liter.

(2) This method is not suitable for the determination of chlorophyll *c*.

6.3.10.9.3 Chlorophyll in Phytoplankton by High-pressure Liquid Chromatography

Method: B-6530-85

Parameters and codes:

Chlorophyll *a*, phytoplankton, chromatographic/fluorometric (μg/L): 70953
Chlorophyll *b*, phytoplankton, chromatographic/fluorometric (μg/L): 70954

A filtered phytoplankton sample is ruptured mechanically, and the chlorophyll pigments are separated from each other and degradation products by high-pressure liquid chromatography and determined by fluorescence spectroscopy. In this analysis, the concentrations for the chlorophyll are obtained by comparing chromatographic peaks of a known standard with those obtained for the sample. Several steps and calculations are required to accomplish this task.

Absorbances are read for stock chlorophyll solutions at 664 nm for chlorophyll *a* and 647 nm for chlorophyll *be*. This procedure is repeated three times for each chlorophyll and average absorbance calculated for each, separately. These average absorbances are used to calculate concentration of chlorophyll *a* and chlorophyll *b* in the stock solution, which is used later to correct any variation in the standard solution. To calculate exact concentrations of the chlorophyll in the stock solution the user will enter:

(1) a_{664} = absorbance for chlorophyll *a*

(2) a_{647} = absorbance for chlorophyll *b*

(3) α_a= specific absorptivity for chlorophyll *a*, 0.0877 L/mg x cm

(4) α_b = specific absorptivity for chlorophyll *b*, 0.0514 L/mg x cm

(5) f = path length (centimeters)

The system calculates:

$$C_{SA} = \frac{a_{664}}{\alpha_a f} \qquad \text{(EQ 134)}$$

Where C_{SA} = concentration of chlorophyll *a* in stock solution (mg/L)

$$C_{SB} = \frac{a_{647}}{\alpha_b f} \qquad \text{(EQ 135)}$$

Where C_{SB} = concentration of chlorophyll *b* in stock solution (mg/L)
[See NOTE 1 for above equations.]

The concentrations of the chlorophyll working standard solutions are verified and corrected using the above results. Next, the response factor for chlorophyll *a* and *b* in the standard solution is calculated. The user enters:

Computations

(1) C_{ma} = **concentration of chlorophyll *a* in mid-range standard solution (milligrams per liter)**

(2) C_{mb} = **concentration of chlorophyll *b* in mid-range standard solution (milligrams per liter)**

(3) I_a = integrated area of component peak, chlorophyll *a*

(4) I_b = integrated area of component peak, chlorophyll *b*

(5) V = volume of midrange standard solution injected (milliliters)

$$F_A = \frac{VC_{ma}}{I_a} \qquad \text{(EQ 136)}$$

Where F_A = response factor for chlorophyll *a* (mg/unit area)

$$F_B = \frac{VC_{mb}}{I_b} \qquad \text{(EQ 137)}$$

Where F_B = response factor for chlorophyll *b* (mg/unit area)

Finally, the concentrations of chlorophyll *a* and *b* in the original sample are calculated. The chlorophyll response factors, F_A and F_B, are accessed from the system. The user will enter:

(1) A_S = sample volume filtered (liters)

(2) I_a = integrated area of component peak from sample extract injection, chlorophyll *a*

(3) I_b = integrated area of component peak from sample extract injection, chlorophyll *b*

(4) V_E = final volume of sample extract (milliliters)

(5) V_I = volume of sample extract injected (microliters)

The system calculates:

$$C_A = \frac{F_A I_a V_E}{A_S V_I} \qquad \text{(EQ 138)}$$

Where C_A = concentration of **chlorophyll *a* in phytoplankton**(μg/L)

$$C_B = \frac{F_B I_b V_E}{A_S V_I} \qquad \text{(EQ 139)}$$

Where C_B = concentration of **chlorophyll *b* in phytoplankton** (μg/L)

Input data will be archived or stored in a near online manner at the local DIS node. The values for **chlorophyll *a*** and **chlorophyll *b*** will be stored on the local node and the national data base (EPA parameters 70953, 70954).

Computations

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a* or *b* to one decimal for levels below 1 microgram per liter, and 2 significant figures for 1 microgram per liter or greater.

(2) NOTE 1: For Calibration: There are three replicate runs done for each sample. The computations are done for the average of three runs, as well as for each run.

6.3.10.9.4 Chlorophyll in Phytoplankton by Chromatography and Fluorometry

Method: B-6540-85

Parameters and codes:

Chlorophyll *a*, phytoplankton, chromatographic/fluorometric (μg/L): 70953
Chlorophyll *b*, phytoplankton, chromatographic/fluorometric (μg/L): 70954

A filtered phytoplankton sample is ruptured mechanically, and the chlorophyll pigments are separated from each other and degradation products by thin-layer chromatography and determined by spectrofluorometry. To standardize the spectrofluorometer, standard solutions of chlorophyll *a* and *b* are prepared, analyzed with the fluorometer, and the absorbance read at 664 nm for chlorophyll *a* and at 647 nm for chlorophyll *b*. The concentrations of the chlorophyll in the standard solutions are then calculated. The user will enter:

(1) A_{664} = absorbance at 664 nm

(2) A_{647} = absorbance at 647 nm

(3) α_a= specific absorptivity for chlorophyll *a* (0.0877 L/mg x cm)

(4) α_b = specific absorptivity for chlorophyll *b* (0.0514 L/mg x cm)

(5) f = path length (centimeters)

The system calculates:

$$C_A = \frac{A_{664}}{\alpha_a f} \quad \text{(EQ 140)}$$

Where C_A = concentration of chlorophyll *a* (mg/L)

$$C_B = \frac{A_{647}}{\alpha_b f} \quad \text{(EQ 141)}$$

Where C_B = concentration of chlorophyll *b* (mg/L)

The sample concentrate chlorophyll concentrations are then determined. The spectrofluorometer is standardized with the standard solution and the sample concentrate is analyzed. The sample concentration is taken from the standard solution curve and corrected for the concentration step using (EQ 142) or (EQ 143). The user enters:

(1) C_{SA} = concentration of sample chlorophyll *a* (micrograms per milliliter)

(2) C_{SB} = concentration of sample chlorophyll *b* (micrograms per milliliter)

(3) V_C = volume of sample concentrate (microliters)

(4) V_S = volume of sample streaked (microliters)

(5) V = volume of sample filtered onsite (liters)

$$C_A = \frac{3C_{SA}\left(\frac{V_C}{V_S}\right)}{V} \quad \text{(EQ 142)}$$

Where C_A = concentration of **chlorophyll** *a* (µg/L)

$$C_B = \frac{3C_{SB}\left(\frac{V_C}{V_S}\right)}{V} \quad \text{(EQ 143)}$$

Where C_B = concentration of **chlorophyll *b*** (µg/L)

Input data will be archived or stored in a near online manner at the local DIS node. The values for **chlorophyll *a*** and **chlorophyll *b*** will be stored on the local node and the national data base (EPA parameters 70953 and 70954, respectively).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a* or *b* to one decimal for levels below 1 microgram per liter, and 2 significant figures for 1 microgram per liter or greater.

(2) NOTE: Use this method if absorbance is less than or equal to 0.01.

6.3.10.9.5 Biomass/Chlorophyll Ratio for Phytoplankton

Method: B-6560-85

Parameter and code:

Biomass-chlorophyll ratio, phytoplankton: 70949

Since periphyton and phytoplankton communities are usually dominated by algae, the biomass/chlorophyll ratio can be used as an indicator of increased entry of quantities of degradable, nontoxic organic materials into natural waters because this frequently causes an increase in the biomass of heterotrophic organisms, such as bacteria and fungi. Comparison of the biomass/chlorophyll ratios of samples collected over time therefore are important water-quality indicators.

A filtered phytoplankton sample is ruptured mechanically, and the chlorophyll pigments are separated from each other and degradation products by high-pressure liquid chromatography and determined by fluorescence spectroscopy. The dry weight and ash weight of the phytoplankton are determined to obtain the weight of organic matter (biomass). The biomass/chlorophyll ratio is calculated from these values.

Computations

Chlorophyll computations:

Absorbances are read for stock chlorophyll solutions at 664 nm for chlorophyll *a* and 647 nm for chlorophyll *b*. This procedure is repeated three times for each chlorophyll and average absorbance calculated for each, separately. These average absorbances are used to calculate concentration of chlorophyll *a* and chlorophyll *b* in the stock solution, which is used later to correct any variation in the standard solution. To calculate exact concentrations of the chlorophyll in the stock solution the user will enter:

(1) A_{664} = absorbance at 664 nm

(2) A_{647} = absorbance at 647 nm

(3) α_a= specific absorptivity for chlorophyll *a* (0.0877 L/mg x cm)

(4) α_b = specific absorptivity for chlorophyll *b* (0.0514 L/mg x cm)

(5) f = path length (centimeters)

The system calculates:

$$C_{SA} = \frac{A_{664}}{\alpha_a f} \quad \text{(EQ 144)}$$

Where C_{SA} is stock solution concentration (mg/L)

$$C_{SB} = \frac{A_{647}}{\alpha_b f} \quad \text{(EQ 145)}$$

Where C_{SB} is stock solution concentration (mg/L)
{See NOTE 1 for above equations.}

The concentrations of the chlorophyll working standard solutions are verified and corrected using the above results. Next, the response factor for chlorophyll *a* and *b* in the standard solution is calculated. The user will enter:

(1) C_{ma} = concentration of chlorophyll *a* in mid-range standard solution (milligrams per liter)

(2) C_{mb} = concentration of chlorophyll *b* in mid-range standard solution (milligrams per liter)

(3) I_a = integrated area of component peak, chlorophyll *a*

(4) I_b = integrated area of component peak, chlorophyll *b*

(5) V = volume of midrange standard solution injected

$$F_A = \frac{VC_{ma}}{I_a} \quad \text{(EQ 146)}$$

Where F_A = response factor for chlorophyll *a*
(mg/unit area)

$$F_B = \frac{VC_{mb}}{I_b} \qquad \text{(EQ 147)}$$

Where F_B = response factor for chlorophyll *b* (mg/unit area)

Finally, the concentrations of chlorophyll *a* and *b* in the original sample are calculated. The chlorophyll response factors, F_A and F_B, are accessed from the system. The user will enter:

(1) V_s = sample volume filtered

(2) I_a = integrated area of component peak from sample extract injection, chlorophyll *a*

(3) I_b = integrated area of component peak from sample extract injection, chlorophyll *b*

(4) V_E = final volume of sample extract, milliliters

(5) V_I = volume of sample extract injected, microliters

The system calculates:

$$C_A = \frac{F_A I_a V_E}{V_I V_s} \qquad \text{(EQ 148)}$$

Where C_A = concentration of **chlorophyll *a*** (µg/L)

$$C_B = \frac{F_B I_b V_E}{V_I V_s} \qquad \text{(EQ 149)}$$

Where C_B = concentration of **chlorophyll *b*** (µg/L)

Biomass computations:

The remaining sample is transferred to a 30-ml porcelain crucible and processed for dry and ash weights. The organisms are dried thoroughly in an oven to stable weight, cooled in a desiccator jar, and weighed to determine the dry weight. The user will enter:

(1) D = dry weight of organisms including crucible weight (milligrams)

(2) T = Tare weight of crucible (milligrams)

The system then calculates:

$$D_S = D - T \qquad \text{(EQ 150)}$$

Where D_S = dry weight (milligrams)

The analysis continues by determining the ash weight of the sample. The sample is reduced to ash at high temperature in a muffle furnace. The sample and crucible are then cooled, rinsed, redried, and reweighted. If this computation is being performed in sequence with the previous computation, the crucible tare weight will be accessed by the system and reused. The user will enter:

Computations

(1) A = ash weight of organisms including crucible weight (milligrams)

(2) T = tare weight of crucible (milligrams)

The system then calculates:

$$A_S = A - T \qquad \text{(EQ 151)}$$

Where A_S = ash weight (mg)

After completing the dry-weight and ash-weight determinations, the ash-free weight of the sample is determined. This computation determines the organic weight or **biomass** of biological material in the sample. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and re-used. Otherwise, the user will enter:

(1) A_S = ash weight of sample (milligrams)

(2) D_S = dry weight of sample (milligrams)

(3) V_S = volume of sample filtered on site (liters)

The system then calculates:

$$B_S = \frac{D_S - A_S}{V_S} \qquad \text{(EQ 152)}$$

Where B_S = Ash-free weight or **biomass** (mg/L)

To complete the computations, the biomass/chlorophyll ratio is calculated. If proceeding from the above equations, the necessary data will be accessed by the system. If not, the user will enter:

(1) B_S = Biomass (milligrams per liter)

(2) C_A = Concentration of chlorophyll *a* (micrograms per liter)

(3) C_B = Concentration of chlorophyll *b* (micrograms per liter)

Biomass/Chlorophyll ratio:

The system then calculates:

$$R_A = \frac{1000B_S}{C_A} \qquad \text{(EQ 153)}$$

Where R_A = **biomass/chlorophyll *a* ratio** for phytoplankton

$$R_B = \frac{1000B_S}{C_B} \qquad \text{(EQ 154)}$$

Where R_B = **biomass/chlorophyll *b* ratio** for phytoplankton

Computations

Input data will be archived or stored in a near online manner at the local DIS node. The value for **biomass/ chlorophyll *a* ratio** will be stored on the local node and the national data base (EPA parameters 70949).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a* or *b* to one decimal for levels below 1 microgram per liter, and 2 significant figures for 1 microgram per liter or greater.

(2) Report concentrations of biomass to one decimal for levels below 1 milligram per liter, and 2 significant figures for 1 milligram per liter or greater.

(3) Report ratio to three significant figures.

(4) NOTE 1: For Calibration: There are three replicate runs done for each sample. The computations are done for the average of three runs, as well as for each run.

6.3.10.9.6 Chlorophyll in Periphyton by Spectroscopy

Method: B-6601-85

Parameters codes:

Chlorophyll *a*, periphyton, spectrometric, uncorrected (mg/m^2): 32228
Chlorophyll *b*, periphyton, spectrometric (mg/m^2): 32226
Chlorophyll *c*, periphyton, spectrometric (mg/m^2): 32227
Chlorophyll, total, periphyton, spectrometric, uncorrected (mg/m^2): 32225

Chlorophyll pigments are determined simultaneously without detailed separation. A periphyton sample is scraped from a known area, suspended in water, and concentrated on a membrane filter. A water sample is filtered, and the periphyton cells retained on the filter are ruptured mechanically, using 90-percent acetone, to facilitate extraction of pigments. Concentrations of chlorophyll are calculated from measurements of absorbance by spectroscope of the extract at four wavelengths, corrected for a 90-percent acetone blank (Britton and Greeson, 1989, p. 235).

Absorbances of properly prepared samples are read at 750 nm, 664 nm, 647 nm, and 630 nm and compared to a 90-percent acetone blank. The absorbance at 750 nm is subtracted from the absorbances at each of the other wavelengths and each result is divided by the measurement of the light path of the spectrometer cell, in centimeters. The user will prompt the system to compute the chlorophyll in periphyton by·spectroscopy calculations and begin by entering:

(1) A_{750} = absorbance at 750 nm

(2) A_{664} = absorbance at 664 nm

(3) A_{647} = absorbance at 647 nm

(4) A_{630} = absorbance at 630 nm

(5) f = measurement of spectrometer cell light path (centimeters)

Computations

The system will calculate:

$$e_{664} = \frac{A_{664} - A_{750}}{f} \tag{EQ 155}$$

where e_{664} = absorption for chlorophyll *a*

$$e_{647} = \frac{A_{647} - A_{750}}{f} \tag{EQ 156}$$

where e_{647} = absorption for chlorophyll *b*

$$e_{630} = \frac{A_{630} - A_{750}}{f} \tag{EQ 157}$$

where e_{630} = absorption for chlorophyll *c*

The values calculated above are then converted to the concentrations of chlorophyll in the extract, in micrograms per milliliter, by using equations (EQ 158) through (EQ 160), below. The system calculates:

$$D_{av} = 11.85e_{664} - 1.54e_{647} - 0.08e_{630} \tag{EQ 158}$$

Where D_{av} = concentration of chlorophyll *a* (μg/mL)

$$D_{bv} = -5.43e_{664} + 21.03e_{647} - 2.66e_{630} \tag{EQ 159}$$

Where D_{bv} = concentration of chlorophyll *b* (μg/mL)

$$D_{cv} = -1.67e_{664} - 7.60e_{647} + 24.52e_{630} \tag{EQ 160}$$

Where D_{cv} = concentration of chlorophyll *c* (μg/mL)

Finally, the concentrations of the chlorophyll in the sample are converted to milligrams per square meter. The results computed above are accessed by the system and input as shown below. The user will enter:

(1) V_E = volume extracted for spectroscopic analysis (milliliters)

(2) A = area scraped (square meters)

For each chlorophyll, the system will access concentrations of the chlorophyll calculated above and then calculate:

$$C_a = \frac{D_{av}V_E}{1000A} \tag{EQ 161}$$

Where C_a = concentration of **chlorophyll *a* in periphyton** (mg/m^2)

$$C_b = \frac{D_{bv}V_E}{1000A} \tag{EQ 162}$$

Where C_b = concentration of **chlorophyll *b* in periphyton** (mg/m^2)

Computations

$$C_c = \frac{D_{cv}V_E}{1000A} \quad \text{(EQ 163)}$$

Where C_c = concentration of **chlorophyll c in periphyton** (mg/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. The values for ***chlorophyll a*, *chlorophyll b*,** and ***chlorophyll c*,** will be stored on the local node and the national data base (EPA parameters 32228, 32226, 32227, respectively).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a, b, c* or total chlorophyll in milligrams per square meter to 3 significant figures.

(2) The precision of chlorophyll determinations is affected by the volume of water filtered, the range of chlorophyll values calculated, the volume of extraction solvent, and the light path of the spectrometer cells.

6.3.10.9.7 Chlorophyll in Periphyton by Chromatography and Spectroscopy

Method: B-6620-85

Parameters and codes:

Chlorophyll *a*, periphyton, chromatographic/spectrometric (mg/m^2): 70955
Chlorophyll *b*, periphyton, chromatographic/spectrometric (mg/m^2): 70956

The periphyton sample is filtered, and the chlorophyll are extracted from the algae cells. The chlorophyll are separated from each other and from chlorophyll degradation products by thin-layer chromatography. Chlorophyll are eluted and measured using a spectrometer.

Absorbances of properly prepared samples are read at 664 nm for chlorophyll *a* and at 647 nm for chlorophyll *b*. If the absorbance is less than 0.01, use the fluorescence technique. If the absorbance is greater than 0.01, determine concentrations using the specific absorptivities of 0.0877 L/mg x cm for chlorophyll *a* and 0.0514 L/mg x cm for chlorophyll *b* using the following equation. The user will enter:

(1) A_{664} = Absorbance at 664 nm

(2) A_{647} = absorbance at 647 nm

(3) α_a = specific absorptivity of chlorophyll *a*

(4) α_b = specific absorptivity of chlorophyll *b*

(5) f = measurement of spectrometer cell light path (centimeters)

Computations

The system will calculate:

$$C_a = \frac{A_{664}}{\alpha_a f} \qquad \text{(EQ 164)}$$

Where C_a = concentration for chlorophyll *a* (mg/L)

$$C_b = \frac{A_{647}}{\alpha_b f} \qquad \text{(EQ 165)}$$

Where C_b = concentration for chlorophyll *b* (mg/L)

To begin final calculation of the chlorophyll in milligrams per square meter, the user will enter:

(1) V_{SA}= concentration of sample chlorophyll *a* (micrograms per milliliter)

(2) V_{SB} = concentration of sample chlorophyll *b* (micrograms per milliliter)

(3) V = sample area scraped (square meters)

The system will then perform the final calculations:

$$C_A = \frac{(3mL)\,V_{SA}\left(\frac{500\ \mu L}{25\ \mu L}\right)}{V} \qquad \text{(EQ 166)}$$

Where C_A = concentration of **chlorophyll *a* in periphyton** (mg/m^2)

$$C_B = \frac{(3mL)\,V_{SB}\left(\frac{500\ \mu L}{25\ \mu L}\right)}{V} \qquad \text{(EQ 167)}$$

Where C_B = concentration of **chlorophyll *b* in periphyton** (mg/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. The values for **chlorophyll *a*** and **chlorophyll *b*** will be stored on the local node and the national data base (EPA parameters 70955 and 70956, respectively).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a* or *b*, in milligrams per square meter, to three significant figures.

(2) This method is not suitable for the determination of chlorophyll *c*.

(3) NOTE: If absorbance is less than 0.01, use the fluorescence technique (I.9).

6.3.10.9.8 Chiorophyli in Periphyton by High-pressure Liquid Chromatography

Method: B-6630-85

Parameters and codes:

Chlorophyll *a*, periphyton, chromatographic/fluorometric (mg/m^2): 70957
Chlorophyll *b*, periphyton, chromatographic/fluorometric (mg/m^2): 70958

A filtered periphyton sample is ruptured mechanically, and the chlorophyll pigments are separated from each other and degradation products by high-pressure liquid chromatography and determined by fluorescence spectroscopy. In this analysis, the concentrations for the chlorophyll are obtained by comparing chromatographic peaks of a known standard with those obtained for the sample. Several steps and calculations are required to accomplish this task.

Absorbances are read for stock chlorophyll solutions at 664 nm for chlorophyll *a* and 647 nm for chlorophyll *b*. This procedure is repeated three times for each chlorophyll and average absorbance calculated for each, separately. These average absorbances are used to calculate concentration of chlorophyll *a* and chlorophyll *b* in the stock solution, which is used later to correct any variation in the standard solution. To calculate exact concentrations of the chlorophyll in the stock solution the user will enter:

(1) A_{664} = absorbance at 664 nm

(2) A_{647} = absorbance at 647 nm

(3) α_a= specific absorptivity for chlorophyll *a*, 0.0877 L/mg x cm

(4) α_b = specific absorptivity for chlorophyll *b*, 0.0514 L/mg x cm

(5) f = path length (centimeters)

The system calculates:

$$C_{SA} = \frac{A_{664}}{\alpha_a f} \qquad \text{(EQ 168)}$$

Where C_{SA} = concentration of chlorophyll *a* in stock solution (mg/L)

$$C_{SB} = \frac{A_{647}}{\alpha_b f} \qquad \text{(EQ 169)}$$

Where C_{SB} = concentration of chlorophyll *b* in stock solution (mg/L)

{See NOTE 1 for above equations.}

The concentrations of the chlorophyll working standard solutions are verified and corrected using the above results. Next, the response factor for chlorophyll *a* and *b* in the standard solution is calculated. The user will enter:

Computations

(1) C_{ma} = concentration of chlorophyll *a* in midrange standard solution (milligrams per liter)

(2) C_{mb} = concentration of chlorophyll *b* in midrange standard solution (milligrams per liter)

(3) I_a = integrated area of component peak, chlorophyll *a*

(4) I_b = integrated area of component peak, chlorophyll *b*

(5) V = volume of midrange standard solution injected (milliliters)

$$F_A = \frac{VC_{ma}}{I_a} \qquad \text{(EQ 170)}$$

Where F_A = response factor for chlorophyll *a* (mg/unit area)

$$F_B = \frac{VC_{mb}}{I_b} \qquad \text{(EQ 171)}$$

Where F_B = response factor for chlorophyll *b* (mg/unit area)

Finally, the concentrations of chlorophyll *a* and *b* in the original sample are calculated. The chlorophyll response factors, F_A and F_B, are accessed from the system. The user will enter:

(1) V_S = sample volume filtered (liters)

(2) I_a = integrated area of component peak from sample extract injection, chlorophyll *a*

(3) I_b = integrated area of component peak from sample extract injection, chlorophyll *b*

(4) V_E = final volume of sample extract (milliliters)

(5) V_I = volume of sample extract injected (microliters)

The system calculates:

$$C_A = \frac{F_A I_a V_E}{1000 V_S V_I} \qquad \text{(EQ 172)}$$

Where C_A = concentration of **chlorophyll *a* in periphyton** (mg/m^2)

$$C_B = \frac{F_B I_b V_E}{1000 V_S V_I} \qquad \text{(EQ 173)}$$

Where C_B = concentration of **chlorophyll *b* in periphyton** (mg/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. The values for **chlorophyll *a*** and **chlorophyll *b*** will be stored on the local node and the national data base (EPA parameters 70957 and 70958, respectively).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a* or *b*, in milligrams per square meter, to 3 significant figures.

(2) NOTE 1: For Calibration: There are three replicate runs done for each sample. The computations are done for the average of three runs, as well as for each run.

6.3.10.9.9 Chlorophyll in Periphyton by Chromatography and Fluorometry

Method: B-6540-85

Parameters and codes:

Chlorophyll *a*, periphyton, chromatographic/fluorometric (mg/m^2): 70957
Chlorophyll *b*, periphyton, chromatographic/fluorometric (mg/m^2): 70958

A filtered periphyton sample is ruptured mechanically, and the chlorophyll pigments are separated from each other and degradation products by thin-layer chromatography and determined by spectrofluorometry. To standardize the spectrofluorometer, standard solutions of chlorophyll *a* and *b* are prepared, analyzed with the fluorometer, and the absorbance read at 664 nm for chlorophyll *a* and at 647 nm for chlorophyll *b*. The concentrations of the chlorophyll in the standard solutions are then calculated. The user will enter:

(1) A_{664} = absorbance at 664 nm

(2) A_{647} = absorbance at 647 nm

(3) α_a= specific absorptivity for chlorophyll *a* (0.0877 L/mg x cm)

(4) α_b = specific absorptivity for chlorophyll *b* (0.0514 L/mg x cm)

(5) f = path length (centimeters)

The system calculates:

$$C_A = \frac{A_{664}}{\alpha_a f} \quad \text{(EQ 174)}$$

Where C_A = concentration of chlorophyll *a* (mg/L)

$$C_B = \frac{A_{647}}{\alpha_b f} \quad \text{(EQ 175)}$$

Where C_B = concentration of chlorophyll *b* (mg/L)

The sample concentrate chlorophyll concentrations are then determined. The spectrofluorometer is standardized with the standard solution and the sample concentrate is analyzed. The sample concentration is taken from the standard solution curve and corrected for the concentration step using (EQ 176) or (EQ 177). The user will enter:

Computations

(1) C_{SA} = concentration of sample chlorophyll *a* (micrograms per milliliter)

(2) C_{SB} = concentration of sample chlorophyll *b* (micrograms per milliliter)

(3) V = volume of sample filtered on site (liters)

$$C_A = \frac{(3mL)\,C_{SA}\,(\frac{500\ \mu L}{25\ \mu L})}{1000V} \qquad \text{(EQ 176)}$$

Where C_A = concentration of **chlorophyll *a* in periphyton** (mg/m^2)

$$C_B = \frac{(3mL)\,C_{SB}\,(\frac{500\ \mu L}{25\ \mu L})}{1000V} \qquad \text{(EQ 177)}$$

Where C_B = concentration of **chlorophyll *b* in periphyton** (mg/m^2)

Input data will be archived or stored in a near online manner at the local DIS node. The values for **chlorophyll *a*** and **chlorophyll *b*** will be stored on the local node and the national data base (EPA parameters 70957 and 70958, respectively).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a* or *b*, in milligrams per square meter, to three significant figures.

(2) NOTE: this method can be used if absorbance is less than or equal to 0.01.

6.3.10.9.10 Biomass/Chlorophyll Ratio for Periphyton

Method: B-6660-85

Parameter and code:

Biomass-chlorophyll ratio, periphyton: 70950

Since periphyton and periphyton communities are usually dominated by algae, the biomass/chlorophyll ratio can be used as an indicator of increased entry of quantities of degradable, nontoxic organic materials into natural waters because this frequently causes an increase in the biomass of heterotrophic organisms, such as bacteria and fungi. Comparison of the biomass/chlorophyll ratios of samples collected over time therefore are important water-quality indicators.

Computations

A filtered periphyton sample is ruptured mechanically, and the chlorophyll pigments are separated from each other and degradation products by high-pressure liquid chromatography and determined by fluorescence spectroscopy. The dry weight and ash weight of the periphyton are determined to obtain the weight of organic matter (biomass). The biomass/chlorophyll ratio is calculated from these values.

Chlorophyll computations:

Absorbances are read for stock chlorophyll solutions at 664 nm for chlorophyll *a* and 647 nm for chlorophyll *b*. This procedure is repeated three times for each chlorophyll and average absorbance calculated for each, separately. These average absorbances are used to calculate concentration of chlorophyll *a* and chlorophyll *b* in the stock solution, which is used later to correct any variation in the standard solution. To calculate exact concentrations of the chlorophyll in the stock solution the user will enter:

(1) A_{664} = absorbance at 664 nm

(2) A_{647} = absorbance at 647 nm

(3) α_a= specific absorptivity for chlorophyll *a* (0.0877 L/mg x cm)

(4) α_b = specific absorptivity for chlorophyll *b* (0.0514 L/mg x cm)

(5) f = path length (centimeters)

The system calculates:

$$C_{SA} = \frac{A_{664}}{\alpha_a f} \qquad \text{(EQ 178)}$$

Where C_{SA} is stock solution concentration (mg/L)

$$C_{SB} = \frac{A_{647}}{\alpha_b f} \qquad \text{(EQ 179)}$$

Where C_{SB} is stock solution concentration (mg/L)
{See NOTE 1 for above equations.}

The concentrations of the chlorophyll working standard solutions are verified and corrected using the above results. Next, the response factor for chlorophyll *a* and *b* in the standard solution is calculated. The user will enter:

(1) C_{ma} = concentration of chlorophyll *a* in mid-range standard solution (milligrams per liter)

(2) C_{mb} = concentration of chlorophyll *b* in mid-range standard solution (milligrams per liter)

(3) I_a = integrated area of component peak, chlorophyll *a*

(4) I_b = integrated area of component peak, chlorophyll *b*

(5) V = volume of midrange standard solution injected

Computations

$$F_A = \frac{VC_{ma}}{I_a} \tag{EQ 180}$$

Where F_A = response factor for chlorophyll *a* (mg/unit area)

$$F_B = \frac{VC_{mb}}{I_b} \tag{EQ 181}$$

Where F_B = response factor for chlorophyll *b* (mg/unit area)

Finally, the concentrations of chlorophyll *a* and *b* in the original sample are calculated. The chlorophyll response factors, F_A and F_B, are accessed from the system. The user will enter:

(1) A_S = sample area scraped (square meters)

(2) I_a = integrated area of component peak from sample extract injection, chlorophyll *a*

(3) I_b = integrated area of component peak from sample extract injection, chlorophyll *b*

(4) V_E = final volume of sample extract, milliliters

(5) V_I = volume of sample extract injected, microliters

The system calculates:

$$C_A = \frac{F_A I_a V_E}{1000 A_S V_I} \tag{EQ 182}$$

Where C_A = concentration of **chlorophyll *a*** (mg/m^2)

$$C_B = \frac{F_B I_b V_E}{1000 A_S V_I} \tag{EQ 183}$$

Where C_B = concentration of **chlorophyll *b*** (mg/m^2)

Biomass computations:

The remaining sample is transferred to a 30-ml porcelain crucible and processed for dry and ash weights. The organisms are dried thoroughly in an oven to stable weight, cooled in a desiccator jar, and weighed to determine the dry weight. The user will enter:

(1) D = dry weight of organisms including crucible weight (milligrams)

(2) T = Tare weight of crucible (milligrams)

The system then calculates:

Computations

$$D_S = D - T \quad \text{(EQ 184)}$$

Where D_S = dry weight (milligrams)

The analysis continues by determining the ash weight of the sample. The sample is reduced to ash at high temperature in a muffle furnace. The sample and crucible are then cooled, rinsed, re-dried, and re-weighed. If this computation is being performed in sequence with the previous computation, the crucible tare weight will be accessed by the system and re-used. The user will enter:

(1) A = ash weight of organisms including crucible weight (milligrams)

(2) T = tare weight of crucible (milligrams)

The system then calculates:

$$A_S = A - T \quad \text{(EQ 185)}$$

Where A_S = ash weight (mg)

After completing the dry-weight and ash-weight determinations, the ash-free weight of the sample is determined. This computation determines the organic weight or **biomass** of biological material in the sample. If this computation is being performed in sequence with the previous computation, previously entered data will be accessed by the system and reused. Otherwise, the user will enter:

(1) A_S = ash weight of sample (milligrams)

(2) D_S = dry weight of sample (milligrams)

(3) V_S = area of sample scraped (square meters)

The system then calculates:

$$B_S = \frac{D_S - A_S}{V_S} \quad \text{(EQ 186)}$$

Where B_S = Ash-free weight or **biomass** (mg/m^2)

To complete the computations, the biomass/chlorophyll ratio is calculated. If proceeding from the above equations, the necessary data will be accessed by the system. If not, the user will enter:

(1) B_S = Biomass (milligrams square meter)

(2) C_A = Concentration of chlorophyll *a* (milligrams square meter)

(3) C_B = Concentration of chlorophyll *b* (milligrams square meter)

Biomass/Chlorophyll ratio:

The system then calculates:

<u>Computations</u>

$$R_A = \frac{B_S}{C_A} \qquad \text{(EQ 187)}$$

Where R_A = **biomass/chlorophyll *a* ratio for periphyton**

$$R_B = \frac{B_S}{C_B} \qquad \text{(EQ 188)}$$

Where R_B = **biomass/chlorophyll *b* ratio for periphyton**

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **biomass/ chlorophyll *a* ratio**, will be stored on the local node and the national data base (EPA parameter 70950).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report concentrations of chlorophyll *a* or *b*, in milligrams square meter, to three significant figures.

(2) Report concentrations of biomass to one decimal for levels below 1 milligram per meter, and two significant figures for 1 milligram per meter or greater.

(3) Report ratio to three significant figures.

(4) NOTE 1: For Calibration: There are three replicate runs done for each sample. The computations are done for the average of three runs, as well as for each run.

6.3.10.9.11 Adenosine Triphosphate

Method: B-6700-85

Parameter and code:

Adenosine triphosphate (μg/L): 70998

Since the discovery in 1947 that luminescence in fireflies has an absolute requirement for adenosine triphosphate (ATP), very sensitive methods of ATP analysis have been developed. It has been determined that mixing ATP with a buffered luciferin-luciferase enzyme solution produces a reaction in which the reaction rate is proportional to the ATP concentration, and one photon of light is produced for every molecule of ATP hydrolyzed in the reaction. Therefore, measurement of the light produced by the reaction of five ATP solutions allows the creation of a standard curve. The curve is linear with a slope of 1. The value of a sample containing an unknown concentration of ATP can be picked off the curve after the light emitted during its analysis is measured using an ATP photometer. This value of ATP is corrected for analysis dilution by the following computation. The user will enter:

(1) A = ATP measured (micrograms per liter)

(2) D = dilution (liters) [See NOTE 1]

(3) V_S = volume of sample filtered (liters)

(4) V_R = volume recovered after extraction (liters)

Computations

The system calculates:

$$ATP = \frac{AD}{V_S V_R} \qquad \text{(EQ 189)}$$

Where ATP = **concentration of ATP** in original sample (µg/L)

Input data will be archived or stored in a near online manner at the local DIS node. The value for **ATP** will be stored on the local node and the national data base (EPA parameters 70998).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) NOTE 1: If solution is undiluted, the value for dilution = 1.

(2) The volume recovered after extraction commonly is 2.2 X 10^{-3} L.

(3) Reproducibility of this analysis is approximately 2 percent.

(4) Report ATP to the nearest 0.1 microgram per liter.

6.3.10.10 Primary Productivity

Bodies of water differ greatly in their populations of plants and animals, and these differences may be used in the interpretation of water quality. Biological differences may be expressed qualitatively and quantitatively. For many purposes, new organic matter is formed and accumulated in the system being studied. Organic matter can be produced by photosynthesis and chemosynthesis. Through photosynthesis, organic compounds are synthesized from water and carbon dioxide using energy absorbed from sunlight by chlorophyll. This implies that primary productivity could be determined by measuring any of the following parameters: (1) Uptake of carbon dioxide, (2) production of oxygen, or (3) increases in pH. In addition, changes in biomass or nutrient concentrations per unit time also can be a measure of primary productivity.

The underlying assumptions in the following methods are that the change in oxygen and dissolved carbon concentrations is a result of photosynthesis and respiration.

6.3.10.10.1 General Equations

The first general equation included in this section deals with changes in the dissolved-oxygen concentration in a reach of stream or in a standing body of water are results of photosynthesis, respiration, diffusion, and inflowing surface and ground water. If how these factors affect the oxygen concentration in the study area is known, a dissolved-oxygen curve can be drawn, and the primary productivity can be determined. The equation for the oxygen curve is used for this purpose. Preparation of the oxygen curve requires use of the Oxygen Curve Equation, section 6.3.10.10.1.1.

Secondly, in many of the methods described below, sampling from natural waters requires samplings at set depths based on the depth of the euphotic zone. Determining this depth is described in Euphotic Zone Depth Determination, section 6.3.10.10.1.2.

6.3.10.10.1.1 Oxygen Curve Equation

Preparation of the oxygen curve requires knowledge of how physical factors affect the oxygen concentration in the study area. Photosynthesis, respiration, diffusion, and inflowing surface and ground water all affect the oxygen levels in natural waters. The equation for the oxygen curve is used by determining values for these variables and entering:

(1) P = rate of gross primary production per unit area

(2) R = rate of oxygen use (respiration) per unit area

(3) D = rate of oxygen uptake or loss by diffusion per unit area

(4) A = rate of supply of oxygen from drainage or accrual

$$Q = P - R + D + A \qquad \text{(EQ 190)}$$

Where Q = rate of change of dissolved oxygen per unit area

P and R, the rates of gross primary production and oxygen use, respectively, are measured by methods described in the TWRI (Britton and Greeson, 1989) and are calculated using computations described later in this document. A, the rate of supply of oxygen from drainage or accrual (i.e., losses to or gains from surface and ground waters) should be controlled by selecting a study area where accrual has a negligible affect on the dissolved-oxygen concentration when compared with the other components.

D, the rate of oxygen uptake of loss by diffusion, is the product of the gas-transfer coefficient, K, and the percentage-saturation deficit of oxygen between the water and air, S. If values for these variables are known, they may be entered and the system will calculate:

$$D = \frac{KS}{100} \qquad \text{(EQ 191)}$$

Where D = diffusion rate of oxygen per unit area

The TWRI (Britton and Greeson, 1989) provides references for obtaining various equations for calculating K and D, as well as for obtaining example values. In the methods described, the diffusion rate generally is obtained by the plastic-dome technique or is calculated from measurements of hydraulic (mean-flow) parameters. The determination of K and D by one of these methods is preferred, but if that is not possible, a value for K may by estimated from the data on page 256 of the TWRI. The system will offer the option of entering a user-calculated K or of using a K from a lookup table. Values for S, the percent-saturation deficit, may be calculated as shown in Diel Oxygen-Curve Method for Estimating Primary Productivity and Community Metabolism in Streams, section 6.3.10.10.5.

Input data will be archived or stored in a near online manner at the local DIS node. Output data, diffusion rate and rate of change of oxygen (Q), will be archived or stored in a near online manner at the local DIS node. The values for these parameters are not currently stored in WATSTORE or QWDATA. These are general equations presented as introductory material to following determinations.

6.3.10.10.1.2 Euphotic Zone Depth Determination

Many of the methods described in Britton and Greeson's TWRI that quantify production and respiration rates require samplings at set depths based on the depth of the euphotic zone. The euphotic zone depth can be determined using an irradiance meter or submarine photometer. If no other method is available, an estimate of the bottom of the euphotic zone is obtained by multiplying the Secchi disk depth by 2 (p. 256).

To select sampling depths using the sampling depth equation, (EQ 193), the extinction coefficient (K) must be calculated first. The user will enter:

(1) I_S = irradiance at the surface

(2) I_z = irradiance at depth z

(3) z = photometer depth

The system will calculate:

$$K = \frac{ln\left(\frac{I_S}{I_z}\right)}{z} \qquad \text{(EQ 192)}$$

Where K = extinction coefficient

Sampling depths are then calculated equivalent to 100-, 50-, 25-, 10-, 3-, and 1-percent of light-penetrating depth using the following equation. The extinction coefficient (K) will be accessed from above and the sampling depths for the light-penetrating depth percentages listed above will be automatically calculated using (EQ 193). However, the user will have the option to calculate individual depths. If so desired, the user will enter:

(1) x = light-penetration depth percentage desired

(2) K = extinction coefficient

The system then calculates:

$$D = \frac{ln\left(\frac{100}{x}\right)}{K} \qquad \text{(EQ 193)}$$

Where D = depth at (x)-percent light

Input data will be archived or stored in a near online manner at the local DIS node. Output data, extinction coefficient and depth at (x)-percent light, will be archived or stored in a near online manner at the local DIS node. The values for these parameters are not currently stored in WATSTORE or QWDATA. These are general equations presented as introductory material to following determinations.

6.3.10.10.2 Oxygen Light- and Dark-Bottle Method for Phytoplankton

Method: B-8001-85

Parameters and codes:

Productivity, primary, gross [mg(O_2/m^3)/d]: 70959
Productivity, primary, gross [mg(O_2/m^2)/d]: 70960
Productivity, primary, net [mg(O_2/m^3)/d]: 70963
Productivity, primary, net [mg(O_2/m^2)/d]: 70964
Respiration [mg(O_2/m^3)/d]: 70967
Respiration [mg(O_2/m^2)/d]: 70968

Light and dark bottles filled with water samples are suspended at several depths in the euphotic zone for a known period of time. The concentration of dissolved oxygen is measured at the beginning and at the end of the incubation period. Changes in the dissolved oxygen concentrations of the enclosed samples are interpreted in terms of photosynthesis and respiration. Productivity is calculated on the basis of one carbon atom assimilated for each oxygen molecule released.

After a suitable incubation time, remove the BOD bottles from the suspension system. As quickly as possible, add the first two Winkler reagents to each bottle to arrest biological activity and to fix the dissolved oxygen. Complete the Winkler determination of dissolved oxygen for all samples; average the results from duplicate samples.

Primary productivity is expressed as the quantity of oxygen released, or of carbon assimilated, per unit time. Adjust the following calculated values for the appropriate incubation period. Gross or net primary productivity is calculated on the assumption that one atom of carbon is assimilated for each molecule (two atoms) of oxygen released.

Gross primary productivity of oxygen:

The user will enter:

(1) LB = dissolved-oxygen concentration, in milligrams per liter, in the light bottle after incubation

(2) DB = dissolved-oxygen concentration, in milligrams per liter, in the dark bottle after incubation

(3) t = incubation period (hours or days)

The system then calculates:

Computations

$$G_O = \frac{1000\,(LB - DB)}{t} \qquad \text{(EQ 194)}$$

Where G_O = gross primary productivity for oxygen $[mg(O_2/m^3)/t]$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **gross primary productivity for oxygen**, will be adjusted to a *per day* equivalent and stored on the local node and the national data base (EPA parameter 70959)

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report primary productivity to one decimal for values less than 10 mg; at 10 mg and above, report two significant figures.

Gross primary productivity of carbon:

The user will enter:

(1) LB = dissolved-oxygen concentration, in milligrams per liter, in the light bottle after incubation

(2) DB = dissolved-oxygen concentration, in milligrams per liter, in the dark bottle after incubation

(3) t = incubation period (hours or days)

The system then calculates:

$$G_C = \left(\frac{1000\,(LB - DB)}{t}\right)\left(\frac{12}{32}\right) \qquad \text{(EQ 195)}$$

Where G_C = gross primary productivity for carbon $[mg(C/m^3)/t]$,
12 = atomic weight of carbon and 32 = molecular weight of oxygen

Input data will be archived or stored in a near online manner at the local DIS node. Output data, gross primary productivity for carbon, will be adjusted to a *per day* equivalent and archived or stored in a near online manner at the local DIS node. The value is not currently stored in WATSTORE or QWDATA.

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report primary productivity to one decimal for values less than 10 mg; at 10 mg and above, report two significant figures.

Net primary productivity of oxygen:

The user will enter:

Computations

(1) LB = dissolved-oxygen concentration, in milligrams per liter, in the light bottle after incubation

(2) IB = initial dissolved-oxygen concentration, in milligrams per liter, in the light bottle before incubation

(3) t = incubation period (hours or days)

The system then calculates:

$$N_O = \frac{1000\,(LB - IB)}{t} \qquad \text{(EQ 196)}$$

Where N_O = net primary productivity for oxygen [$mg(O_2/m^3)/t$]

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **net primary productivity for oxygen**, will be adjusted to a *per day* equivalent and stored on the local node and the national data base (EPA parameter 70963)

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report primary productivity to one decimal for values less than 10 mg; at 10 mg and above, report two significant figures.

Net primary productivity of carbon:

The user will enter:

(1) LB = dissolved-oxygen concentration, in milligrams per liter, in the light bottle after incubation

(2) IB = initial dissolved-oxygen concentration, in milligrams per liter, in the light bottle before incubation

(3) t = incubation period (hours or days)

The system then calculates:

$$N_C = \left(\frac{1000\,(LB - IB)}{t}\right)\left(\frac{12}{32}\right) \qquad \text{(EQ 197)}$$

Where N_C = net primary productivity for carbon [$mg(C/m^3)/t$]

Input data will be archived or stored in a near online manner at the local DIS node. Output data, net primary productivity for carbon, will be adjusted to a *per day* equivalent and archived or stored in a near online manner at the local DIS node. The value is not currently stored in WATSTORE or QWDATA.

Computational Boundary Conditions, Checks, and Reporting Precision:

Computations

(1) Report primary productivity to one decimal for values less than 10 mg; at 10 mg and above, report two significant figures.

Respiration:

The user will enter:

(1) DB = dissolved-oxygen concentration, in milligrams per liter, in the dark bottle after incubation

(2) IB = initial dissolved-oxygen concentration, in milligrams per liter, in the light bottle before incubation

(3) t = incubation period (hours or days)

The system then calculates:

$$R_O = \frac{1000\,(IB - DB)}{t} \tag{EQ 198}$$

Where R_O = respiration of oxygen $[mg(O_2/m^3)/t]$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **respiration**, will be adjusted to a *per day* equivalent and stored on the local node and the national data base (EPA parameter 70967).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report respiration to one decimal for values less than 10 mg; at 10 mg and above, report two significant figures.

6.3.10.10.3 Carbon-14 Light- and Dark-bottle Method for Phytoplankton

Method: B-8020-85

Parameters and codes:

Productivity, primary, gross $[mg(C/m^3)/d]$: 70961
Productivity, primary, gross $[mg(C/m^2)/d]$: 70962
Productivity, primary, net $[mg(C/m^3)/d]$: 70965
Productivity, primary, net $[mg(C/m^2)/d]$: 70966

Phytoplankton primary productivity as determined by the carbon-14 light- and dark-bottle method measures the rate of assimilation of carbon dioxide into particulate organic material by contained algal populations. The carbon-14 method measures productivity by determining the rate of incorporation of a radioisotope tracer, $^{14}CO_2$, into organic material.

Computations

After incubation, photosynthesis in the sample is stopped by chemical means, an aliquot of the sample is acidified and bubbled, and an unfiltered subsample and a filtrate subsample are analyzed by scintillation counting. The uptake and reduction of carbon dioxide is assumed to be proportional to the uptake of carbon-14 bicarbonate. Primary productivity, as the quantity of carbon fixed per unit time, is calculated from the proportion of carbon-14 fixed to carbon-14 available and total carbon dioxide in the sample.

The first computation necessary for this analysis is the calculation of counting efficiency for spiked samples. The user will enter:

(1) R_1 = average counting rate of the sample after addition of carbon-14 labeled toluene standard (counts per minute)

(2) R_2 = average counting rate of the sample (counts per minute)

(3) S = total activity of the carbon-14 labeled toluene standard [disintegrations per minute (DPM)]

The system then calculates:

$$E = \frac{(R_1 - R_2)}{S} \times 100 \qquad \text{(EQ 199)}$$

Where E = counting efficiency (percent)

See NOTE 1.

Primary productivity is expressed as the quantity of carbon assimilated per unit time. Gross photosynthesis, based on incubations of 2 to 4 hours, should be reported as productivity per hour (milligrams carbon per cubic meter per hour). Net photosynthesis, based on 24-hour incubations, should be reported in milligrams carbon per cubic meter per day.

The general equation to calculate net primary productivity is:

$$\text{Net primary productivity} = \text{total carbon}_{\text{fixed}} - \text{excreted carbon}_{\text{fixed}} \qquad \text{(EQ 200)}$$

Where

$$\text{Gross primary productivity} = \text{total carbon}_{\text{fixed}} \qquad \text{(EQ 201)}$$

Where:

- Total $\text{carbon}_{\text{fixed}}$ = unfiltered sample fixation rate
- Excreted $\text{carbon}_{\text{fixed}}$ = 0.45-µm filtrate sample fixation rate

To calculate any of the above, the user must calculate fixed carbon. To calculate gross primary productivity, the user will indicate calculation of unfiltered sample fixation rate when prompted. To calculate net primary productivity, the user will first indicate calculation of both unfiltered sample and filtrate sample fixation rates. Both calculations use the same basic equation for which the user enters:

Computations

(1) $\bar{R}_s$ = average dark-bottle counting rate [disintegrations per minute (DPM)]

(2) $\bar{R}_x$ = average light-bottle counting rate (DPM)

(3) W = alkalinity (^{12}C-total inorganic carbon) (mg/L)

(4) V_i = volume incubated (mL)

(5) V_a = volume of aliquot acidified and bubbled (m/L)

(6) D = unit time

The system accesses the sample counting efficiency (E), from (EQ 199), and calculates:

$$\bar{B}_l = \frac{\bar{R}_x}{E} \quad \text{(EQ 202)}$$

$$\bar{B}_d = \frac{\bar{R}_s}{E} \quad \text{(EQ 203)}$$

$$\bar{S} = \bar{R}_s E \quad \text{(EQ 204)}$$

The system then uses these results and calculates:

$$C_F = \frac{1.064W(\bar{B}_l - \bar{B}_d)\left(\frac{V_i}{V_a}\right)}{\bar{S}D} \quad \text{(EQ 205)}$$

Where C_F = $Carbon_{fixed}$ and 1.064 = isotopic preference factor

Input data will be archived or stored in a near online manner at the local DIS node. The resultant values will be stored on the local node and the national data base (in appropriate EPA parameters).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report Gross Productivity in milligrams carbon per cubic meter per hour and net photosynthesis reported in milligrams carbon per cubic meter per day.

(2) Report to two significant figures.

(3) See Britton and Greeson, 1989, p. 272, paragraph 9, for discussion of precision.

6.3.10.10.4 Oxygen Light- and Dark-enclosure Method for Periphyton

Method: B-8040-85

Parameters and codes:

Productivity, primary, gross [mg(O_2/m^2)/d]: 70960
Productivity, primary, gross [mg(C/m^2)/d]: 70962

<u>Computations</u>

Productivity, primary, net [mg(O_2/m^2)/d]: 70964
Productivity, primary, net [mg(C/m^2)/d]: 70966
Respiration [mg(O_2/m^2)/d]: 70968

Known areas of substrates containing living periphyton are isolated in sealed containers and filled with filtered stream or lake water of known dissolved-oxygen concentration. The samples are exposed in the euphotic zone, usually at the original depth, for a known period of time. Changes in the dissolved-oxygen concentrations of the enclosed samples are interpreted in terms of photosynthesis and respiration per unit area of periphyton (Britton and Greeson, 1989, p. 281).

Primary productivity is expressed as the quantity of oxygen released or carbon assimilated per unit time. REspiration is expressed as the quantity of dissolved oxygen assimilated per unit time. Adjust the following calculated values for the appropriate incubation period. Gross or net primary productivity is calculated on the assumption that one atom of carbon is assimilated for each molecule (two atoms) of oxygen released. Average results from duplicate measurements (Britton and Greeson, 1989, p. 282).

Gross primary productivity of oxygen:

The user will enter:

(1) A = area of periphyton-covered substrate, in square meters

(2) LC = dissolved-oxygen concentration, in milligrams per liter, in the light circulating chamber after incubation

(3) DC = dissolved-oxygen concentration, in milligrams per liter, in the dark circulating chamber after incubation

(4) t = incubation period (hours or days)

(5) V = volume of water in the circulating chamber, in liters

The system then calculates:

$$G_O = \frac{(LC - DC)V}{tA} \qquad \text{(EQ 206)}$$

Where G_O = **gross primary productivity of oxygen** [mg(O_2/m^2)/t]

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **gross primary productivity of oxygen**, will be adjusted to a *per day* equivalent and stored on the local node and the national data base (EPA parameter 70960).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report primary productivity to one decimal for values less than 10 mg; at 10 mg and above, report two significant figures.

Computations

Gross primary productivity of carbon:

The user will enter:

(1) A = area of periphyton-covered substrate, in square meters

(2) LC = dissolved-oxygen concentration, in milligrams per liter, in the light circulating chamber after incubation

(3) DC = dissolved-oxygen concentration, in milligrams per liter, in the dark circulating chamber after incubation

(4) t = incubation period (hours or days)

(5) V = volume of water in the circulating chamber (liters)

The system then calculates:

$$G_C = \left(\frac{(LC - DC)\,V}{tA}\right)\left(\frac{12}{32}\right) \qquad \text{(EQ 207)}$$

Where G_C = **gross primary productivity of carbon** [mg(C/m^2)/t],
12 = atomic weight of carbon and 32 = molecular weight of oxygen

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **gross primary productivity of carbon**, will be adjusted to a *per day* equivalent and archived or stored on the local node and the national data base (EPA parameter 70962).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report primary productivity to one decimal for values less than 10mg; at 10mg and above, report two significant figures.

Net primary productivity of oxygen:

The user will enter:

(1) A = area of periphyton-covered substrate (square meters)

(2) LC = dissolved-oxygen concentration, in milligrams per liter, in the light circulating chamber after incubation

(3) IC = initial dissolved-oxygen concentration, in milligrams per liter, in the light circulating chamber before incubation

(4) t = incubation period (hours or days)

(5) V = volume of water in the circulating chamber (liters)

The system then calculates:

Computations

$$N_O = \frac{(LC - IC) V}{tA} \qquad \text{(EQ 208)}$$

Where N_O = **net primary productivity of oxygen** $[mg(O_2/m^2)/t]$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **net primary productivity of oxygen**, will be adjusted to a *per day* equivalent and stored on the local node and the national data base (EPA parameter 70964).

Net primary productivity of carbon:

The user will enter:

(1) A = area of periphyton-covered substrate (square meters)

(2) LC = dissolved-oxygen concentration, in milligrams per liter, in the light circulating chamber after incubation

(3) IC = initial dissolved-oxygen concentration, in milligrams per liter, in the light circulating chamber before incubation

(4) t = incubation period (hours or days)

(5) V = volume of water in the circulating chamber (liters)

The system then calculates:

$$N_C = \left(\frac{(LC - IC) V}{tA}\right)\left(\frac{12}{32}\right) \qquad \text{(EQ 209)}$$

Where N_C = **net primary productivity of carbon** $[mg(C/m^2)/t]$

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **net primary productivity of carbon**, will be adjusted to a *per day* equivalent and stored on the local node and the national data base (EPA parameter 70966).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report primary productivity to one decimal for values less than 10 mg; at 10 mg and above, report two significant figures.

Respiration:

The user will enter:

(1) A = area of periphyton-covered substrate (square meters)

(2) DC = dissolved-oxygen concentration, in milligrams per liter, in the dark circulating chamber after incubation

(3) IC = initial dissolved-oxygen concentration, in milligrams per liter, in the light circulating chamber before incubation

(4) t = incubation period (hours or days)

(5) V = volume of water in the circulating chamber (liters)

The system then calculates:

$$R_O = \frac{(IC - DC)V}{tA} \qquad \text{(EQ 210)}$$

Where R_O = **respiration of oxygen** [$mg(O_2/m^2)/t$]

Input data will be archived or stored in a near online manner at the local DIS node. Output data, **respiration**, will be adjusted to a *per day* equivalent and stored on the local node and the national data base (EPA parameter 70968).

Computational Boundary Conditions, Checks, and Reporting Precision:

(1) Report respiration to one decimal for values less than 10 mg; at 10 mg and above, report two significant figures.

6.3.10.10.5 Diel Oxygen-Curve Method for Estimating Primary Productivity and Community Metabolism in Streams

Method: B-8120-85

Parameters and codes:

Productivity, primary, gross [$mg(O_2/m^3)/d$]: 70959
Productivity, primary, gross [$mg(O_2/m^2)/d$]: 70960
Productivity, primary, net [$mg(O_2/m^3)/d$]: 70963
Productivity, primary, net [$mg(O_2/m^2)/d$]: 70964
Respiration [$mg(O_2/m^3)/d$]: 70967
Respiration [$mg(O_2/m^2)/d$]: 70968

From Biological User Group document, Appendix XIX:

"There needs to be some extensive programming done to convert the graphical method presented in this section of the TWRI into a computerized method. There may already be some Fortran program existing out there that can be utilized or modified in the new system."

This item will be referred to PC&TS for development and will be included in a future release.

6.3.10.10.6 Diel Oxygen-Curve Method for Estimating Primary Productivity and Community Metabolism in Stratified Water

Method: B-8100-85

Parameters and codes:

Productivity, primary, gross [mg(O_2/m^3)/d]: 70959
Productivity, primary, gross [mg(O_2/m^2)/d]: 70960
Productivity, primary, net [mg(O_2/m^3)/d]: 70963
Productivity, primary, net [mg(O_2/m^2)/d]: 70964
Respiration [mg(O_2/m^3)/d]: 70967
Respiration [mg(O_2/m^2)/d]: 70968

From Biological User Group document, Appendix XIX:

"There needs to be some extensive programming done to convert the graphical method presented in this section of the TWRI into a computerized method. There may already be some Fortran program existing out there that can be utilized or modified in the new system."

This item will be referred to PC&TS for development and will be included in a future release.

6.3.10.11 Bioassay - Algal Growth Potential

Method: B-8502-85

Parameters and codes:

Algal growth potential, filtered (mg/L): 85209
Algal growth potential, filtered and spiked with 0.05 mg/L P
Algal growth potential, filtered and spiked with 1.0 mg/L N
Algal growth potential, filtered and spiked with 0.05 mg/L P and 0.05 mg/L P
Algal growth potential, unfiltered (mg/L): 70988
Algal growth potential, unfiltered and spiked with 0.05 mg/L P
Algal growth potential, unfiltered and spiked with 1.0 mg/L N
Algal growth potential, unfiltered and spiked with 0.05 mg/L P and 0.05 mg/L P

A water sample is autoclaved or filtered, or both, and placed in a covered Erlenmeyer flask. This sample is inoculated with the test algal species and incubated under constant temperature and light intensity until the rate of growth is less than 5 percent per day. The number of algal cells and the mean cell volume are determined using an electronic particle counter, and these values are used to determine the maximum standing crop.

Algal growth potential is considered equivalent to the Maximum Standing Crop, which is determined when the increase in algal density (cells per unit volume) is less than 5 percent per day and is defined as milligrams dry

weight algae per liter. The user will indicate whether they are entering data for cell counts filtered or unfiltered sample analysis and will enter:

(1) C = coincident corrected cell count per milliliter

(2) D = dilution factor

(3) V_{mc} = mean cell volume (cubic micrometers) See NOTE 1.

The system then calculates:

$$C_{ms} = \frac{2.5\times10^{-7}CDV_{mc}}{1000} \quad \text{(EQ 211)}$$

Where C_{ms} = maximum standing crop (mg/L), 2.5×10^{-7} = factor to convert maximum standing crop to dry weight (See NOTE 2), and 1000 converts micrograms to milligrams.

Input data will be archived or stored in a near online manner at the local DIS node. The results for filtered or unfiltered analyses will be stored on the local node and the national data base (EPA parameters 85209 and 70988, respectively).

Computational Boundary Conditions and reporting Results:

(1) Report maximum standing crop, in milligrams dry weight algae per liter, to two significant figures.

(2) The precision is dependent on the biomass of *Selenastrum capricornutum* produced. For typical samples, the precision is approximately 10 percent.

NOTE 1: This equation is valid only when mean cell volume has been determined using an electronic particle counter calibrated using an appropriate reference particle.

NOTE 2: The factor used to convert the wet mass to dry weight should be determined for each laboratory performing the analysis (Britton and Greeson, 1989, p. 304).

6.3.11 Ground-Water Computations

R.L. Moffatt

The computation of ground water and associated data will be an available function within NWIS-II. The data stored in the data base include information about ground-water measurement sites, chemical and physical characteristics of aquifers, and geologic structures. Ground-water data types include discrete measurements of hydraulic features, descriptive information about associated features, and water levels that are frequently monitored on a continuous basis using field recorders and water-level sensing devices. The computations needed for some discrete types of data are provided for in the following requirements.

Computations

Water levels that are monitored on a continuous basis as recorded unit values shall be processed by the NWIS-II similar to stream-stage data. with the provisions for making adjustments for time and datum, and to compute common statistics such as maximum and minimum water levels. Also, as with other time-series data, the user shall have the ability to interactively and graphically edit water-level data.

Requirement 6.3.11-1 Conversion to altitude from a known datum

Depths to water levels, well features (i.e., bottom of hole, tops and bottoms of open well sections), and tops and bottoms of stratigraphic and lithologic features will be stored and shall be converted to altitudes, when applicable, from known datum (i.e., land-surface datum or reference point). Because the altitude of the reference point can be verified by GIS only to the accuracy of the maps available, users will need the ability to verify GIS-defined reference-point altitudes upon data input (Geographic Information System Checks, section 5.1.5).

$$DTW(ls) = DTW(mp) - MP(ht) \quad \text{(EQ 212)}$$

$$WL(alt) = LSD(alt) - DTW(ls) \quad \text{(EQ 213)}$$

$$WL(alt) = MP(alt) - DTW(mp) \quad \text{(EQ 214)}$$

$$WL(alt) = MP(alt) - DTT + H(p) \quad \text{(EQ 215)}$$

DTW(ls) = Depth to water below land-surface datum

DTW(mp) = Depth to water below the measuring point

MP(ht) = Height of measuring point above (+) or below (-) land surface datum

WL(alt) = Water-level altitude above sea level

LSD(alt) = Land-surface datum altitude above sea level

MP(alt) = Measuring-point altitude above sea level

DTT = Depth to pressure transducer below MP

H(p) = Pressure head

Requirement 6.3.11-2 Computations of thickness

The thickness of lithologic and stratigraphic features and the saturated zone of an aquifer shall be computed as the difference between the top and bottom altitude of the feature. This is for output information only.

$$L=a-b \quad \text{(EQ 216)}$$

L = thickness

a = top of feature

b = bottom of feature

condition: $a>b$

Requirement 6.3.11-3 Computation of drawdown

Drawdown shall be automatically computed from user input of static water level and related, fully developed production water level given for a specific-capacity event which may occur over several days or several times within one day.

Computations

$$D=WLs-WLp \quad \text{(EQ 217)}$$

D = drawdown

WLs = static or prepumping water level

WLp = fully developed production level

WL = transducer elevation + pressure head (as measured with a transducer)

condition: WLs>WLp

Requirement 6.3.11-4 Computation of specific capacity

The specific capacity of a well can either be input to the database by the user or will be automatically computed and linked to the specific capacity event when paired values of discharge from a well and drawdown are determined and subsequently input to the database.

$$Sp=Q/D \quad \text{(EQ 218)}$$

Sp = specific capacity

Q = discharge

D = drawdown

condition: D>0

Requirement 6.3.11-5 Computation of discharge from a totalizer meter

Users shall have the option to compute discharge from the starting and ending values of the totalizer meter from the appropriate data input to the data base.

$$Q=c(V2-V1)/(T2-T1) \quad \text{(EQ 219)}$$

Q = discharge from totalizer meter

c = constant (a factor for converting totalizer reading to gallons)

V1 = totalizer meter reading at beginning of period

V2 = totalizer meter reading at end of period

T1 = time at beginning period

T2 = time at end of period

conditions: c>0, V2>=V1, T2>T1

Requirement 6.3.11-6 Computation of pressure head

Pressure head of a fluid in a well shall be computed automatically given values of pressure of the fluid column in the well and specific weight of the fluid.

$$Hp=P/\gamma \quad \text{(EQ 220)}$$

Hp = pressure head

P = fluid pressure

γ = specific weight of fluid

conditions: $\gamma>0$

Requirement 6.3.11-7 Computation of spring flow variability

The flow variability of a spring shall be computed and stored, in percent as expressed by the formula given below. The basis for variability also will be indicated as determined from the length of record (continuous or intermittent), used to make the calculation. The variance of a spring's discharge can also be calculated like a sample variance at the user's request but the result will not be stored.

$$V=100[(Qmx-Qmn)/Qavg] \qquad \text{(EQ 221)}$$

V = variability in percent

Qmx = maximum discharge

Qmn = minimum discharge

Qavg = average discharge

condition: Qmx>Qmn, Qavg>0

Requirement 6.3.11-8 Computation of common statistics

NWIS-II shall provide for the computation of common statistics to include the maximum, minimum, mean, and median unit and daily values of water levels and discharges for the time period specified in a retrieval.

6.3.12 NAWDEX/OWDC Computations

The computations needed to process water-data index information in the MWDI consists of simple counters. The counting algorithms are used to provide specifics about information stored in the indexes. The counters include a sum of the number of:

- stations maintained by an organization
- observations at water-related sites
- sites in a county associated with an organization
- samples associated with a high-level data-index category
- days samples for a given index category were collected
- times a constituent was sampled at a site
- days that samples were collected for a given constituent

Requirement 6.3.12-1 Provide counters for Master Water Data Index

NWIS-II shall provide a series of counters for data in the Master Water Data Index.

7. Data Output

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Data output is the production of information delivered to a user as paper copy or video display, or transferred to tape or disk. Data output results from a user's request or query for data in NWIS-II using the subfunctions described in the data retrieval section of this document. Data are displayed using preselected formats and output media (i.e., screen or paper) that are described in this section, using NWIS-II and DIS-II software (see Chapter 7, Design Constraints). Data displays or outputs in support of other functions (e.g., input and edit, user interface) are discussed in the appropriate section.

Data output will be displayed in a standard format with predefined units of measurement and number of significant digits. Data also may be output using user-defined formats, units of measurement, and number of significant digits. Some standard output formats will duplicate input forms used to enter data into the NWIS-II data base. Information not stored in NWIS-II, but derived from NWIS-II data through calculations, will be output.

The NWIS-II data base allows for the qualification of data by using special characters or symbols associated with the data values. Special characters or symbols also include representations for missing and null data values. The NWIS-II output must be able to display special characters. For some outputs, the special characters may need to be substituted with other values or removed. The interpretation or manipulation of special characters may be necessary if the display of these special characters is irrelevant or unnecessarily complicates the output. A list of these special characters and symbols is given in section 2.2, Retrieval Specifications. Additionally, the process with which NWIS-II substitutes or removes special characters or symbols from data values should be based on judicious statistical analyses. For NWIS-II supplied outputs, special characters will be handled by embedded software that is transparent to users. For user-definable outputs, special characters will be handled by NWIS-provided software utilities.

Requirement 7-1 Allow users to output data to a variety of media

NWIS-II shall support the output of data to graphics and character-based monitors or storage media, such as floppy disks, magnetic tapes, and paper.

Requirement 7-2 Allow users to specify units of measure for output data

Tables and figures shall be output with default units of measure to meet publication and report requirements. Users can specify units of measure for an output that differ from those stored in the data base. Users shall be able to specify the time system; for example, PST, CST, EST, CDST, MST, and UTC. Users also will be able to supplement the list of default units of measure applicable for specified outputs with additional units.

Requirement 7-3 Provide the ability to compute intermediate or derived values for output

Users will be able to request that data not normally stored in the data base, such as intermediate or derived values, be recomputed.

Requirement 7-4 Allow the output of special characters, data flags, and symbols

Special characters are handled in NWIS-II supplied outputs by embedded software that is transparent to users. When requested by users, NWIS-II shall show a complete or pertinent partial listing of data flags, special characters, and symbols with their associated meanings; see computation section for partial listing of special characters.

Requirement 7-5 Output data with different levels of significant digits or rounding

The precision associated with numeric data can vary due to methods of data collection, data analyses and output, and computer representation of the data. NWIS-II shall allow users to output numeric data by one of three methods:

(1) Unrounded numeric data: The actual numeric representation or precision of the data as stored in the data base.

(2) NWIS-II data dictionary rounding: the rounding or precision of numeric data is based upon the type of constituent, its method of collection and analysis, and use of final output.

(3) User-defined rounding - see note below.

Note: User-definable rounding will not be allowed on WRD standard tables and figures. For other tables and figures, users will be warned when outputting data in a form where the number of significant figures exceeds the number of significant figures originally used.

7.1 Manuscript Preparation

A manuscript is a document with a collection of text, tables, and figures. A manuscript could be an annual data report or a one-page description of a site that contains a daily-value table and station-analysis information, as seen in Figure 20 . A DIS-II editor will provide users with the ability to create a manuscript that will meet publication standards and be acceptable to users. This editor will allow users to cut and paste information and edit a document in preparation for output. The DIS-II editor will allow users to integrate text, tables, and figures into various reports styles, including data reports. NWIS-II will provide a postprocessing function to extract data from the data base for generating or building the various tables, figures, and text associated with each page of the report and assemble the report. If a report has been previously published and stored in its entirety on some output media for dissemination (i.e., CD-ROM), the DIS-II editor or NWIS-II would not necessarily provide the ability to reassemble this report

Requirement 7.1-1 Provide the ability to generate page layouts from annual data reports

Users shall have the ability to generate pages from annual data reports and information stored in the NWIS-II data base. Since the textual descriptions and report headings are stored in NWIS-II, the output function will provide the ability to retrieve pertinent data tables with their proper headings and station/site descriptions. This functionality will be the responsibility of DIS-II.

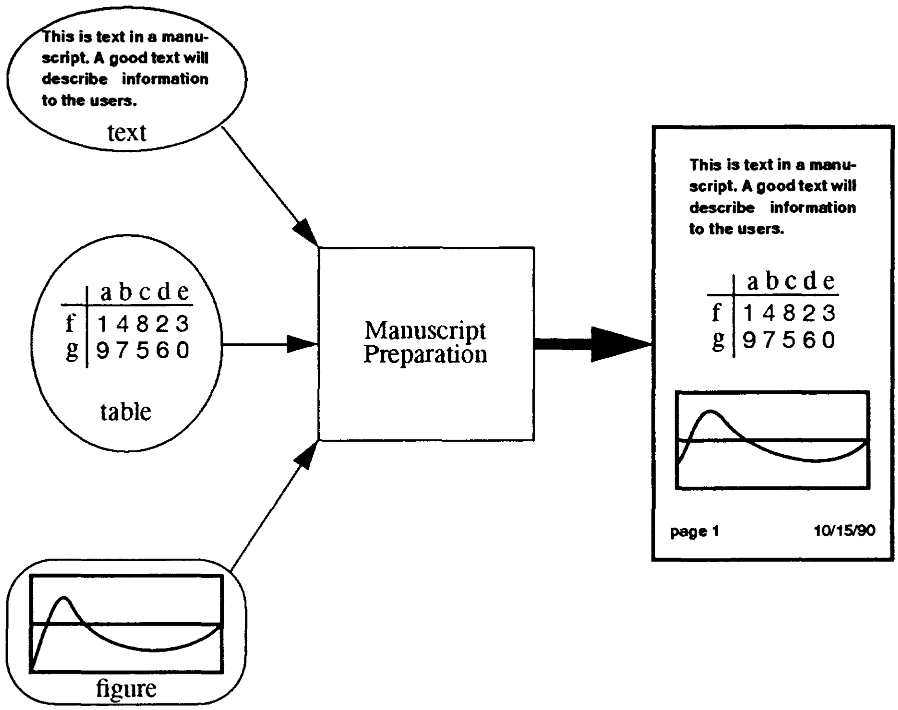

Figure 20. -- Manuscript preparation integrates text, tables, and figures to create a manuscript

Requirement 7.1-2 Provide the ability to output to USGS publications standards

Users shall be able to make requests, and DIS-II would assemble and output pages, manuscripts, or reports in USGS standards (see Chapter 7, Design Constraints). Some standard publications that may be accommodated by the manuscript requirement are:

- annual data reports (including camera-ready manuscript with tables)
- open-file reports dealing with the reporting and analysis of NWIS-II data
- any predesigned formal reports that contain NWIS-II data
- common components of reports (title page, table of contents, references, units of measure, letterheads, WRISC abstracts, list of illustrations)

Requirement 7.1-3 Provide the ability to customize the layout of manuscripts with text, figures and tables

DIS-II Electronic Report Processing (ERP) software package shall have direct access to NWIS-II data. Additionally, information could indirectly be added to the ERP package by cutting and pasting. The ERP package provides users with an editing environment for using NWIS-II output and other outputs to customize a document.

Requirement 7.1-4 Provide the ability to verify technical words

The ability to verify technical words shall be provided. Users shall be able to verify these words using appropriate standard and technical references, including scientific dictionaries and acronym lists.

7.2 Textual Data

NWIS-II textual data are collections of characters that form words used to augment and clarify hydrologic data. Textual entries are used to supplement reports, tables, and figures, and could come from paragraphs, field notes or the data dictionary. Users will be able to output textual descriptions to aid in assembling tables. Users will be able to produce annual data report headings that will contain textual information. For station headings, textual information typically includes station number, station name, station location, equipment present, land owner, and contact person.

Requirement 7.2-1 Provide the ability to output textual descriptions

Users shall have the ability to output text to aid in creating manuscripts, reports, notes, memos, or tables.

7.3 Figures

Users shall have the ability to graphically display data in a variety of configurations and dimensions. The types of figures provided for output will include a wide diversity of graphics and scanned images. Users will be able to edit and customize figures to fit project needs, and insert figures into manuscripts or other files. PC&TS shall provide the majority of the WRD users' graphics needs (see Chapter 7, section 2.3.1). NWIS-II will provide simple graphics and figures to support the data input and verification functions.

Requirement 7.3-1 Provide the ability to output scanned images

Users shall have the ability to output scanned images from NWIS-II. These images may include sketches of sites, reference points, and well-measuring points; diagrams of pumps; images of taxa (flora and fauna); and schematics of water-user systems.

Requirement 7.3-2 Provide the ability to output a standard and consistent plotted or printed map

Users will routinely require maps plotted or printed with selected NWIS-II features overlaid on the appropriate thematic layers. These maps shall be consistent, all will have scale bars, north arrows, explanations, titles, and meaningful symbols by default. Output shall be at standard scales such as 1:24,000, 1:100,000, 1:250,000, and 1:2,000,000. Users will be able to register the maps to USGS topographic quadrangle maps. Page size plots, 8.5 x 11 inches, shall be an available output. Users shall have a default set of thematic layers available for use as a base map. Other thematic layers could be plotted on this base map (see section 2.3.5 DIS and AAU Software).

Requirement 7.3-3 Provide the ability to output preprinted forms

Users shall have the ability to output preprinted forms, including the following:

(1) log-log forms--large (9-279-K) and small (9-279-G)

(2) log-log forms with rectangular sections--large (9-279-N) and small (9-279-S)

(3) rectangular forms--large (9279-A) and small (9-279)

This function may be provided by PC&TS.

Requirement 7.3-4 Provide the ability to output graphics plot, charts, and diagrams

Users shall have the ability to output graphics plots, charts and diagrams. Most of these graphics functions will be provided by PC&TS (see Chapter 7, section 2.3.1). The NWIS-II design and development team shall develop functions for the following graphical outputs:

(1) logx-logy plots

(2) probability plots

(3) time-series plots

(4) duration hydrographs

(5) channel cross-sections

Requirement 7.3-5 Provide the ability to incrementally move overlaid time-series plots

Users shall have the ability to move time-series plots for comparison purposes. With this ability, a user could overlay a flood hydrograph of a downstream station on a hydrograph of the same flood at an upstream station and move the plots until the peaks matched.

Requirement 7.3-6 Provide the ability to output user-customized figures

Users shall have the ability to annotate and enhance figures for customized output and to graphically display data using different scale notations (See Graphical Input and Editing, section 4.7). Examples of scale notations are listed below:

- arithmetic
- logarithmic (base 10 & natural)
- exponential
- probability

Requirement 7.3-7 Provide the ability to output thematic maps to meet publication standards.

Users shall have the ability to produce thematic map output to meet publication standards. This functionality will be the responsibility of DIS-II.

7.4 Tables

Data, including support data used to complete a process (e.g., shifts, coefficients) or provide information (e.g., constituent codes, data dictionary listings), can be output from NWIS-II in tabular form. Users may output data in

an NWIS-II standard format, or choose to output in a user-defined format. The existing tabular formats may be modified to generate new tabular formats. The formats for tabular output are templates that can be saved and reused. As specified in Requirement 7.5, users shall be able to display these tables.

Requirement 7.4-1 Provide the ability to output standard tables of data

NWIS-II shall provide the function to output standard data tables.

Requirement 7.4-2 Provide the ability to output publication-quality tables

Users shall have the ability to output tables of data that conform to WRD publication standards. The table output should be camera-ready quality so that no additional editing is necessary before including in a manuscript.

7.4.1 Interdisciplinary Tables

Interdisciplinary tables and table formats are common to more than one discipline and therefore are presented before discussing discipline-specific tables.

Requirement 7.4.1-1 Provide the ability to output time-based data in tabular form

The system will be able to output tables of unit values, daily values, or data based on discrete time periods. These tables also will display extreme values either by day, month, year, or period of record.

Requirement 7.4.1-2 Provide the ability to output tabular forms of ratings

Users shall have the ability to output lists of points that define rating curves and possible offsets. Lists of points may originate from graphical representations of surface-water stage-discharge or sediment-transport curves. The output form for the rating table will include gage-heights to the nearest 100th of a foot and the corresponding discharge. Scale capability of probability will be provided.

Requirement 7.4.1-3 Provide the ability to output a summary of retrieval specifications

The system shall allow users to output a summary of retrieval specifications. This summary will contain the number of times each requested keyword was found in the data base using boolean logic. For example, a user requests all information from the Yakima NAWQA Project, for the years 1988 through 1990, that have fish biomass data not to include species X.

Requirement 7.4.1-4 Provide the ability to output data dictionary information

NWIS-II will be able to output data dictionary and meta data listings, as well special characters and symbology information. This can include the definition of the data or meta data listed, size allowable and the range of values allowed for the data element. Associated constituent and method identities also are included as information that may be output.

Output

Requirement 7.4.1-5 Provide the ability to output a data base dump

Users shall have the ability to output the complete contents of a data base. The data could be used for simple viewing, archiving, or repopulating a damaged file after making fixes.

Requirement 7.4.1-6 Provide the ability to output unit-values data

The standard output of unit-values data will be provided in two tabular formats to be combined with a plot of the computed daily values of any parameters selected. One format will provide adjusted recorded values, interpolated for each hour of the day, along with the mean, maximum, and minimum daily recorded and computed values and their corresponding corrections. This format shall be the default of standard output. Users shall have the option to select a second format, which will provide daily minimum, maximum, and mean values of the recorded and computed values, along with their corresponding corrections. Both forms of standard output also shall include any flags generated during processing and selected information about measurements made during a given day.

Requirement 7.4.1-7 Provide the ability to output daily values

Daily values shall be output in a standard format for publication in the annual data report, the exact format will depend on the parameter selected. These tables shall be combined with a plot of the selected daily values.

Requirement 7.4.1-8 Provide the ability to output notes associated with data

Users shall have the ability to output notes related to all aspects of data analysis, such as shift analysis, to include but not be limited to output notes on instrument performance, estimates, levels, and gage height record.

Requirement 7.4.1-9 Provide the ability to output station descriptions

A station description is the narrative portion of the station record. The description can consist of statements on the location, drainage area, records available, gage details, extremes of stage and discharge, and general remarks on accuracy and other conditions affecting the record The NWIS-II shall retrieve and consolidate these types of information from the data base for users to help them prepare the narrative in the DIS-II ERP.

Requirement 7.4.1-10 Provide the ability to output station-analysis report

Station-analysis reports for surface water and for sediment are listed in Appendix J.

Requirement 7.4.1-11 Provide the ability to output Water Data Sources Directory

The system shall output the information from the Water Data Sources Directory (WDSD) upon request by users. This will include the ability to output WDSD labels to a printer or to a text field.

Requirement 7.4.1-12 Provide the ability to output quality-assurance data

Users shall have the ability to output quality-assurance data in a table.

7.4.2 Water-Use Discipline Tables

NWIS-II shall provide for standard water-use discipline tabular formats that can be modified periodically. Standard water-use tables will include the series of water-use and water-withdrawal tables found in the 5-year compilation of Estimated Use of Water in the United States (Solley and others, 1988). Also to be included is a table that summarizes by State, withdrawals by source and category of use found in the National Water Summary report (U.S.Geological Survey, 1990). Users will be able to report "no usage" as different from "no reports" on output forms.

Requirement 7.4.2-1 Provide the ability to output standard water-use tables that are periodically modifiable

Output for water-use discipline tables for aggregation will be standard nationally but NWIS-II shall provide new table formats for the report. In addition, users will be able to output different sources of water and different years of data at one facility. The default unit of measure in output forms will be million gallons of water per day. Users also will be able to specify units of measure. For population numbers, the default will be in thousands of persons. Both elements will be reported to two decimal places to the right of the decimal point.

7.4.3 Water-Quality Discipline Tables

Water-quality discipline tables will follow the existing WRD standard. These tables are listed in Appendix J.

Requirement 7.4.3-1 Provide the ability to output a table of non-target compounds

Non-target organic substances form a special class of analytical results, which are determined through a mass spectrometer. There are thousands of potential compounds listed in mass spectral libraries. These substances are tentatively identified and semi-quantitatively estimated. They are not on the U.S. Environmental Protection Agency list of organic compounds. The values do not meet USGS standards for acceptance, but they represent potentially useful information to users so they would be stored online.

Requirement 7.4.3-2 Provide the ability to output the National Water Quality Laboratory catalog

The NWQL catalog lists the available analytical schedules that they evaluate. This list helps water-quality persons and project managers plan the cost of taking water-quality samples. This list also helps hydrologists determine what is needed to do a sample, from bottle sizes and types to the preservation method.

Requirement 7.4.3-3 Provide the ability to output the district sampling plans

The District sample plans are developed on a form that will be sent from the districts to the NWQL. The form will provide the NWQL with information on regular and irregularly scheduled sampling events.

Requirement 7.4.3-4 Provide the ability to output summaries of yearly district sampling activities

Summaries of yearly district sampling activities shall be available as output.

Requirement 7.4.3-5 Provide the ability to output quality-assurance documentation

Users shall have the ability to output tables of quality-assurance (QA) information. Special QA tables may be produced from QA protocols that use reference, blind, or field blank samples. There also are two types of laboratory quality-assurance tables: brief and complete. The message in the brief table will contain information on a single file. The message in the complete table will contain information on all parameters that exceed the QA criteria.

7.4.4 Biology Discipline Tables

Biological discipline tables include taxonomic information stored in NWIS-II, as well as the guidelines for publishing taxonomic nomenclature.

Requirement 7.4.4-1 Provide a tabling package that conforms to accepted publishing guidelines for taxonomic nomenclature

NWIS-II shall include a tabling package that conforms to USGS publishing standards and accepted publishing guidelines for taxonomic nomenclature. For taxonomic names, the genus and species should be underlined or italicized and the first letter of the genus name should be capitalized.

Requirement 7.4.4-2 Provide the ability to output an approval-pending taxonomic list

Users shall have the ability to output a list of taxonomic names that were entered into the NWIS-II data base but did not match the NODC file. Before the list can be added to the official taxonomic list, the NODC must first review and approve the list. The status of submitted names will also be output.The list will contain the organism's name, authority, the number of users who submitted the organism's name, and all known information about this organism. The list will also contain the date the taxon was submitted to NODC and whether there will be an extended time (more than the 2 weeks allowed in the Memorandum of Understanding with NODC) before the taxon is approved. A list of taxonomic names that have received NODC approval since the last revision of the NODC tape should be available.

In the taxonomic system there are sub and super forms of categories; i.e., in the class for man there is a superclass called tetrapod, and the class is mammalia.

7.4.5 Ground-Water Discipline Tables

Ground-water tables include system dumps, standard tables, subfiles, and special tables. Also, 5-day summary and summary tables will be produced. The ground-water tables are listed in Appendix J.

7.4.6 Surface-Water Discipline Tables

Various tables of surface-water data are needed for the analysis, review, and reporting of the data that are collected and computed. The tables referred to in the following paragraphs will have a default format for output, but the table of primary computations of unit values of surface-water data will be user-selectable in two formats.

Requirement 7.4.6-1 Provide for output of discharge measurement and shift analysis

For every measurement selected for output, the number of the rating curve or shift curve used to compare the measurement will be displayed.

Requirement 7.4.6-2 Provide the ability to output a summary of level note histories

A complete list of the data elements that will be output with this table will be developed.

Requirement 7.4.6-3 Provide the ability to output summary of gage-height corrections

Users will be able to output a summary of all gage-height corrections at a specified station for the water year. These include change-of-station height and equipment corrections.

Requirement 7.4.6-4 Provide the ability to output an end-of-year summary

Users will be able to output a tabular summary of maximums, minimums, and peaks above base for the entire water year.

Requirement 7.4.6-5 Provide the ability to output a rating curve with shift curves included

Users will be able to output a rating curve with shift curves included.

7.4.7 Meteorologic Data Tables

NWIS-II shall provide the ability to output tables of meteorologic data. These will include such tables as precipitation data by user-defined time and geographic criteria, summary statistics, and trends tables and plots.

Requirement 7.4.7-1 Provide the ability to output tables of meteorologic data

NWIS-II will provide the ability to output tables of meteorologic measurements, such as rainfall (intensity and cumulative amount), wind (speed, duration, and vector direction), and sunlight (intensity and duration).

7.4.8 Sediment Discipline Tables

Tables for sediment data include suspended or total sediment discharge per day and bedload discharge per day. These tables can cover different times such as total sediment per year. In addition to the annual tables for sediment load and tables for bed load, tables shall include for suspended-sediment particle size, bed material, bedload particle size, concentration, and periodic tables of sediment data for reports and data requests. The sediment discipline output tables are listed in Appendix J.

Requirement 7.4.8-1 Provide the ability to output tables of sediment loads

The amount of sediment detected at surface-water sites will be used to estimate the amount of material moving downstream over a period of time. Users will have the ability to output sediment loads in tons per day, as well as to make monthly and annual sediment load tables from daily load information. If direct computations are being performed, users will be able to output the computed instantaneous readings and the interpolated discharge; and if a regression is being used, then regression coefficients may be output. Users also shall have the ability to output concentrations, particle size, and bed materials.

7.4.9 Master Water Data Index Tables

When MWDI data are verified, a verification report and a cover letter will be generated. They will be in a format suitable for sending to providers of water-data index information. The report will summarize the entry to the NWIS-II data base and request clarification from the provider of unverified information. The cover letter will acknowledge their contribution to the MWDI. There are several default output tables that can be requested in a MWDI data-availability retrieval. Some tables are general summaries of the MWDI. Some default tables follow the format of the most current Catalog of Information on Water Data published by the Office of Water Data Coordination.

Requirement 7.4.9-1 Provide the ability to output a water-data index verification report

NWIS-II shall provide the ability to output a verification report for water-data index information. The report should be in a format that is clearly understood. It should be suitable for government officials, as well as the citizen who provides information.

Requirement 7.4.9-2 Provide the ability to output a cover letter for the water-data index verification report

NWIS-II shall provide the ability to output a cover letter designed to acknowledge the provider of water-data index information, increase the awareness of the availability of water-data information, and increase and maintain the integrity of the information contained in the water-data index.

Requirement 7.4.9-3 Provide the ability to output standard data-availability information from the MWDI using a default table

NWIS-II shall provide the ability to retrieve data-availability information from the MWDI through a series of default output tables. The default output tables include:

(1) Master Water Data Index listing - general information

(2) Number or sites for each State, country, or territory by type of site and type of data

(3) Number of sites for each State and county by type of data

(4) Number of sites by hydrologic unit and type of data

(5) Number of sites for each State, country, or territory by organization and type of data

(6) Number of sites for each State, country, or territory by parameter and frequency of measurement

(7) Number of all sites by water-data parameter and frequency of measurement

(8) Number of surface-water data sites for each State, country, or territory by type of site and period of record

(9) Number of surface-water-quality data sites for each State, country, or territory by type of site and period of record

(10) Number of ground-water data sites for each State, country, or territory by type of site and period of record

(11) Number of ground-water-quality data sites for each State, country, or territory by type of site and period of record

(12) Number of stream sites for each site, country, or territory by drainage area

(13) Number of sites by source organization and type of data

(14) Number of sites for each State and county by type of site

(15) Number of sites for each State, country, or territory by organization and type of site

(16) Number of sites for each State, country, or territory by parameter and type of site

Requirement 7.4.9-4 Provide the ability to output user-defined data-availability information

NWIS-II shall provide the ability to retrieve data-availability information from the MWDI by allowing users to select retrieval of constituents stored in the respective data base.

7.4.10 Customization of Output Table formats

The system shall allow users to customize table formats for output. Users may create these table formats in their entirety or modify a copy of an existing format that will meet their needs. As with other NWIS-II standard output formats, the user-customized output format will interact with the data base retrieval software so that users' data are retrieved and displayed in the designated format. Once created, the formats for tabular output can be stored and reused as needed.

There will be three levels at which output formats will be customized. These are:

(1) User-defined - created by users for their own use; others may have the right to browse and copy the formats.

(2) Project - created/approved by the project chief use within a project; other personnel have the capability to browse and copy these formats.

(3) District - created by district personnel for use within the district. A district here can mean a field office, or the district office and any subdistrict and field offices. An example may be a report by different projects to administration listing lab requests and samples sent to different labs for cost accounting.

Requirement 7.4.10-1 Provide the ability to customize output forms

Users shall be able to customize existing output table formats or create new ones. The user-customized output format shall interact with the data base retrieval software so that a user's data are retrieved and displayed in the designated format. Customization of output table formats shall exist at the District, Project and User-defined levels. User-defined forms are created for specific users so others will not be able to modify these forms. Project-level forms are defined by project personnel for a group of users. District forms are designed for users in a district. The system also shall provide the ability for self-scaling of column widths. For example, if a field for well name is 40 characters wide, but the longest name retrieved is 25 characters, the field should optionally be rescaled to 25 characters.

Requirement 7.4.10-2 Provide the ability to generate a remarks field for infrequently occurring parameters.

Users shall have the ability to generate a remarks field for infrequently occurring parameters.

7.5 Export of Formatted Files

NWIS-II users want to use data from the NWIS-II data base in other software packages. Output from the NWIS-II data base must, therefore, be in a format that can be interchanged with other software packages. There are three ways that NWIS-II can accomplish this interchange of its output data with other software packages. First, provide the NWIS-II output in a format that is directly readable by other packages. Second, output NWIS-II data in an intermediate format that can be interpreted by the other software packages. Third, provide users with a set of tools to reformat the NWIS-II output. The first two ways of formatting output data for interchange with other software packages will be supplied by the NWIS-II. The last way provides users with the ability to define instructions that would reformat the NWIS-II output by performing postprocessing manipulations on the output data file. The instructions or series of manipulations could be stored by users for reuse on other NWIS-II output data files.

Requirement 7.5-1 Provide the ability to output a summary of data stored in NWIS-II

Users would like to see what types of data and the number of entries for each type of data are stored in a file. This information would be stored in a "header" file at the front of the disk and would include what types of data are stored, as well as the format in which the data are stored.

7.5.1 Supplied Interchange Formatted Files

Since it is not feasible for NWIS-II to accommodate all possible software interchange formats for use in exporting data to other software, a minimum set will be provided. These NWIS-II supplied output formats will be either directly readable by the outside software package or put in an intermediate format that can be interpreted by the outside software data-importing utilities.

7.5.1.1 Geographic Information System

Users require the ability to output NWIS-II information into a format that can be utilized by a GIS. Two types of GIS-compatible formats can be produced. The first type, a GIS coverage, will provide an output format that can be used directly by a GIS without any transformations to the data. The second type, a GIS export file, will provide an interchange format that must be interpreted by the data-importing utility of the GIS.

Requirement 7.5.1.1-1 Provide the ability to output GIS-compatible formats

Users shall have the ability to output NWIS-II information into two GIS compatible formats, 1) GIS coverage and 2) a GIS export file.

7.5.1.2 DIS-II Software Packages Excluding GIS

The software awarded on the DIS-II contract affords users with a flexible set of tools to perform a variety of tasks. NWIS-II provides a set of software tools for the analysis and storage of hydrologic information. The

linking of DIS-II software with NWIS-II has the potential to increase the productivity of the typical NWIS-II user.

If possible, transfer of NWIS-II data into DIS-II software should occur without users needing to manipulate the data. To achieve this, NWIS-II shall provide its output data in a format that is directly readable by the DIS-II software packages.

The exact format that NWIS-II will export or output data depends on the type of data being exported and the import requirements of the DIS-II software package. For example, constituent data from NWIS-II will need to be output along with location data if users wish to import this information into the DIS-II surface-analysis package. The transfer of data between NWIS-II and DIS-II software packages ranges in complexity. In the simplest of instances, a user may be able to copy data from a NWIS-II window into a window running a DIS-II software package, such as the ERP package. More often, the transfer of data will involve a translation of data from NWIS-II into a format meaningful to the DIS-II software. NWIS-II will provide the software to translate data into the formats readable by DIS-II software.

Requirement 7.5.1.2-1 Provide the ability to output data in a form readable by DIS-II software

Users shall be able to output data to the DIS-II software package, such as graphical, spreadsheet, word processing, statistical, and surface-analysis software packages.

7.5.1.3 Hydrologic Applications

Over the years, WRD has developed numerous hydrologic applications for modeling, interpretation, and analysis. The hydrologic applications utilize the data currently stored in WATSTORE and NWIS-I by retrieving the data in the WATSTORE card formats. The redesign effort should attempt to keep the existing formats for data exchange between the data base and the applications. In addition to the WRD applications, NWIS-II must continue to provide hydrologic data to EPA's STORET data base in a format that EPA can accept.

Requirement 7.5.1.3-1 Provide the ability to output in WATSTORE card format

Provide data output in the WATSTORE card formats for the following data: unit values, daily values, and water quality.

Requirement 7.5.1.3-2 Provide the ability to output in STORET file format

Provide data output as STORET-compatible ASCII text files. Working files will not be sent to STORET. Data-uploading requirements from NWIS-II to STORET are discussed in Section 9.3.3, Maintenance.

7.5.1.4 Industry-Standard Formats

NWIS-II can accommodate the interchange or transfer of its output data to an unlimited number of software packages. To do this, NWIS-II will provide output to an intermediate file structured according to industry-standard formatting conventions. Many commercially available software packages have the ability to import standard data formats.

Requirement 7.5.1.4-1 Provide the ability to export data in industry-standard formats

NWIS-II shall have the ability to output information in the following formats:

(1) DIF format

(2) Postscript

(3) ASCII and ASCII-delimited

(4) CGM files and/or other graphics formats

7.5.2 User-Defined Postprocessing

Output file formats other than those supplied by NWIS-II can be defined by users for input into other programs or software packages that are not part of NWIS-II or DIS-II. The postprocessing of NWIS-II output allows users to rearrange, eliminate, or browse the data before final disposition of the file. An example is a quality-assurance file based on primary and secondary keys. Features used to manipulate the data in an output file are: sort, reformat by row and column, merge files, and change values. Instructions on how the data were manipulated may be saved by users for reuse, similar to the way scripts are defined for computations and stored in NWIS-II.

Requirement 7.5.2-1 Provide the ability to sort postprocessed data

Users will have sorting capabilities, which include:

- Sort output data set on any element by numeric values, to include maximum and minimum values
- Sort output data set on any element by alpha values
- Use boolean logic
- Compare differences and similarities.

Requirement 7.5.2-2 Provide the ability to reformat data by row and column position

Reformatting of data shall include:

- Output columns of data that are aligned
- Output data separated by spaces
- Trim rows and columns to eliminate labels such as date
- Delete columns or rows of data

Requirement 7.5.2-3 Provide the ability to merge data sets

The system should be able to merge whole or sections of output files.

Requirement 7.5.2-4 Provide the ability to manipulate special characters

NWIS-II's use and output of special characters could present problems to other software packages unable to read or interpret these characters or symbols. Users should have the ability to visualize these special characters and use tools to substitute or remove these characters and symbols as necessary. NWIS-II shall provide the tools to manipulate these special characters. The tools will use the same methods needed to meet **(Requirement 7-4, Allow the output of special characters, data flags, and symbols)** but will be presented to users as interactive utilities for user-defined postprocessing of output data. The manipulation software shall allow users to redefine the special characters and symbols used in NWIS-II output data, so the data can be interpreted by external software packages.

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8. Project Management

R.L. Moffatt, W.R. Roddy, and J.D. Christman

The functions for project management are designed to help the manager of a project to schedule and monitor hydrologic activities such as data collection, data analyses and review, and report preparation. The use of the word project in this section refers to a hydrologic study, a hydrologic data network, a special studies section, a hydrologic data section, or any other special group involved in the collection, analyses, or reporting of hydrologic data. A necessary subfunction included within project management is hydrologic event notification. This subfunction provides for the means to inform project personnel about occurrences of relative hydrologic significance that need validating and may require some alternate action. There are three major subfunctional areas that will be discussed: scheduling, monitoring, and hydrologic event notification.

8.1 Scheduling

Project managers usually have several activities ongoing throughout the life of a project, be it a single project or as in the case of a section manager, many projects. Managers need to be able to schedule these activities to effectively meet commitments or timelines imposed on the project.

A workload utility can provide project managers the means to manage the number of site visits, the number of water-quality samples to be collected and analyzed each year, and the cost of the project. Requirements for a project- or laboratory-function resource must be anticipated and fulfilled ahead of time so that the opportunity to acquire the resource does not disappear. Yet, an infinite amount of the resource is not affordable and excess must be minimized. The same utility could compute the expected income to the laboratory or automatically poll inventory and sample schedules for "just-in-time" restocking of supplies.

As part of this utility, project managers or district water-quality specialists could define a suite of analyses that best meets their needs. The National Water Quality Laboratory (NWQL) could then catalog the requested suite of analyses in their library to make it available to other projects. Scheduling particular samples for laboratory analyses can be done with an Electronic Analytical Service Request form (Requirement 4.6.2.2-6). This allows sample information to be electronically logged in to the NWQL from field or district offices after the samples have been collected and made ready to enter the analytical process.

Requirement 8.1-1 Provide the ability to plan sampling activities and laboratory analyses

All project personnel will have access to those AIS, LIMS-II, and NWIS-II data functions dealing with the planning of sample collection, the remote submission of laboratory requests, the tracking of the status of sample analyses, the information regarding the methodologies, and quality assurance of constituent determination. The AIS software will have a utility that will allow them to plan site visits and sampling activities, and particularly to schedule laboratory analyses of water, sediment, or biological samples that are planned for a particular project each fiscal year (see Chapter 7, section 2.3.3). Prior to the beginning of each fiscal year, each project will populate workload files with the number and types of samples scheduled to be collected during the upcoming fiscal year. This information will include but not be limited to:

- site identifier
- project identifier
- laboratory schedule and cost
- add-on parameter and cost
- number of times each schedule and add-on parameter will be collected
- sampling interval (regular or irregular); if irregular, include approximate sampling time (e.g., early spring or during July)

Once data are entered into workload files, yearly totals for each schedule and add-on parameter will be computed and a report will be transmitted to the laboratory chief, district water-quality specialist, and project manager. Yearly totals will include but not be limited to:

- number of times each schedule is sampled at regular intervals and cost
- number of times each schedule is sampled at irregular intervals, approximate sampling time and cost
- number of times each add-on parameter is sampled at regular intervals and cost
- number of times each add-on parameter is sampled at irregular intervals, approximate sampling time and cost

Requirement 8.1-2 Provide the ability to update project sampling schedules

Project managers shall have the ability to update project sampling schedules throughout the term of a project as work plans are modified to keep the laboratory chief and district water-quality specialist informed on changes to project plans during a fiscal year (see Chapter 7, section 2.3.3).

Requirement 8.1-3 Provide the ability for districts to define a suite of laboratory analyses

The NWQL shall help project managers and district water-quality specialists define a suite of laboratory analyses that best meet the needs of district or office programs (see Chapter 7, section 2.3.4). The quantity of sample needed and quantity of preservative to add to the sample shall be computed for the defined suite of constituent analyses and included on the analytical service request.

8.2 Monitoring

Monitoring the activities associated with a project is an important part of overall project management. Monitoring such activities as project funding, scheduling, and progress of work is the responsibility of AIS and is discussed in Chapter 7, Design Constraints. Other monitoring activities are discussed here and include monitoring instruments, monitoring information requests, and monitoring laboratory activities.

8.2.1 Monitoring Instruments

Monitoring instruments, such as documenting the calibration of DO meters and pH meters, is of primary importance to ensure data quality assurance and quality control. For example, a project reviewer should be able to check all of the calibration records of a field trip to check for meter drift or an incorrect calibration. A project chief should also be able to check the repair history and costs of an instrument or a piece of equipment, for management purposes (see Chapter 7, sections 2.3.2 and 2.3.3).

Monitoring instruments, such as data collection platforms (DCP's) and data loggers, transmit data and information via radio, telephone, or microwave signals for input to NWIS. The performance of these and other remote sensing instrumentation will be assessed within NWIS-II using both manual and automated procedures. Performance data (e.g., battery voltage, effective radiated power, signal-to-noise ratio, nitrogen pressure) will be monitored and verified. Through examination and comparison of these data over time, the appropriate user can be forewarned and notified of any potential equipment failures. Figure 21 shows the instrument data flow path

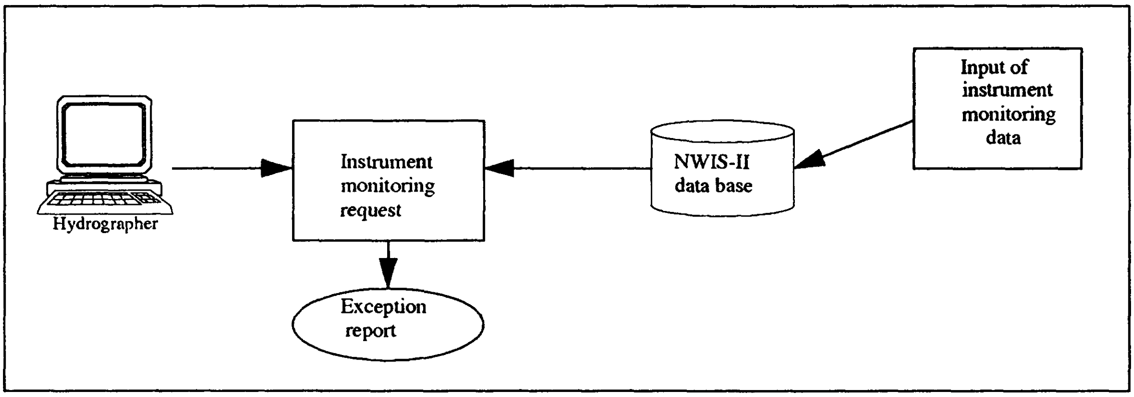

Figure 21. -- Data flow diagram for the instrument monitoring subfunction

Requirement 8.2.1-1 Provide ability to store information on instrument condition

NWIS-II will provide the ability to store all types of instrument numbers, calibration data, and comments about the instruments' general conditions.

Requirement 8.2.1-2 Provide ability to monitor the performance of monitoring instruments

NWIS-II shall have the capability of monitoring data from monitoring instruments for performance and shall send alerts when conditions for failure exist.

8.2.2 Monitoring Information Requests

Managers of large data networks should be able to monitor data requests from their network to determine what kinds of data are requested, who made a request, and how frequent are similar requests. Such information can assist managers in developing programs and writing project proposals to meet cooperators' needs. When USGS personnel enter pertinent information about the data request, the system should be able to generate a report that compiles data request information, whether the request was made automatically by direct access to the system, by phone, or by mail.

Requirement 8.2.2-1 Provide ability to automatically log data requests made by direct access

The software shall be able to sense when an automatic data retrieval was made by a remote system, identify the requester, and log the request in a file to be retrieved for review by project or data base managers.

Requirement 8.2.2-2 Provide ability to log non-direct access data requests

This feature shall provide for logging data requests made by telephone or mail. The software shall be able to open a file of requests and allow the user to update the file with information concerning the kind of data requested, who made the request, and when it was requested.

8.2.3 Monitoring Laboratory Activities Associated with a Project

The NWQL, USGS sediment laboratories, and contract laboratories routinely conduct laboratory analyses on samples received from district and field offices. Project managers need the ability to monitor the activities associated with the analyses of water, sediment, and biological samples. To effectively plan and manage their projects, managers need to be kept informed of laboratory prices, analytical schedules, supply inventories, and charges made against project funds for laboratory services rendered. Laboratory prices, type of schedules available, and supply inventories will be a part of the laboratory's library and can be accessed by district personnel for viewing.

Project personnel must be able to maintain accurate and timely sample tracking and accounting information. If samples are missing or their containers are broken after shipment to the laboratory, the project manager should be notified these situations. After an analytical service request, project personnel need to be able to monitor the status of samples through the analytical process — from receipt of an analytical services request, to receipt of samples at the lab, to inputting analytical results into the data base, and finally, to updating the national data base.

The NWQL's sample management system will be fully integrated in NWIS-II, and many of the functions of the sample management system will be automated. For USGS sediment laboratories and contract laboratories, PC&TS will provide standardized forms for districts to send sample and field information to the laboratories and for laboratories to send sample status information and results of analyses back to the districts (see, Chapter 7, section 2.3.1). Billing and other administrative functions for USGS sediment laboratories and contract laboratories will be the responsibility of AIS (see Chapter 7, section 2.3.3).

Requirement 8.2.3-1 Provide the ability to monitor NWQL charges against project funds

Project managers shall be able to get a report listing laboratory charges against project funds. The same data should be reported to BFM for assessment of the charges against project funds. This functionality will be the responsibility of AIS (see Chapter 7, section 2.3.3).

Requirement 8.2.3-2 Provide ability to monitor the status of NWQL samples

Project personnel shall be able to track samples scheduled for laboratory analytical services by the NWQL. This will be done with the aid of a sample-tracking utility consisting of the EASR, the bottle shipment and condition

status, bottle identification (with bar coding), bottle location and disposition, the schedule status, the reporting group status, and the test-identifier status. The tracking is done by a series of dates associated with the request and status of the sample, documenting the progress of analyses as the samples move through various processing steps. The sample-tracking utility will operate on district and central laboratory computers and use common files to document the status of each sample. Project and laboratory personnel can check on the status of samples by retrieving status reports based on information in the common files. The responsibility for the development of these functions will be shared by the development teams of NWIS-II and LIMS-II (see Chapter 7, section 2.3.4).

Requirement 8.2.3-3 Provide the ability for notification of samples received by the NWQL

As samples are received by the NWQL, a check ensures that every bottle size and type needed for the requested analysis are present. Software will be developed by the NWQL to automatically notify project managers about receipt of samples and missing samples or broken sample containers at the time the samples are logged into the NWQL sample processing system. The LIMS-II team will be responsible for the development of this requirement.

Requirement 8.2.3-4 Provide the ability to enter NWQL analyses results

Personnel of the NWQL will need to enter data into NWIS-II. Techniques of efficient data-entry will be developed by the LIMS-II team so that data-entry has the same function and "look and feel" as the rest of NWIS-II.

Each session will include the following information:

- name of lab person entering data
- telephone number of lab person entering data
- date and time of session
- data to be entered
- number of days until sample containers are destroyed

Requirement 8.2.3-5 Electronic transfer of NWQL analyses to districts

Data transfer files created by the laboratories will be electronically transferred to the districts automatically. A utility program will be developed by the LIMS-II team to send the transfer files electronically across the computer network.

Requirement 8.2.3-6 Provide the ability for acknowledgment of successful transfer of NWQL data

The NWIS-II team will provide the districts with the ability to acknowledge a successful transfer of data from the NWQL to the district. After transmission, the receiving district's system will automatically send notification to the NWQL, using the computer mail system. The notification will include the following:

- date of transfer
- time of transfer
- identification of district that received the data
- a brief message indicating whether the transfer was successful
- summary statistics describing the transferred data

Requirement 8.2.3-7 Provide ability to automatically enter transferred data

The NWIS-II team will provide the districts with the ability to automatically process transfer files sent to districts from NWQL and enter the data into district data bases. The processing of transfer files will be prioritized by date. If more than one transfer file is available for processing, the file having the oldest date will be processed first.

Requirement 8.2.3-8 Provide the ability to create and send a status report

The NWIS-II team will provide districts with the ability to produce a status report for each transfer file processed. The status report will be in an electronic form. Status reports can only be deleted by DBA's. If the data are from an initial sample-run analysis or a laboratory-initiated-rerun analysis, project managers shall be informed of how many days they have to request an analytical rerun before the sample is disposed. At that time, the data will automatically be flagged as 'working' and should have had its initial review for quality assurance by project personnel. The status report will contain the following information:

- date of transfer
- time of transfer
- complete description of data transfer errors
- summary statistics describing the data transferred
- date of data entry
- complete description of data entry errors
- summary statistics describing the data entered into the data base
- number of days until samples are destroyed and data are flagged as 'working'

The status report will be sent to the project manager and DBA using the computer mail system.

Requirement 8.2.3-9 Provide ability to notify when data were uploaded to the NWIS-II data base

As data are uploaded to the NWIS-II data base either by polling at the national level or by actions of the district's data base administrator, a message documenting the transmission shall be sent to the project manager and data base administrator summarizing the contents transmitted and the success or failure of the transmission.

8.3 Hydrologic Event Notification

Hydrologic event notification is the system's response to sensing that the magnitude of a data value or the rate of change in values has exceeded a predefined limit. Regardless of how entered into the system, the data should be compared against limits which, if exceeded, cause the system to alert appropriate project personnel. The type of alert should be determined by the nature of the event. Some alerts need to be executed in near real-time mode and others are less urgent. For example: an alert in response to a stream's discharge increasing rapidly could trigger the system to activate a telephone dial-up of a beeper; a ground-water level dropping below a specified limit could trigger the system to send a message to project personnel via their computer terminals; the concentration of a chemical constituent of water exceeding a certain value could trigger the system to send a message to the district water-quality specialist and project personnel via their computer terminals. The ability to specify and update criteria that will activate alerts needs to be built into the NWIS-II software to provide for effective project management. Instrumentation alerts, aggregated data alerts, and laboratory analyses alerts are system responses to three different ways that data can be checked against user-defined threshold values.

8.3.1 Instrumentation Alerts

Instrumentation alerts emanate from recorded data processed by the NWIS-II software. As the recorded data are verified, they are checked against user-defined limits. When the limits are exceeded, the software will trigger a user-supplied action.

Requirement 8.3.1-1 Provide the ability to establish thresholds for monitored field parameters

The project worker shall be able to define threshold conditions for any monitored parameter that will constitute a hydrologic event on the basis of:

- a value greater than the limit
- a value less than the limit
- values exceeding a rate-of-change limit
- values exceeding some limit provided by a computer algorithm (i.e., test against historical extremes or selected percentiles)
- minimum change in data value not occurring in data sampling cycles ("deadband test")
- values failing a relational test against other monitored data types.
- initiate user-signaled exits for executing user-supplied procedures for data verification.
- n data points exceeding or below defined high or low limit.

Requirement 8.3.1-2 Provide the ability to initiate a process or user-supplied action after an instrumentation alert

Any data value on input that exceeds the specified limits will trigger a software-controlled process or user-supplied action. Output will be in the form of a message to a log file, electronic mail, radio or telephone contact, or alarm.

8.3.2 Laboratory Analyses Alerts

Threshold values of certain physical-, biological-, and chemical-based data need to be defined by water-use type for effective project management. The threshold values can be defined as national and non-national and are applied as a test on data obtained from laboratories. The values are stored in support files. When threshold values are exceeded, the software will trigger an action to notify appropriate project personnel about who could verify the alert as valid, and take further action as required.

Requirement 8.3.2-1 Provide the ability to check NWQL analytical results that exceed water-quality alert limits

The concentration values of chemical constituents in water undergoing laboratory analyses shall be checked against national and non-national acceptable limits of concentration based on the particular use of the water being analyzed, using software developed by the LIMS-II team . The analyst will then check the work to verify that it is not an error.

Requirement 8.3.2-2 Provide the ability to check *in situ* values of certain physical and biological characteristics of water.

The *in situ* measured values of certain physical and biological characteristics of water shall be checked against defined limits. If the values of the acceptable limits vary in scope, users shall have the ability to specify several threshold values to check against.

Requirement 8.3.2-3 Provide the ability to initiate a process or user-supplied action after a laboratory analysis alert

Any data value that exceeds the specified limits will initiate either a software process or a user-supplied action, or both. When a water-quality limit is exceeded the project manager and laboratory shall be alerted by a report sent via electronic mail. If, after review, the value is found to be valid, an alert report shall consist of a letter to the appropriate agency on USGS letterhead. The letter should list the station ID, Station name, date sample was collected, parameter alert level, and the parameter name and value detected. In addition to the letters generated, a mailing-list labels file also shall be generated. The alert system shall ignore values modified by the '<' or 'e' (estimated) characters.

Requirement 8.3.2-4 Provide the ability for appropriate routing of alert notifications through NWQL personnel to appropriate personnel

The LIMS-II team will provide the analyst with the ability to send an alert notification to the appropriate personnel (see National Water Quality Laboratory Software, section 2.3.4). The requirements for notification are spelled out by the EPA Office of Drinking Water.

8.3.2.1 Nationally Defined Alert Limits

National standards for the quality of water have been established to set limits on the physical, biological, and chemical characteristics of water. A list of national standards should reside in the NWIS-II data base dictionary

so project personnel could be alerted when the values of certain water-quality data exceed specified limits. These values could only be input and modified at the national level of system maintenance.

Requirement 8.3.2.1-1 Provide listing of nationally defined alert limits.

The NWIS-II software shall provide for, at a minimum, the following national alert limits:

- national EPA primary and secondary drinking water limits
- aquatic life limits
- recreation use limits

The values for these limits will be supplied by the Office of Water Quality.

8.3.2.2 Non-National Alert Limits

Other standards for the quality of water may be established at the state, local, or project level to set limits on the physical, biological, and chemical characteristics of water. A list of such standards should reside in the NWIS-II data base dictionary so the software could trigger alerts to project personnel when the values of certain water-quality data exceed specified limits.

Requirement 8.3.2.2-1 Provide the ability to add non-national alert limits.

The local DBA and local project managers will have the ability to add the following types of alert-limit checks to their system:

- State alert limits
- local alert limits
- project alert limits (which include alerts established by site)

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9. Maintenance

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The maintenance functional requirements include the "care and tending" of NWIS-II. This includes maintenance of the data stored in the data base, the software used to interact with the data base, the operating system that controls the interaction between the data base and input and output devices, and third-party software associated with the data base. Electronic mail software and USGS computer models will not be maintained as parts of the NWIS-II.

Maintenance requirements are organized in the following subsections: data distribution, data base maintenance, and system maintenance and administration. Data are distributed using functions that allow the transfer of data within the NWIS-II data base. Data base maintenance involves functions that protect and maintain data base files. System maintenance and administration involves functions that control changes in NWIS-II.

9.1 Data Distribution

Data distribution describes the function that allows the transfer and sharing of data sets among different nodes within the NWIS-II distributed data base. This function provides the ability for a node to collect a data set for transfer to EPA's STORET data base by polling all NWIS-II nodes. Multi-State projects will be able to develop a project data set by polling the appropriate district data base.

The concepts of "primary" and "secondary" nodes are introduced to explain the nature of data distribution within NWIS-II. A primary node is a node (e.g., headquarters, district, or subdistrict) that has responsibility for maintaining a portion of the NWIS-II data base. A secondary node is any node not maintaining a specific portion of the NWIS-II data base. Data may be modified only at the primary node by persons with the appropriate data base-access protection level. The primary node for a data set can be relocated. Secondary nodes may receive copies of a primary node's data set for use by hydrographers at that node. Copies of data sets at secondary nodes only provide view access. Copies can be updated at intervals determined by the users at the secondary node. Either the primary or the secondary node will have the ability to perform the update. An update procedure must be completed or the entire transaction of the update will be nullified.

A variety of management functions will be provided for maintaining and overseeing the update procedure. Concurrence control will be supported where applicable. Also, an access-control list can be created for proprietary data that are "approved" to determine who and to what extent users have access to specific data. If access is needed to view a specific data set, the access control list will be available so that the appropriate individual may be contacted.

Requirement 9.1-1 Provide the ability to copy data between a primary and a secondary node

Data with an "approved" status can be copied from a primary node to a secondary node by any user. Data sets marked as "working" can be copied from a primary to a secondary node by users with sufficient data-base access.

Requirement 9.1-2 Provide the ability to change the primary node of a data set

The primary node for a set of "working" data may be changed to another node upon request by the project chief who has control of the data set.

Requirement 9.1-3 Provide the ability to transfer information about access control

If data are proprietary (classified), an access control list of users who have access to the data shall be sent to the secondary node(s).

9.2 Data Base Maintenance

Maintenance is conducted on the NWIS-II data base to sustain its integrity and to help facilitate efficient interaction with users. At any given time, portions of the data base may be online, near online, or temporarily offline. Data base maintenance is discussed in terms of data preservation, site administration, maintenance of data-processing histories, maintenance of transaction logs and audit trails, maintenance of reference and device-configuration lists, and maintenance of data indexes.

9.2.1 Data Preservation

Backup, recovery, and archival operations are used to preserve data stored within the NWIS-II data base. Scheduling software used for timing a maintenance function will be available to perform an operation automatically on a routine basis. A specific operation can also be performed 'manually' at any time without the use of scheduling software.

The successful completion of data-preservation activities requires that the DBA have control over the use of the NWIS-II data base by other users at all times. The DBA will have the ability to block or suspend data base activities to complete a maintenance operation. A summary of an operation will be produced automatically during a maintenance operation.

Requirement 9.2.1-1 Provide the ability to monitor data base activities

The DBA shall have the ability to monitor data base activities to identify users of the NWIS-II data base and processes that are active.

Requirement 9.2.1-2 Provide the ability to suspend or block data base activities

To complete a data base maintenance operation, the DBA shall be able to block or suspend:

- an outside data base polling operation;
- local use of the data base;
- a data base process that is not interactive.

If a user initiates a process that requires the use of a portion of the data base not accessible due to maintenance, the blocking or suspension of data base activities shall allow the DBA to send a message to that user (local or

remote). The DBA's message will include an operating system message informing the user why the process is not being completed.

Requirement 9.2.1-3 Provide the ability to operate NWIS-II if a portion of the data base is not accessible

If only a portion of the data base and NWIS-II functionality at a given node cannot be accessed, users and the DBA shall continue to have access to other portions of the data base.

9.2.1.1 Backup

A backup operation involves the copying of a data base to an offline media, such as magnetic tape. The purpose of backup is to allow for easy recovery of lost data as a result of either hardware or power failures. A variety of backup techniques exist. A full backup is a backup of everything in the data base at one point in time. An incremental backup is a backup of changes that occurred to files since the last full backup.

Requirement 9.2.1.1-1 Provide the ability to perform full or incremental backups

The DBA shall have the ability to perform full or incremental backups at regular or irregular intervals. A backup log file will automatically be generated during a backup operation. The backup log file will contain the following information:

- Date and time of backup
- A list of the data that were backed up
- Whether it was a full or partial backup.

The DBA will have the ability to edit the backup log file to remove unwanted entries, and to configure the backup log file for the following parameters:

- Turn automatic logging on (the default), or off
- Specify the number of entries to be maintained in the backup log file (options are either unlimited (the default) or a specific number--older entries will be deleted as new entries are made to the log file to keep the number of entries below the specified number).

9.2.1.2 Recovery

Data recovery is used to restore the data base to a state that existed at a previous point in time. All data should be recoverable to the most recent backup completed prior to the data base being damaged. The DBA will have the ability to delete data sets and 1) replace them in their entirety with a copy created by a previous full backup or 2) replace them in part with a copy created during an incremental backup. The DBA will be able to obtain the date and time of the backup from the storage medium prior to recovery.

Requirement 9.2.1.2-1 Provide the ability to rebuild the data base from either full or incremental backups

The DBA shall have the ability to rebuild all or part of the NWIS-II data base from full or incremental backups.

9.2.1.3 Archival

Data are archived for long-term storage by copying the data to tape or disk and removing the data from the online data base. Therefore, archived data may not be as readily accessible as data in the online data base. Data that are used infrequently will be archived to enhance performance of user interaction with the data base. Data that has been archived cannot be changed. However, if data are revised and subsequently archived, anyone accessing these data will be informed that revisions to the data exist.

Data are archived rather than destroyed because challenges to published hydrologic information may be made many years after the data are collected. Thus, there is a need to retain field data to support interpretive conclusions, calculated values, and statistical determinations. Other reasons why data are archived include: use in legal matters, storage for future research and investigations, support of published reports, support of working and online computer data bases, and security and accessibility of original data.

The DBA will be able to decide when to archive data and how those data will be accessed. The archival procedure will be flexible enough to allow the DBA to decide the timeframe for data archival. Every NWIS-II node will be able to develop a local data archival policy. Archived, restricted data will have qualifiers showing the protection status of the data. All users should have access to the files that document the data that have been archived.

The following information will be archived:

- original records
- data labeled as approved
- support data used to generate other data or generated from other data
- electronic images, such as scanned papers or photographs
- data-processing histories

The following information will not be archived:

- data with “working” status
- data with “in-review” status
- personal files (e.g., correspondence, monthly summaries, login scripts, mail files)

The following requirement, 9.2.1.3-1, lists the data to be archived. At the time of this document’s preparation, the management of WRD appointed a committee to make policy decisions for what data was original data and what data should be archived, when it should be archived, and how often it might be accessed or modified. The findings of the WRD Committee on Data Policy shall supplement or supersede this requirement.

Requirement 9.2.1.3-1 Provide the ability to archive NWIS-II data

Original data will be archived, subject to policy and decisions of the Data Policy Committee. Original data include the following:

- Time-series unit or daily values from field recorders (in standard format, unedited)
- Time-of-travel data

- Manual observations
- Dye-dilution data
- Field inspection sheets
- Discharge-measurement field notes
- Lab analyses
- Sediment laboratory data
- Station level notes
- Crest-stage measurement notes
- Miscellaneous field note sheets
- Quality-assurance/quality-control data
- Chain of custody protocol information
- Edited unit values of gage-height

Data with approved-for-release status will be archived. Examples include the following:

- Time-series data or computed unit values
- Daily values
- AWUDS water-use estimates and associated aquifer data

Data used to derive computed values will be archived. Examples of this type of data include the following:

- Rating tables, rating curves, rating equations
- Shifts, shift diagrams, and applied shifts
- Unit values corrections (datums)
- Primary sheet output
- Sediment concentration curve
- Sediment mean value file
- Sediment-transport curve and data file
- Verification and computations scripts and data
- Comment files (text information) regarding methods, procedures, etc.
- Analytical notes generated in estimation processes
- "K" values used with the Discharge-Ratio technique

Electronic images, such as scanned papers or photographs, will be archived, including the following:

- Maps and sketches
- Newspaper clippings
- Historical data - including old paper copies of ground-water data
- Backsides of discharge-measurement sheets
- Field notes, sketches of the site or sampling, area and site schedules
- Electronic station file
- Geophysical logs/site sketches

Data-processing histories also will be archived, including the following:

- Transaction files
- Audit trails

- Data-processing comments, remarks, and notes

NWIS-II shall provide archival procedures to assist the DBA in archiving information. Only the DBA shall have access to archiving procedures in NWIS-II. The following attributes are expected to be available as part of the archival software:

- Identification of interactive users, background processes, and polling operations.
- Identification of what to archive
- Selection of the output device
- Write archive header to output device
- Write all information to output device
- Verification of information on the output medium
- Indexing of the archived information
- Write index to the output device
- Verification of information in the index
- Creation of a duplicate copy of output, if desired
- Deletion of information in the data base, if desired
- Reinitiate access to the NWIS-II after archival is completed

Requirement 9.2.1.3-2 Provide the ability to identify what data have been archived

The date and time of archival and a description of what was archived shall be made on the archival media.

Requirement 9.2.1.3-3 Use archival media that provides optimum accessibility

All information will be archived on media that provides prompt accessibility and easy load capability.

9.2.2 Site Administration

NWIS-II will have both site and national system administrator functions. The site administrator functions will be performed at each installation of NWIS-II and includes the maintenance of the local computer system, as required to support and maintain the installation of NWIS-II. Site administration functions include unlocking files, unlocking records, recovering disk-space, structuring data base tables, and moving data base files.

Requirement 9.2.2-1 Provide the ability to unlock NWIS-II files and records

File records and files may lock occasionally, which prevents users from accessing data. A procedure will allow the DBA to globally unlock files and records.

Requirement 9.2.2-2 Provide the ability to recover disk space

File cleanup utilities will be available to recover disk space as a result of file deterioration caused by file fragmentation and storage of deleted records. The recovery utilities will rebuild the data files and physically delete records marked for deletion.

Requirement 9.2.2-3 Provide the ability to set maintenance procedures to run automatically

Maintenance procedures can be set to run automatically. The procedures will generate notices to appropriate personnel when nonautomated maintenance is required (such as notification of file space shortage, need for archiving, or need for clean-up of temporary records and user areas).

Requirement 9.2.2-4 Provide for the ability to locate data files

NWIS-II software will allow data sets to be located anywhere on the local-area network (DIS-II equipment). Data sets are not required to reside on the same storage media as the NWIS-II operational software. Examples of files that can be located anywhere on the local area network are:

- Data base files
- Nationally supported reference lists
- Transaction log files
- Audit trail files.

NWIS-II will keep track of the location of these files. The initial installation (at any software version) will provide a default location for data files. However, once the initial installation is complete, software updates for each succeeding software version will not overwrite changes made to the data base of data-file locations.

Requirement 9.2.2-5 Provide the ability to perform global changes on files

Global changes can be made to NWIS-II by the DBA. Global changes to data files should be done judiciously; the DBA may need to consult with district discipline specialists and others before committing global changes. The role of the DBA is discussed in Data Protection, section 3. of this chapter. The DBA can limit updates to a single station, a single project, or an entire data base. Regular selection criteria described in Data Retrieval, section 2.2 of this chapter, can be used to select the stations for running global updates.

9.2.3 Data-Processing Histories

Information on data-processing history will be stored in the NWIS-II. This information will include the source of the data (e.g., paper, electronic), whether values were derived by NWIS-II or entered manually, and information about attributes of the data. Data-processing histories will be available for access by the DBA and the project chiefs, project workers, and WRD reviewers associated with the appropriate project data-protection group. These users would use the data-processing histories to track changes to the data and information for data-quality reviews and data-processing progress reports. As data are processed, a history is automatically kept of the computations performed, the options used on the computations, and any variables specified for use during the computations. Users can annotate the history with additional information.

Requirement 9.2.3-1 Provide data-processing histories

NWIS-II shall provide data-processing histories and make them accessible. Data-processing histories shall include but not be limited to the following items.

- Methods used to derive values
- Updates and modifications to data
- Quality-assurance checks on data
- Notifications of access violations
- Accesses to spatial data coverages
- Changes in spatial coverages

9.2.4 Transaction Logs and Audit Trails

Transaction logs and the associated audit trails can be used to rebuild damaged data files. Along with data-processing histories, the transaction logs and audit trails provide a "chain of custody" or accountability for the data files. The transaction log will include what is being added, deleted, or changed including the site identification, constituent identification, the date and time of the data or information, and the values (e.g., existing, new). The audit trail will be linked to the transaction log and will include the following items.

- Transaction identifier
- File identifier
- Date and time of transaction
- Individual doing the transaction
- Lab identifier, if lab data are being processed

NWIS-II may have a single or multiple transaction log and audit files. The DBA will have the ability to assign a specific group of data files to a transaction log and audit-trail file. The DBA will have the ability to view transaction log and audit-trail files. The DBA will have the ability to edit transaction log and audit-trail files using an operating system editor. The purpose of editing will be to remove unwanted entries at the end of transaction log and audit-trail files prior to data recovery.

NWIS-II will allow information to be automatically appended to existing transaction logs or audit-trail files. Transaction logs or audit-trail files may be isolated on a disk drive that does not contain the data base. Date and time tags will be included with each transaction in a transaction log file in a format compatible with the date and time tag recorded on the backup medium. The date and time tags must be compatible in order to provide full recovery of data after the data base is damaged.

Requirement 9.2.4-1 Provide the ability to create transaction logs or audit-trail files

A procedure shall be provided to allow the DBA to create transaction logs or audit-trail files. These files must exist prior to allowing users access to the NWIS-II data base. The files shall contain an entry for the date and time the file was created.

Requirement 9.2.4-2 Provide the ability to automatically recover NWIS-II files using transaction logs and audit-trail files

NWIS-II shall provide a procedure to perform data recovery using transaction logs and audit-trail files. This data-recovery procedure shall:

- Identify whether an update should be applied or undone (undo transactions).
- Identify the start date and time of the transaction log or audit-trail file.
- Identify end date and time of the transaction log or audit-trail file (default will be present date and time).
- Modify the data base by applying transactions in the transaction log and audit-trail files between specified dates.
- Create new entries in the transaction log and audit-trail files for the performed procedure.

Requirement 9.2.4-3 Provide independence between transactions listed in transaction logs and audit-trail files

Entries to a given transaction log file or audit-trail file must be unique. Two or more transaction logs or audit-trail files cannot contain the same entry.

Requirement 9.2.4-4 Provide the ability to automatically stop access to the NWIS-II data base if transaction logs or audit-trail files are not accessible

An entry shall be made to the transaction log and audit files prior to updating the data base. If a transaction log or audit-trail file cannot be accessed, NWIS-II shall not allow users to update files.

Requirement 9.2.4-5 Provide ability to monitor transaction logs and audit trails

Transaction logs shall provide for documenting the date, time, type, and quantity of data input to NWIS-II. During edits of the data base, audit trails will provide for documenting the date, time, and person performing the updates. Project managers and data base administrators shall have the ability to view these reports and combine audit trails with commentary logs to produce a report used to review the quality of their data and manage project activities.

9.2.5 Reference List Maintenance

Reference lists that are specific to the needs of an individual district will be maintained by that district. Some reference lists that are utilized system wide (e.g., NODC species codes) will be maintained at NWIS-II headquarters. Users will be able to request updates to these lists in a way that will ensure consistency for all NWIS-II users. All updates to reference lists must be approved by the appropriate, designated authorities at headquarters.

Requirement 9.2.5-1 Provide an automatic process for requesting changes to a reference list

NWIS-II users shall have the ability to submit requests to update reference lists to the headquarters NWIS QA&CM unit. Electronic forms or reference-list update files shall be available for users to submit update requests.

The update request form shall include the following information:

- User name
- User office
- User phone number
- New term
- Additional descriptions and definitions of term
- References

No new terms shall be allowed in the reference list without the above information. Once the update form is completed, the request shall be submitted to NWIS headquarters and a copy sent to the user. The term will be flagged as "not approved, pending approval." Terms approved by headquarters will be flagged as "approved" and unapproved terms will be flagged as "not approved, not pending approval." Data associated with reference list entries marked "not approved, pending approval" shall not be accessible for use in the NWIS-II until approved. An exception shall be data associated with a requested update to the taxonomic reference file; these data shall be accessible for use within NWIS-II. See section 5, Data Verification, for further discussion on reference lists and refer to Appendix G: System-Defined Reference Lists for a complete listing of NWIS-II reference list files.

Requirement 9.2.5-2 Provide headquarters approval of new reference list terms

Reference list update requests shall be received and logged in by the QA&CM Unit of NWIS at headquarters. The requests shall then be routed to the appropriate person or persons for approval. These persons may be NWIS staff, PC&TS technical experts, the Biology Users Oversight Committee, or other technical persons tasked to manage specific reference lists.

Requirement 9.2.5-3 Provide the automatic approval after designated time has elapsed

After the configuration manager of NWIS submits a user-requested change for the reference list to the appropriate approval authority, approval or disapproval must occur within 30 days. If the approval or disapproval action has not occurred within 30 days, the configuration manager shall consider the user-requested change approved by default. The only exceptions to the 30-day limit are approvals of changes to the taxonomic reference file from NODC. See verification section for a detailed description of the taxonomic reference file.

Requirement 9.2.5-4 Provide the ability to update system-wide reference lists

The NWIS-II system-wide reference lists will be updated by NWIS headquarters periodically. Updates will most often occur as a result of updates generated by other agencies, such as NODC taxonomic codes, STORET parameter codes, and approved updates requested by users. These updates will be sent to primary nodes automatically by an NWIS-II system administrator at the national level.

Requirement 9.2.5-5 Provide the ability to store a history of reference list changes

Changes to the reference list shall be maintained in the district data set and at NWIS headquarters.

Requirement 9.2.5-6 Provide the ability to verify technical words and phrases with the use of a scientific dictionary and acronym list

Users shall be able to verify technical words and phrases. These terms are scientifically correct, as accepted by an oversight committee, and are stored in reference files. The contents of these reference files (e.g., taxonomic names, geologic names) can be modified only at the national level of system maintenance.

9.2.6 Device-Configuration List Maintenance

Configuration of the operating system for specific peripheral devices (CPU's included) occurs at each computer site. Input/output device configuration is the process of identifying the availability of devices, communication specifications, and other information needed to utilize the devices. The DBA will maintain a list of available peripherals that is up to date and can be queried from within NWIS-II. This list also will list the names of CPU's and the available execution time limits.

Requirement 9.2.6-1 Provide the ability to build a list of peripherals

The DBA shall configure the NWIS-II software to handle peripheral devices. The names and descriptions of these devices shall be maintained in lists that are viewable by users.

9.2.7 Data-Index Maintenance

The NWIS-II data indexes are composed of three types of indexes: the Master Water Data Index (MWDI), the Local Water Data Index (LWDI) and the Non-USGS Water Data Index (NWDI). The MWDI contains data-availability information and data-base summary statistics to help users determine the existence, accessibility, and location of water data and associated information. The MWDI will exist as a set of LWDI's and an NWDI. The LWDI will contain an index of data collected and stored by the USGS and data provided to the USGS by cooperating agencies at a primary node (roughly analogous to a district). The NWDI is a set of aggregated indexes that will be provided by the various NAWDEX member organizations. The LWDI and NWDI subsets of the MWDI will be updated independently. A complete copy of the MDWI can be stored at headquarters (or any other node) by polling each primary node. A read-only copy is then retrieved to the site of interest. CD-ROM's of the complete MWDI may be generated annually by headquarters and distributed to users of the data index.

Each LWDI will be automatically maintained by the respective primary node. As data values in the NWIS-II data base are added and deleted, the related information in the appropriate LWDI also should be updated. LWDI updates will be continuous. Data base administrators will be responsible for ensuring that the data values stored on their node are properly indexed and that the index is current.

The NWDI will be maintained by headquarters. Information in the NWDI will not be updated continuously, but rather quarterly or semi-annually. Headquarters (NAWDEX) will be responsible for obtaining and maintaining

the index information received from non-USGS sources. Procedures will be developed to transfer data from outside water data indexes into the NWDI in an accurate and timely manner.

The MWDI is set up with a list of high-level attributes. However, additional attributes can be added to these indexes. Since the list of attributes will not necessarily be the same between nodes, it must be possible to distribute indexes with only the high-level attributes. Each node must develop a list of attributes stored in their respective LWDI.

Requirement 9.2.7-1 Provide the ability to automatically update the LWDI

Each LWDI shall be updated on a continuous basis to reflect the current status of the data values stored at the node for which the LWDI exists (the primary node).

Requirement 9.2.7-2 Provide the ability to periodically update the NWDI

The NWDI shall be periodically updated with data obtained from the various NAWDEX member organizations.

Requirement 9.2.7-3 Provide the ability to aggregate each LWDI to form the MWDI

NWIS-II shall provide the ability to generate the MWDI from the aggregation of portions of each of WRD's LWDI's. Since the LWDI's may contain attributes that vary from node to node, the MWDI can only be created from high-level LWDI attributes that all nodes have in common. The aggregated LWDI's and the NWDI shall form the MWDI.

Requirement 9.2.7-4 Maintain cross-references to STORET parameter codes

A cross-reference of all STORET/NWIS-II parameter codes shall be maintained by NWIS-II.

Requirement 9.2.7-5 Maintain cross-references to STORET agency codes

A cross-reference of all STORET/NWIS-II agency codes shall be maintained by NWIS-II. Updates will be handled in a similar manner as parameter code updates.

9.3 System Maintenance and Administration

The system administration functions are activities performed by headquarters, as required to support and maintain all of NWIS-II.

9.3.1 Software Maintenance

NWIS-II software will be installed as new releases become available. The software will be distributed in a compiled format and each new release of the software will be independent of the previous releases. Installation procedures that will create a minimum impact to users, site administrators, and DBA's will be designed. Releasing software in a compiled or binary format has the following installation and maintenance benefits:

- Reduces installation time because code does not need to be compiled on each computer.
- Decreases maintenance costs because special compilers do not need to exist on all computer systems.
- Provides better protection when special software and data base protection exists.

Software independence means that the current version can be installed on a computer system without the need to install any previous version of the software still available. However, once a new version of the software has been installed and data have been entered into the data base, all future versions must be applied in the order in which they are released. This is necessary to assure continuity in data base operations so that changes in file structures or software changes do not cause file damage or software failure.

Requirement 9.3.1-1 Provide the ability to distribute pre-compiled software

Program code and NWIS-II files shall be available in uncompiled, ASCII format for requesters. Requests for source code shall be approved only at headquarters.

Requirement 9.3.1-2 Provide independence of software versions

Software versions shall be independent.

Requirement 9.3.1-3 Provide guidelines to fine-tune NWIS-II at each node

NWIS-II shall develop procedures and instructions for optimizing the software to enhance performance. If subcomponents of NWIS-II software are installed on multiple file servers, the subcomponents must be updated with each new version of the software. Subcomponents that have been modified since the last version need to be re-installed. The installation instructions sent out with a new version shall include a list of modified subcomponents.

Requirement 9.3.1-4 Provide a method of software installation to fine-tune the data base that will not overwrite changes

Software updates to fine tune a district's or subdistrict's installation will not overwrite changes.

Requirement 9.3.1-5 Provide NWIS-II testing when changes occur in operating systems, third-party software, and hardware updates

NWIS-II shall be fully tested prior to the release of a new version if changes occur in the operating system and third-party software or hardware. Testing will be completed and new NWIS-II software releases will be available (if necessary as a result of testing) prior to the delivery of software and/or hardware to nodes.

Requirement 9.3.1-6 Provide standardization of NWIS-II libraries and utilities

NWIS-II shall provide standard libraries and utilities that can be used by programmers to develop applications. Changes to argument lists or functionality in a routine that cause software developed with a prior version of the routine to not function correctly will be minimized. Documentation shall be provided at each release that will identify all changes to libraries and utilities.

Requirement 9.3.1-7 Provide the ability to link applications to NWIS-II

NWIS-II shall provide the ability for DBA's to add software applications that access the NWIS-II data bases and other software modules. These software applications would be accessible through the NWIS-II menus.

9.3.2 Configuration Management

The arrangement of various parts of the NWIS-II determine the properties and configuration of the system. Configuration management (CM) is used to document changes in support files, NWIS-II's software, and data base configuration. Four versions of NWIS-II will be maintained at any given time. The four versions are: (1) a duplicate version of the current released system; (2) a new version that has been tested and is ready for release; (3) a working version being used for modification; and (4) a version being tested for approval and release. The QA&CM Unit of NWIS approves the release of software fixes deemed critical to the integrity of NWIS-II. These critical fixes are software revisions or patches sent out in lieu of a scheduled NWIS-II software release when the delay in waiting for a scheduled release would adversely affect the NWIS-II data bases.

Requirement 9.3.2-1 Provide version control of NWIS-II

NWIS-II will document enhancements and changes to support data, software, and the data base through version control. A version-control document shall be available to determine the changes included in a given version of NWIS-II.

Requirement 9.3.2-2 Provide electronic software updates for critical fixes

When the QA&CM Unit of NWIS approves a critical software fix, the fix shall be sent from headquarters through the network to computer nodes where it shall be applied, the status log will be updated, and a message will be sent back to headquarters on the successful or unsuccessful completion of the update. The NWIS-II software will be designed so that changes can be made easily without affecting other parts of NWIS-II.

Requirement 9.3.2-3 Provide error reporting

The NWIS-II software at each node shall provide users with a software error-reporting function. This function will allow users to create error reports and have them sent to NWIS-II headquarters, where they will be entered into the software tracking system.

Requirement 9.3.2-4 Provide software error tracking system

Users shall generate error reports at their local computer node. These error reports will be sent electronically to the NWIS-II headquarters where they will be entered in the software tracking system. Error tracking will be used to assign priorities for correcting errors and to track progress of error corrections.

Requirement 9.3.2-5 Provide in-place test software and test data sets

As part of headquarters system administration, test software and test data sets will be maintained in the NWIS-II so that new software versions can be easily evaluated.

Requirement 9.3.2-6 Provide test data sets and test software

Test data sets and test software will be available to the network nodes.

Requirement 9.3.2-7 Maintain software status log

A log shall be kept that documents NWIS-II software status. The log shall include the software version, installation date, fixes added to the software, and may include certain information on the data base performance.

9.3.3 Data Exchange with U.S. Environmental Protection Agency's Water-Quality Data Base

The USGS provides water-quality and daily-values data to the EPA's STORET data base. Cross-references between STORET parameter codes and the NWIS-II Constituent Identification System will be maintained to facilitate the accurate transfer of data to STORET. [Note: An agreement may be needed with EPA to develop accurate cross-reference tables between STORET's parameter codes and the Constituent Classification Index.] Cross-references will also include acceptable data-coding protocols, e.g., acceptable values for well-construction materials. An additional cross-reference will be established for STORET and USGS agency codes.

The NWIS-II system administrator at headquarters will be responsible for copying data to STORET. Once per month, headquarters will retrieve water-quality data from each primary node to be uploaded to STORET. Twice yearly, headquarters will retrieve daily-values data from each primary node to be uploaded to STORET. Included in the retrievals will be additions and changes to the NWIS-II data base since the previous update was transmitted.

Requirement 9.3.3-1 Provide the ability to copy data from NWIS-II to the STORET data base

All water-quality data labeled "approved" that also have equivalent STORET parameter codes and acceptable data values shall be copied to STORET. A suitable data-exchange format and procedures shall be provided to copy these data from the NWIS-II data base to the STORET data base. See Requirement 7.5.1.3-2 for output format requirements.

Requirement 9.3.3-2 Maintain data transfer formats and tables for copying data to STORET

NWIS-II shall maintain the up-to-date data-transfer formats for copying water-quality and daily-values data to STORET.

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CHAPTER 4. DATA BASE DESCRIPTION

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1. Introduction

This chapter provides a description of the data-base requirements for the NWIS-II. Also included in this chapter is a discussion of data modeling and the relational data model. Physical design and implementation of the NWIS-II data base are also briefly discussed.

Data processing has long been the dominant concept and the major organizational function driving computer systems development. As a function of the organization, data processing has traditionally focused on programs and processes that transform data, rather than data management. The relatively recent acceptance of the concepts of information resources management, business systems planning, enterprise data modeling, and information engineering have resulted from an improved understanding of the need to utilize data as a primary resource of an organization.

Information engineering is a set of interlocking techniques in which enterprise models (a very high-level model of the organization), data models (data requirements of each suborganizational component of the organization), and process models (functional requirements of suborganizational components) are built up into a knowledge base and used to create and maintain more useful and effective computer systems (Martin, 1989). This approach to systems planning has its roots in the strategic plans of the organization, and results in a data model that avoids redundancy and inconsistency, makes data shareable, enforces standards, maintains security and integrity, balances conflicting requirements, and provides data independence. These are the basic goals of the NWIS-II data-base design.

1.1 The Data Base and Software Development Life Cycle

The Requirements Analysis Phase of the life cycle determines the data, functional, and performance requirements of the system. The basic objective of requirements analysis is to obtain a clear, complete, and agreed-upon specification for a feasible systems development. The NWIS-II Logical Data Model represents a point in time within the highly iterative requirements-analysis process. Additional data design stages in the system's development life cycle will refine the data-design specifications for guiding the implementation of NWIS-II. The iterative compilation of specifications will cover decomposition of the total NWIS-II data requirement into complete descriptions of the data files and elements that will comprise the NWIS-II data base. Subsequent physical data-base design will include identification of performance trade-offs, analysis of algorithms, and definition of interactions between components, such as between the data base management system (DBMS) and application programs. Design and integration of prototypes at appropriate stages in the development process will assist in carrying the design into implementation as these prototypes are created and used. Prototyping will enable selected

users to preview major portions of the system design and provide increased user involvement and feedback to the design process.

1.2 Developing the Data Requirements for the NWIS-II Logical Data Model

The goal of the NWIS-II effort is to develop and implement a highly flexible, expandable hydrologic data management and processing system. The NWIS-II Design and Development Team has addressed both the functional and data requirements of the User Groups in parallel. The basic objectives of the NWIS-II Design and Development Team in the development of the high-level logical model as presented in this document have been as follows:

- to interact with User Groups to determine and understand the policies, rules, and processes that govern the day-to-day data and functional requirements of each User Group;
- to discern or infer all relationships between functional activities and the data necessary for carrying out day-to-day activities of each User Group;
- to define and understand all unique data requirements of each User Group;
- to discern, as well as possible, the common data requirements as they might exist both among and between User Groups;
- to define in detail the definition, characterization, parameters, constituents, function, and use of that data; and,
- to identify and understand both the short- and long-term implications of any planning associated with anticipated change in the data or functional needs of each User Group.

The methods and materials used by the NWIS-II Design and Development Team in the development of the Logical Data Model have been:

- User Group documents - policies and procedures, data requirements (including entity-relationship diagrams, activity rules, lists of entities and attributes, and glossaries of terminology);
- reports, publications, and other documents from within each User Group related to their unique activities and disciplines;
- both formal and informal User Group interview sessions;
- formal reviews and walkthroughs of the logical data model during its evolution;
- study of existing WRD computer systems;
- team expertise/experience within a particular discipline or business area;
- published WRD glossaries of selected water-resources and related terms.

1.3 The Relational Data Model

The NWIS-II will be implemented within a relational data-base management system, therefore a brief discussion of the relational data model is presented in this section.

Data-base management involves the sharing of large quantities of data by many users within the organization. Each user, or groups of users, may conceive their view of or actions on the data independent of one another. The possibilities for users to distort, damage, or misinterpret data shared in this way are enormous, unless the data-base design and environment are strictly defined and controlled within a proven design model as needed for successful sharing of organization-wide data. The relational model is now generally accepted as the most appropriate

approach to highly disciplined data management. According to Martin (1988, p. 142), the basic premises of the relational data model are:

- users find it easier to understand data organized as tables than as a hierarchical model (the more traditional structure of data bases); and,
- relationships between and among data need not be determined in advance and pointers to data need not be preset to allow navigation of the data base, as are necessary with a network model.

Implementation of the relational data model approach results in the availability of a high-level data retrieval and manipulation language (such as SQL) that shields the user from data formats, access methods, and concerns regarding storage management. These nonprocedural, set-oriented query languages rest on a relatively simple conceptual structure. The relational model is gaining wide acceptance as the most suitable for end users because its basic formulation is easily understood, and its tabular data structure is obvious, intuitive, and appealing to a much wider audience of users.

The relational approach is based on pioneering work by E. F. Codd (1990) during the 1970's and 80's. Codd's relational model is a reflection of the existence of basic logical structure and relationships within data, and rests on a mathematical foundation for data descriptions based upon the theory of relations). These models define files in terms of such relationships and, as such, have a fundamental simplicity (Chorafas, 1989). A relational data base may be perceived by the user as a collection of two-dimensional tables. A table (also called a file or entity) contains an unordered set of rows (also called records or tuples). Each table has the same number of columns (attributes, or fields of data) in each row, with each column defined as being in its most basic form and incapable of further subdivision. Column entries in a row can be thought of as fields of data; with each row representing individual observations of these attributes (or data fields). Rows in an entity are uniquely identified through the use of a primary key for that entity. This key is an attribute or combination of attributes such that the value of this key in each row uniquely identifies that row. Another way of viewing these concepts include defining an entity as an object or set of objects that exist in the real world, and an attribute as one of the properties of the entity. In general, entities represent a person, place, thing, event, or concept about which organizational data are recorded. According to Ross (1990, p. 173), an entity can be thought of as any business object that has the following properties:

- exists and can be named,
- is necessary to accomplish the business mission,
- has enduring information value to the organization,
- has describable properties,
- is structured in a predictable form,
- has instances or occurrences that can be distinguishable from another, and
- possesses a set of one or more unique identifiers that set the entity apart from others.

Additional properties of entities are:

- attributes describe each entity in a structural and logical manner,
- each occurrence of an entity potentially has a value of each of the attributes defined for that entity, and
- attribute values need not be unique across occurrences of the entity.

In addition to the basic entities themselves, there are also relationships that link entities together; that is, relationships that associate specific groupings of data. These relationships should be thought of as bidirectional;

they imply association between entities in both directions. Keys are used in the process of associating entities. The primary key of an entity becomes a foreign key in an entity to which it is related.

1.4 The Logical Design Process

The logical data design process employs diagrams to assist designers and end users in the visualization and evolution of the modeling process. These visual aids assist in the diagramming and representation of the entity types and relationships among the entities, and are commonly called entity-relationship diagrams (Chen, 1976). The entity-relationship diagram is an object-based, rather than a function or process-based, representation of a static view of the business. The overriding emphasis in entity-relationship modeling and diagramming is on simplicity and readability (Teorey, 1990, p. 267). It is the tool used to represent the conceptual organization of data at the highest level. The logical entity-relationship diagram is used as a communication tool between the various users of data and the designer. It is independent of the DBMS and computer hardware environment, and simply depicts data and their relationships. For its use as a communications tool between developer and end user, the entity-relationship diagram is usually at a presentation level of detail depicting a first-cut, most basic form for the entity model of the enterprise. The detailed logical model, with its high-level representation depicted in an accompanying entity-relationship diagram, is the blueprint for data-base implementation.

Unless controlled, system designers tend to design data bases that group collections of data into any form that they perceive as useful. All types of anomalies can arise because of inappropriate grouping of data items. These anomalies are often subtle and difficult or impossible to perceive; especially in very large and complex systems.

The logical-design process is a structured approach to data-base design that employs principles of rigorous data analysis. Logical design is a modeling process whereby the microworld of the business enterprise is represented in the data model. One of the basic tenets in the logical design process is the perception and analysis of the detailed structure of data independent of processing logic. The processes used by the designer to get from the verbal description of the business model to an implemented, quality data base is the key to the success of that data base. Data modeling should reflect close interaction between system designer and end user. This design process proceeds from a very high-level conceptual view of the business enterprise, into successive refinement of this high-level model, into detail sufficient to achieve agreement between user and developer. This detailed interaction between user and developer can result in users acquiring a clearer view of their business world. Handled properly, this process results in the users determining the quality of the final data base.

Logical data modeling is an art, not a precise science. A variety of techniques should be used to determine what information is required for the design and how to get that information. The goal of the NWIS-II Design and Development Team has been to collect sufficient information about WRD business and discipline activities to fully understand the data, its relationships, and the functional requirements of day-to-day WRD business activities. The need for clarity in the relationship between users and designers has been paramount, and the use of computer and data-base jargon and terminology has been kept to a minimum. As the modeling process progresses, and both user and designer become more familiar with the data, the organizational processes, and the design atmosphere, the language used should gradually become as applicable to the real business world as to the data model itself.

Logical modeling, a highly iterative process, can be structured in several different ways:

- the top-down approach, where business functions are separated and decomposed using a process of stepwise refinement in detail of each function;
- the bottom-up approach, where basic data and groups of data are collected into decreasing levels of complexity and detail; or
- a combined approach, which starts at the top and defines major business themes (homogeneous user/ discipline groupings), using stepwise refinement to decompose functions and data needs. This method uses the bottom-up approach as a check in creating entity-relationship diagrams and detailed data dictionaries.

In general, the NWIS-II design has followed the combined approach in developing the high-level Logical Data Model described in this Systems Requirements Specification. While the use of different data modeling techniques might result in model descriptions and pictorials that appear to be different, each model can produce desired and correct results. An important component of the logical design process has been the development of a data dictionary. Over the life cycle of the data base, the data dictionary will become an indispensable component of the data base and the computing resource. The data dictionary is the single source for identification and localization of data distributed throughout the data base. Over the data-base life cycle, the data dictionary begins life as a passive repository of acquired information about data requirements during the logical design phase, and gradually becomes the active catalog, repository, and controller of all data definition and data-processing information in the implemented data base; in intimate link with the DBMS. The final active dictionary is maintained by the DBMS as tables are created, altered, or destroyed, and consists of DBMS system catalogs, information about structure and size of the data, indexes, access permissions, and integrity constraints. A comprehensive dictionary will also include cross-reference information showing, for example, which applications programs use which pieces of data, which users require which reports, which programs and/or users are likely to be affected by some proposed change to the system, what terminals are connected to the system, and so on. During data-base implementation, the data dictionary will be used to drive automated code generators, which assist in the actual construction and population of the data base itself.

Just as functional requirements give detailed information beyond user concept diagrams, the data dictionary gives data-model details beyond the data structure or entity-relationship diagram level. The data dictionary will become an information system in its own right, containing information about the data within NWIS-II -- more precisely, detail about the elements in the data base (Date, 1990). However, a data dictionary differs from a data base. While a data base contains actual values <u>for</u> an attribute, a data dictionary contains detailed information <u>about</u> that attribute. In the nomenclature of the data dictionary, this information about data is sometimes called metadata.

A data dictionary helps establish and maintain correct data with minimum redundancy, controls data usage, and acts as a central control mechanism. An integrated data dictionary helps to ensure that data descriptions are stored only once, and that direct access to data in the data base is provided only through this controlled dictionary. The ideal data dictionary supports:

- the conceptual model,
- the logical model,
- physical integration with the data base,
- various versions of documentation associated with the data base,

- efficient transfer of information (both internal to the physical data base and external between developers and users), and
- reorganization of production versions of the data base.

Regardless of which method or modeling approach is chosen, the primary focus of the logical design process is to define business data requirements and function in its simplest, or most primitive form. The basic goals of this design process are to reduce data redundancy and to provide eventual stability and flexibility in the design. Creating the high-level model is only one part of data modeling. Iterative refinement, development, and evolution of this high-level model will result in a data base that is stable, flexible, and easy to use; and has acceptable performance.

2. The NWIS-II Logical Data Model

The NWIS-II Logical Data Model is the result of a process of determining the fundamental conceptual data structure needed to support the hydrologic information resources of WRD in its day-to-day business. In the software development life cycle, this logical data-base design process encompasses the Initiation and Requirements Analysis Phases. During the Initiation Phase, the context and boundaries of the NWIS-II development effort were defined, and the scope, priorities, and initial requirements were established. The Requirements Analysis Phase involved the integration of the data requirements of a diverse group of end-users, represented by the eight discipline-specific User Groups. This highly iterative integration process is now nearly complete, and will continue until the Logical Data Model is baselined at its lowest level of detail. From the requirements analysis, the Logical Data Model has evolved. The decomposition and integration of user functional requirements, as described in the Functional System Specification in the previous chapter, was conducted concurrently with the development of the logical data model.

2.1 Objectives

The objectives of the logical data-base design for NWIS-II are consistent with those defined by the National Bureau of Standards (Fong and others, 1985), to develop a Logical Data Model that is:

- Independent of the hardware and software environment within which it is implemented, so the model will remain relevant, even if the supporting hardware or software changes.
- Independent of the implementation data model and DBMS, so the design will apply to any present or future data model or DBMS.
- Comprehensive in supporting all present and anticipated hydrologic WRD applications, to avoid costly system alterations in the future.
- Able to satisfy the hydrologic information requirements of all of WRD, encompassing all possible applications, so the data model and subsequent data base will be a comprehensive information resource.

The implications of producing a high-quality Logical Data Model for NWIS-II with these characteristics are significant, in that it describes only the required data objects and the logical relationships between those objects. It does not describe the physical structure of the implemented data base, and therefore has no implications as to how the data base will provide the required functionality. Later in the Design Phase, during the physical design of the data base, the Logical Data Model will be adapted to the particular hardware, software, and DBMS implementation environment to form the physical data-base schema. The procedures to complete the NWIS-II data-base design,

including validation and normalization of the Logical Data Model, its adaptation to the physical data-base schema, and optimization of the physical data base are discussed later in this chapter.

The NWIS-II Logical Data Model has been designed to ensure that efficiency, consistency, and integrity are supported in the data structure underlying the NWIS-II data base. In addition, it is robust to allow for the adaptation of the data structure in response to changes in the hydrologic information requirements of WRD. While the logical data-base design for NWIS-II is a massive undertaking, and its short-term cost has been considerable, the long-term benefits of better information and flexibility will provide substantial savings over the NWIS-II life cycle.

2.2 Components of the Logical Data Model

As presented in this document, the NWIS-II Logical Data Model is composed of two closely interrelated components: an entity-relationship diagram and an annotated entity list. Although both of these components provide valuable information independent of the other, they are most effectively used together in a complementary manner.

The fundamental framework of the NWIS-II Logical Data Model is represented by the entity-relationship diagram, illustrated in Figure 22. In the context of this document, we distinguish between the entity-relationship diagram and the actual NWIS-II Logical Data Model that it graphically represents according to the usage given by Date (1990): "An entity-relationship diagram constitutes a technique for representing the logical structure of a data base in a pictorial manner. As such, it provides a simple and readily understood means of communicating the salient features of the design of any given data base. In a sense, an entity-relationship diagram is an abstract data-base design. If we attempt to map such a design into the formalisms of a specific DBMS, however, we will soon discover that the diagram is still somewhat imprecise in certain respects and that it still leaves a number of details unspecified."

In reality, the entity-relationship diagram is both a mechanism for communicating that the NWIS-II Design and Development Team understands the data requirements of the end users and a tool for developing the Logical Data Model itself. In developing the entity-relationship diagram for this document, an emphasis was placed on simplicity and readability. Paramount to this emphasis was the selection of an appropriate level of detail of entities and relationships between entities. An entity-relationship diagram containing the hundred or so entities in the detailed NWIS-II Logical Data Model would be far too complex and incomprehensible to the average reader. Instead, a relatively high or "presentation" level of detail is used, which shows the major entities and entity groups, with selected lower-level details shown as examples of entity-group contents. As suggested by Ross (1988), "a model at a lower level of detail is generally too detailed for communication to be effective. Consequently, there is a need for conversion of such a model to some higher level, where only the more basic objects (and less detail) are represented."

Additional lower-level details of the NWIS-II Logical Data Model, beyond those illustrated on the entity-relationship diagram, are listed in the annotated entity list in Appendix J. For each high-level entity shown on the entity-relationship diagram, the annotated entity list contains a detailed description, a comprehensive list of all

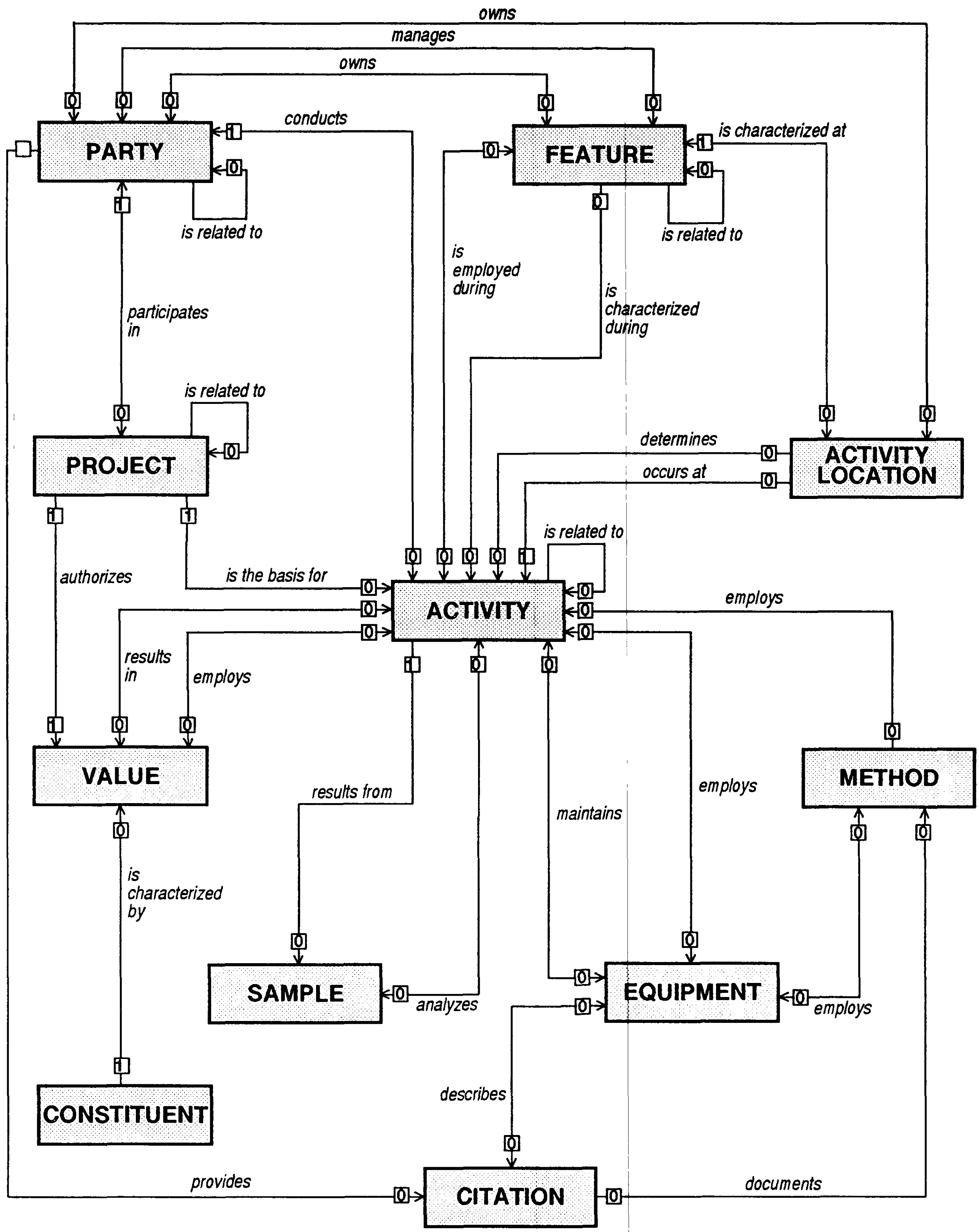


Figure 22.-- High-level entity-relationship diagram representing the National Water Information System II logical data model.

relationships with other high-level entities, and a detailed decomposition list. The decomposition list contains the low-level entities resulting from the decomposition of the high-level entities. This list includes subtype (characteristic) entities and association entities, and a description of each of these decomposed low-level entities. All of the information contained in the annotated entity list is included in the NWIS-II data dictionary, currently under development.

2.3 Description of the Logical Data Model

The high-level entity-relationship diagram representing the NWIS-II Logical Data Model contains 11 high-level entities or "entity groups" as illustrated in Figure 22. Each of these high-level entities decomposes into a number of low-level entities.

Fundamental to the NWIS-II Logical Data Model is the concept of the "activity" entity group. During the analysis of the NWIS-II data requirements as described in the User Group requirements documents, it was realized that a commonly recurring theme was the need to store information about the date and time, persons, project, methods, and equipment associated with the collection of hydrologic data. From this recurring requirement, resulting from the need for improved quality of hydrologic information in the new NWIS-II data base, the concept of the "activity" entities was borne. Through iterative data-requirements analysis, 12 types of activities have been identified as low-level entities in the NWIS-II Logical Data Model, as listed in Appendix K. These activity entities are central to the philosophy of the model, which has been developed from the perspective of the hydrologic business activities conducted by WRD in support of its mission.

To provide the hydrologic information and understanding required for the wise management of the Nation's water resources, WRD conducts a number of high-level activities in direct support of this mission. Some of these activities are outside the scope of NWIS-II, such as personnel and property management, payroll, accounting, and contracting. Those activities within the hydrologic realm, however, are within the scope of NWIS-II and the information requirements of these activities must be supported by the new system. These activities include the characterization of natural and man-made features; the collection, processing, and analysis of samples; and the analysis and interpretation of hydrologic data. In addition, in support of these activities, WRD conducts a number of lower-level activities. These types of activities are low-level entities in the NWIS-II Logical Data Model.

The activity entities are related to most other entities in the Logical Data Model, and in fact, are the "glue" that hold the model together. It is only through the occurrence of an activity that much of the other information in the data model is related. The characterization of a feature, for example, may involve the direct measurement or observation of a property of that feature. In this relatively simple example, the *value* resulting from the feature measurement *activity* characterizes the *feature* at a particular *activity location* where the *activity* occurred. The *value* itself is characterized by a *constituent*, which indicates the specific property of the *feature* that the *value* characterizes. The *equipment* and *method* employed during the feature measurement *activity* are also related to the *activity*, as are the *party* that conducted the *activity* and the *project* upon which the *activity* was based. The *equipment* is described and the *method* is documented within *citations*.

A somewhat more complex example of the characterization of a *feature* might involve the collection of a *sample* of the *feature*. Sample collection is another type of *activity* in the NWIS-II Logical Data Model. A sample collection *activity* results in a *sample*, which may subsequently undergo sample preservation and/or preparation. During these types of *activities*, new *samples* may or may not be created. A sample analysis *activity* results in a *value*, which characterizes the *sample* or the *feature* from which the original *sample* was collected. All of these *activities* also have relationships to *party*, *project*, *method*, and *equipment*, just as the feature measurement *activity* in the simpler example above.

2.4 Navigation of the Entity-Relationship Diagram

The relationships between high-level entities are illustrated on the entity-relationship diagram and included in the annotated entity list. The degree of each relationship, also known as its cardinality, may be inferred from the diagram by the symbols at the ends of each relationship line. A relationship line that terminates at an entity without an arrowhead indicates that there is a maximum of one occurrence of that entity per occurrence of the entity from which the relationship originates. An arrowhead is indicative of many possible occurrences of the entity at the end of a relationship for a given occurrence of the entity from which the relationship originates. The boxed number (zero or one) near the end of a relationship line indicates the minimum cardinality of a relationship, or put another way, whether the relationship is optional or mandatory. A zero is indicative of an optional relationship. An optional relationship means that a given occurrence of the entity from which a relationship originates does not require a corresponding occurrence of the related entity. Conversely, a number one indicates a mandatory relationship, in which a given occurrence of the originating entity requires at least one corresponding occurrence of the related entity. Additional details on the navigation and interpretation of entity-relationship diagrams may be found in Chen (1976).

3. Completing the NWIS-II Data-Base Design

Prior to actual implementation of the NWIS-II data base, it will be necessary to complete the logical design and adapt it to a physical data model. This is a highly iterative process, and considerable prototyping and testing of various physical data models will be necessary. The following sections detail the procedures to be employed prior to implementing the NWIS-II data base within the target hardware, software, and DBMS environment.

3.1 Completing the Logical Design

One of the difficulties in creating a logical data model is knowing when the model is complete and correct; and when actual construction of the data base should commence (Inmon, 1990). For any given data requirement, there are many possible logical models, with each resultant model providing a complete and accurate solution which fully satisfies the data requirements. The iterative process of logical data design and creation of the entity-relationship diagram will evolve to a stage where verification and validation processes are applied in order to assure that the model is complete and correct. These procedures which comprise verification, validation, and initial construction of the data base mark the transition between the logical design phase and the physical implementation of the design. Latter stages in the process of completing and validating the Logical Data Model consist of three parts:

- Checking that all data requirements have been met. This process includes completing the data dictionary and preparing an accompanying entity-relationship diagram(s).
- Checking that all entities (tables) are normalized. The process of normalization represents a procedural method for checking that the entities are properly constructed. Normalization ensures no unnecessary duplication of data that would make updating the data base difficult; that is, to minimize maintenance of the data base. Normalization is especially useful for analyzing a logical model, as the process forces an intimate analysis of each entity. Normalization is a structured process that proceeds according to well-defined algorithms that define increasing levels of normalization or "normal forms." Malamud (1989, p. 271-272) provides a general description of the first three normal forms. An entity (table) is in first normal form if all occurrences (rows) contain the same number of attributes (columns) and if each column in the table represents a single-valued property of the table. First normal form ensures that there are no repeating data items or groups of data items in the table. A table is in second normal form if it is in first normal form and each nonkey column depends, directly or indirectly, on the primary key (where the primary key is an attribute or combination of attributes that uniquely define an occurrence of the entity). A table is in third normal form if it is in second normal form and each nonkey column depends on the entire primary key and nothing but that key. Although additional normal forms have been described in the literature, normalization of Logical Data Model is considered complete when all entities are in third normal form.
- Rechecking that all entities have the necessary keys; both primary and foreign.

Unsatisfactory data-base design may cause many deficiencies in performance and applications of the data-base. Poor data quality, overly complex programming logic, cumbersome user interfaces, and difficult querying and reporting are some of the problems associated with a poor logical design. Because logical design flaws are not always obvious, developers often try to solve these problems by modifying the code of applications programs. This produces unsatisfactory results and the design remains unsound. Possible deficiencies in logical design underscore the importance of prototype testing during subsequent physical design and implementation of the data base.

3.2 Physical Design and Implementation

Physical design of the data base comes last. The data dictionary will provide a number of services in the actual construction of the physical data base, such as automatically defining the logical data structure in the actual data-definition language of the DBMS and providing needed data descriptions to applications programs. Using some basic assumptions about the physical data-base environment, the designer can make refinements to the logical model that will improve performance of the data base. In general, during physical implementation the designer has the option to pick one of the many normalized forms of the data-base tables, cluster records within a table, cluster related record types together, specify keys for faster access to individual data, define secondary indexes for access to nonkey attributes, and specify physical aspects of how data are stored, accessed, and recovered. In essence, physical data-base design involves implementing the logical design by creating indexes, specifying physical locations, structures, and block sizes for data, and changing or combining tables (Finkelstein, 1990).

Performance deficiencies can be analyzed through selective prototyping or sampling typical data-base activities such as retrieval, update, and reporting functions. This prototyping can take such form as sampling typical queries

by user discipline, and analyzing the order and groupings of table reads and writes. In solving such performance problems, CASE software tools can assist in creating data-flow diagrams, reworking of specifications and extended entity-relationship diagrams, and rapid restructuring of physical data-base structure.

Isolating performance problems during physical implementation can involve analyzing data-access paths and process flows (sometimes requiring some revision in logical design to discover other feasible solutions), or introducing controlled redundancy (denormalization). Selective denormalization can reduce calculation requirements, code complexity, and the number of tables required to be combined to satisfy a data-base query. Some DBMS environments include tools and techniques for query optimization or structured analysis of query plans. Other performance improvement techniques might include detailed analysis of dominant processes (such as frequency of table access or table join complexity) to determine those data-base modifications most likely to improve performance. Analysis of attribute data types and table storage structures, as well as index redesign and separation (subtyping) or combination (pooling) of entity tables, can provide improved performance, additional functionality, and reduce retrieval time. Data-base applications that require complex boolean queries also may require some sort of secondary indexing capability.

Other important factors associated with physical design and implementation include deciding whether the final design will encompass a single integrated data base or a logically integrated but physically distributed design. A well-implemented distributed computing environment can decentralize information processing. Decisions regarding distributed computing will have two components: distributed data and distributed applications. With distributed data, applications can transparently access information in remote files as if it were in local files. With distributed applications, programs can be partitioned into procedures that are executed on several remote server computers. Decisions regarding distributed data bases can be highly dependent on the sophistication and capability of the DBMS and computing environment.

The physical design process is an engineering problem where trade-offs are necessary to achieve acceptable performance. It is unlikely that there is any one optimal physical design for very large and complex data-base problems. The basic tasks of physical data-base design involve prototype testing procedures and the isolation of performance problems using the previously described techniques.

3.3 Populating the NWIS-II Data Base

Once the NWIS-II data base is physically implemented within the target hardware, software, and DBMS environment (that is, the physical schema have been created and initial storage structures for each table have been established), the data base will be initially populated with data. These data will come from a variety of sources, both within and outside of WRD. Data existing in electronic format will be reformatted and copied into the NWIS-II data base via ASCII flat files. Data not presently in electronic format will be input into the data base via keyboard entry, scanning, or other appropriate procedure. Much of the data now existing in WRD data bases and information systems, such as NWIS, will be transferred into the NWIS-II data base. The plans for the transfer of these data are discussed in the next chapter.

SYSTEM REQUIREMENTS SPECIFICATION FOR THE U.S. GEOLOGICAL SURVEY'S NATIONAL WATER INFORMATION SYSTEM II

CHAPTER 5. DATA TRANSFER DESCRIPTION

L.E. Lopp and M.L. Clark

1. Introduction

The principal responsibility of WRD to provide hydrologic information in the past relied on information systems and data processing supported by centralized computing resources of the USGS. Through 1983, the Division used five major systems, which have evolved over the years in a batch processing environment. The key sources of data were the Master Water Data Index (MWDI) and Water Data Sources Directory (WDSD) of NAWDEX, the National Water Data Storage and Retrieval System (WATSTORE), the National Water-Use Data System (NWUDS), and the State Water-Use Data System (SWUDS). In 1983, WRD established the National Water Information System (NWIS), hereafter referred to as NWIS-I, for the processing and dissemination of hydrologic information as part of the Distributed Information System (DIS). NWIS-I consists of four subsystems, the Automated Data Processing System (ADAPS), the Ground-Water Site Inventory (GWSI), the Water-Quality System (QW), and the Water-Use Data System (WUDS). The WUDS has two subsystems: the Site-Specific Water-Use Data System (SSWUDS) and the Aggregated Water-Use Data System (AWUDS). A system encompasses data and software and is defined as the combination of systems of data and systems of application software to process water data and water-data indexes. The processing solves particular problems for the user. When the word data is used, it will refer to water data, distinguishing it from index data.

The transfer of data to the National Water Information System II (NWIS-II) is concerned with two major types of data: water and index. The water data incorporates most of the data stored in WATSTORE and NWIS-I. The index data incorporates the site and areal indexes within the Master Water Data Index (MWDI). This chapter of the System Requirements Specification (SRS) defines the requirements for transferring data from current systems to NWIS-II. Before defining the requirements, there will be a discussion of the current processing of water data in WRD, a list of questions about the alternatives for data transfer, a District user-survey about the alternatives, and recommendations for data transfer developed from evaluating the alternatives and the survey. The last part of this chapter will describe the current data systems designed for transfer to NWIS-II.

2. Current Processing of Water Data

WRD is currently processing water data using two distinct and dissimilar systems: NWIS-I and WATSTORE. Dissimilarities between NWIS-I and WATSTORE exist because of changing user requirements between the early 1970's with the implementation of WATSTORE, and the mid-1980's with the implementation of NWIS-I. Between approximately 1984 and 1986 data processing within the WRD was in transition from centralized processing on a mainframe to distributed processing on minicomputers. Each district retrieved its data from the centralized WATSTORE files for storing in corresponding NWIS-I files for local edit and update within the district office. Table 9 lists the data that were downloaded from WATSTORE to NWIS-I.

Table 9. – Data downloaded from WATSTORE on the mainframe to NWIS-I on the minicomputer.

WATSTORE FILE		NWIS-I FILE
Station Header		Site File (SITEFILE)
Ground-Water Site Inventory		Ground-Water Site Inventory (GWSI)
- (no data to download)		Site-Specific Water-Use Data System (SSWUDS)
Daily Values		Daily Values (DVFILE)
Unit Values		- (no data downloaded)
Water Quality		Water Quality (QWFILE)
Agency Codes		Agency Code File
Parameter	-Codes	Parameter Code File (PARMFILE)
	-Algorithms	Algorithms File (ALGFILE)
	-Fixed Values	Fixed Values File (FVFILE)
	-Taxonomic Codes	Taxonomic Code File (TAXFILE)
FIPS Codes		FIPS File (FIPSFILE)
Geologic Unit Codes		Aquifer Code File (AQFILE)
Hydrologic Unit Codes		Hydrologic Unit Code (HUC)

According to WRD Memorandum No. 88.01, NWIS-I data are to be uploaded at least monthly to the national system, WATSTORE. WATSTORE was not modified nor designed to handle an automatic entry or update of data from NWIS-I. It has provided additional, sometimes redundant, editing of data from NWIS-I with extensive output and errors not easily detected. NWIS has evolved into a system with more functionality than was originally within

WATSTORE and the data associated with this functionality cannot be uploaded to the national system. The goal for data concurrence between the district and national data bases is no longer possible. The goal of NWIS-II is to integrate all data and processes to one system. Several questions were proposed to help define the requirements for the transfer of data to NWIS-II. The questions are:

1. What is the best source of data for transferring hydrologic information into NWIS-II?
2. What quality assurance and data base compatibility problems need addressing in preparation for transfer to NWIS-II?
3. What verification and validation procedures should control the transfer process?
4. How can national and regional retrievals and data sharing best be performed?

During review of the User Group documents for user requirements, there was little discussion addressing the above questions. Dissimilarities of the two data systems, uncertainty about the status of data and data-processing between NWIS-I and WATSTORE, and lack of definition in the documents for data transfer prompted further investigation.

On August 22, 1990, a questionnaire for the district users was sent via electronic mail and postal mail to all District Chiefs. A total of 45 districts and subdistricts responded to the questionnaire; not all responding to each question. The questionnaire contained questions about data base comparisons between NWIS-I and WATSTORE, data base management within their specific district, and the national data base for NWIS-II. The user requirements for data transfer are partially defined from a compilation of the responses to the August 22, 1990, survey. Listed in Figure 23 are the primary questions of the survey divided into three categories; each question followed with the number of districts answering yes or no, or a brief summary of explanations.

Further investigation for data-transfer requirements was conducted. The questionnaire was followed by verbal and written communication with selected District personnel for a preliminary assessment of NWIS-I and WATSTORE. Combining the responses to the questionnaire with the assessment of the major sources of data (NWIS-I and WATSTORE) recommendations were presented by the NWIS Program to the SPG. The recommendations in Figure 24 have become the user requirements for the transfer of data to NWIS-II.

DATA BASE COMPARISON

1. Have you ever compared your NWIS-I data with your WATSTORE data?

- 41 Yes
- 4 No

2. Did you use any of the following programs?

- 30 Yes

a) COMPARE (water-quality data)

- 19

b) DIFWAT (daily-values data)

- 17

3. What other programs or techniques have you used?

- Programs by P. Conrads, J. Gordon, F. Wells,
- T. Liebermann, D. Goolsby, and others.
- Manual comparisons and annual totals.
- Monthly statistics, DV inventory, and geographical plots.
- Fortran to compare by data elements, with SSWUDS.

4. Have you completed the data comparison AND made the necessary updates to make NWIS-I and WATSTORE data the same?

- 20 Yes
- 21 No

5. If so, did you run the comparison again?

- 14 Yes
- 6 No

6. How successful were the updates to WATSTORE and what problems were noted?
Please explain.

- GWSI: edit checks are different from NWIS-I, components with component numbers greater than C700 do not exist inWATSTORE.
- Daily values and water quality relatively trouble free; rounding errors.
- Header file: no header records, locator mismatch, no collecting or analyzing agency code.
- Combined site records in NWIS-I with mismatched locator and sequence numbers.

Figure 23. -- Questions and responses to a survey about transferring data to the National Water Information System II.

7. Do you think that data in your NWIS-I data bases should be checked prior to a transfer into NWIS-II?

- 38 Yes
- 7 No

8. Would your District attempt to clean up all of your existing data without any Division-supplied software?

- 18 Yes
- 27 No

9. Do you prefer to (A) transfer all existing data to NWIS-II and then check and validate the data using a more versatile and complete NWIS-II data base?

OR

Do you prefer to (B) transfer into NWIS-II only data passing certain automatic checking and filtering programs, with remaining data set aside to manually check and edit for later data base entry?

- 22 A
- 23 B

DATA BASE MANAGEMENT

1. What year did you install the following subsystems of NWIS-I? Most districts answered:

- ADAPS —1986-88
- GWSI — 1985-88
- QW — 1984-86
- SSWUDS — N/A or 1988-89

2. Did you download all of your District's data to the NWIS-I subsystems at the initial installation of the software? 25 Yes

- ADAPS (Daily Values) — 19 No
- ADAPS (Unit Values) — N/A
- GWSI — 3 No
- QW — 4 No
- SSWUDS — N/A

3. Do you plan to move that data from WATSTORE on the Amdahl to NWIS-I on the Prime before the implementation of NWIS-II in 1992?

- Daily Values — 6 Yes, 13 No
- QW — 4 No

Figure 23.--Questions and responses to a survey about transferring data to the National Water Information System II—Continued.

•GWSI — 3 No

4. Do you have special project data in NWIS-I that must exist ONLY within your District?

- 26 Yes
- 19 No

5. What should be done with data in WATSTORE on the Amdahl that may exist with invalid or missing downstream order numbers (invalid or nonexistent latitude/longitude sequence numbers)?

Delete all records?

- 7 Yes
- 38 No

Output the data in card-images to tape for edit/entry to NWIS-I?

- 27 Yes
- 18 No

Create a dummy site-identifier for later data base load and edit to NWIS-II?

- 13 Yes
- 32 No

Other:

- 12 Yes
- 33 No

Output the data to tape for edit/update to NWIS-II; create an index, flagging the problem data; and distribute the data (delete from the national data base) to the districts to make the corrections and reenter at their level. Any data that cannot be matched to a district should be deleted.

Figure 23.--Questions and responses to a survey about transferring data to the National Water Information System II—Continued.

NATIONAL DATA BASE

1. Do you ever retrieve data of other districts, for example, project work, regional analysis, or cooperator requests?

- 41 Yes
- 4 No

2. If YES, please estimate how often:

- (more than 5 per yr) 14
- (1-5 per yr) 27

3. Are the retrievals from WATSTORE or from multiple NWIS-I sites?

- From both systems: 21
- From WATSTORE only: 9
- From NWIS-I only: 11

Figure 23.--Questions and responses to a survey about transferring data to the National Water Information System II—Continued.

The following information was received as verbal or written communication from district personnel. Essentially the data in NWIS-I on the Prime and WATSTORE on the Amdahl exist in different levels of completeness:

- Site File (Station Header File) -- During the conversion of WATSTORE to NWIS-I, site data from WATSTORE-GWSI were merged with site data from the WATSTORE Station Header file. This conversion process resulted in producing a site file with many "new" sites in NWIS-I, which were not in the WATSTORE Station Header File. When districts entered automatic-digital-recorder or water-quality data for these "new" sites, the update within NWIS-I was successful. But when the software updating data from NWIS-I to WATSTORE attempted to enter the water-quality data; for example, the update failed because a valid entry in the Station Header File on the Amdahl did not exist. Another problem with updates from the Site File to the Station Header File exists because the merge of site records during the conversion caused additional fields to be added to the Site File record structure in NWIS-I that had no match in the WATSTORE Station Header File.

- Ground-Water Site Inventory File -- The GWSI System in NWIS-I also contains data more complete than WATSTORE. The explanation for lack of concurrence between systems is very similar to that of the Site File: problems with update software and differing record structures between systems.

- Water-Quality File (Quality of Water File) -- Not all Districts have retrieved and stored the complete period of record of the water-quality data in NWIS-I, some data still remain in WATSTORE. Updates to the WATSTORE file equivalent of NWIS-I were not successful because backfile data were not accessed properly and the site

identification numbers entered or updated in NWIS-I were not updated in WATSTORE. If a site record in the Station Header File was updated and none of the sites ID's in the Water-Quality file were updated, that data would appear lost because the site of that data was no longer valid. The water-quality record header in NWIS-I also contains additional data elements, for example project number, which are not part of the water-quality record header in WATSTORE.

- Daily Values File (Daily Values File - ADAPS) -- Not all Districts have retrieved and stored the complete period of record of the daily values in NWIS-I, and like the water-quality problem, NWIS-I updates to site records in WATSTORE do not automatically update the site ID's in the daily values data. Again, this would make data non-retrievable because of no matching site record in the Station Header File, a requirement for retrieving data in WATSTORE.

- Unit Values File, Rating, Shift, Datum-Correction Files, and other files -- ADAPS in NWIS-I has no software to update the equivalent files in WATSTORE for shift and datum-correction, and need not update the unit values except for the most current year as the most historical data is purged from WATSTORE. Other files, such as the instrument, the processor, and data-descriptor files exist only in NWIS-I and are not necessary for processing within WATSTORE.

- Water-Use -- There is no WATSTORE equivalent of the Water-Use Data System (WUDS). The NWUDS data in WATSTORE were not downloaded to NWIS-I, and NWUDS in WATSTORE is no longer available. All site-specific and aggregate water-use data are in NWIS-I on the Prime.

On October 24, 1990, the NWIS Program recommended to and received concurrence from the Strategic Planning Group to designate the list in Figure 24 as the major requirements for the transfer of data to NWIS-II.

- NWIS-I will be the primary source of data for NWIS-II.
- The national NWIS-II data base will be an aggregation of district NWIS-I data bases.
- MWDI-type indexes will not be transferred, but will be created during or following transfer.
- Districts should continue updating WATSTORE with NWIS-I data until NWIS-II is available.
- Districts should be encouraged to clean up NWIS-I data bases.
- NWIS-II Design Team will provide guidelines to districts on priorities for NWIS-I cleanup.
- NWIS Program will serve as a clearinghouse for NWIS-I data validation and verification software.

Figure 24. -- Recommendations to the Strategic Planning Group for the National Water Information System II.

2.1 Major User Requirements for Data Transfer

During this phase of specifying system requirements, the requirements for data transfer are general. To accomplish the tasks involved with the transfer of data to NWIS-II, the requirements shall require more planning, analysis, and detailed specifications. Further detailed specifications and discussion are planned for two future documents for data transfer: The Transfer Plan and Transfer Specifications.

Requirement TR-1 NWIS-I will be the primary source of data for NWIS-II.

There are four sources of data for transferring hydrologic information into NWIS-II: NWIS-I, WATSTORE, MWDI, and WDSD. NWIS-I will be the primary source and WATSTORE the secondary source for those data that do not exist in NWIS-I. Some data will be transferred exclusively from one of the sources and other data will be aggregated from both or all four sources. Data that exist only in NWIS-I:

- Site-Specific Water Use
- Aggregate Water Use

will be transferred from NWIS-I. Data that exist only in WATSTORE:

- Peak Flow
- Stream Flow and Basin Characteristics

will be transferred from WATSTORE and some may be re-created. Data that exist only in the MWDI and WDSD:

- Non-WRD site and descriptive data
- Data indexes

will be transferred from MWDI and WDSD, and some may require reentry by non-WRD agencies. The MWDI-like indexes will be created during or following the population of the NWIS-II data bases within each district and aggregated for national equivalent.

For data that can exist in both NWIS-I and WATSTORE:

- Daily Values
- Unit Values
- Water Quality
- Ground Water

the NWIS-I data will be the most current and will be transferred exclusively from NWIS-I to NWIS-II. The one exception is the daily-values data; these data need to be transferred in a different way. First, daily-values data will be transferred using a defined-selection process from WATSTORE to NWIS-II. Next, the daily values data will be transferred from NWIS-I to update the daily values in NWIS-II. Four districts responded to the survey as having no plans to move their water-quality data that remains in WATSTORE to NWIS-I. Plans must be made on how to deal with the water-quality data in WATSTORE that were not loaded into NWIS-I prior to NWIS-II.

Requirement TR-2 MWDI-type indexes of WRD data will not be transferred, but will be created during or following transfer as a maintenance function

The index of information, MWDI, as part of the national data base for NWIS-II, may be re-created after the NWIS-I district systems have been transferred to NWIS-II. The design of the national data base for NWIS-II is still in review and awaiting approval from SPG (August, 1991).

Certain site-related data in the MWDI that are not presently overlapping with data contained in the NWIS-I Site File will be transferred to the NWIS-II data base.

Requirement TR-3 Districts should continue updating WATSTORE with NWIS-I data until NWIS-II is available

Two major functions are performed by keeping the national data base, WATSTORE, concurrent with the District data bases. The first is maintaining WATSTORE as the link to the outside agencies with whom WRD exchanges data. Water-quality, daily-values, and peak-flow data are updated monthly to the STORET System of the U.S. Environmental Protection Agency. NWIS-I has no functionality for interfacing with STORET except through WATSTORE. The second function performed through the national data base, WATSTORE, is the indexing of data updated from NWIS-I data bases, and storing these indexes in the MWDI.

Requirement TR-4 Districts should be encouraged to clean up NWIS-I data

To the question about cleaning up the NWIS-I data prior to a transfer to NWIS-II, 38 districts agreed it should be done and 7 districts said it was not necessary. To the question about attempting to clean up the data bases without Division-supplied software, 18 districts answered they would attempt to clean up some of the data and 27 districts said they had no intentions of cleaning up their data without help from the Division. Although NWIS-I will be the primary source of data for transfer, these data have problems with quality assurance, compatibility with other data bases, and various types of discrepancies and errors.

Systematic data review, update, and rereview of the NWIS-I data would be very resource intensive and difficult to complete by the time of implementation of NWIS-II. Some redundancy and inconsistencies found while checking the data could be identified and corrected during a transfer. Another option might be to use artificial intelligence codes to flag data that did not pass the data validation criteria for later review and update (Robert Faye, written commun., 1990). The NWIS-II team plans to investigate other options for cleanup of data for both before and after transfer by the Districts.

Requirement TR-5 NWIS-II Design Team will provide guidelines to districts on priorities for NWIS-I cleanup

The NWIS-II Design Team is preparing guidelines on how to systemically verify and validate data, and how to prioritize this task . Future plans for setting priorities on data cleanup will include three areas essential to preserving the integrity of the data before and during transfer to NWIS-II:

1) Data bases that utilize or will utilize a common site file or files should be checked for duplications, inconsistencies, and incompatibilities.

2) GWSI, QW, ADAPS, and WUDS all have common sites and it is feasible to attempt to make the sites compatible among these systems.

3) Guidelines to the districts also should include a cleanup of the Station Header File and the Daily Values File in WATSTORE to transfer and update daily values from NWIS-I.

Requirement TR-6 NWIS Program will serve as a clearinghouse for NWIS-I data validation and verification software

Supporting software to address data-compatibility and quality-assurance problems may be a compilation of in-house district software that can be distributed to others. Some of the functionality of data validation and verification defined for NWIS-II could be used during data transfer and incorporated into the NWIS-II software.

The Data Management and Operations Unit of the NWIS Program will act as the clearinghouse for data validation and verification software, and may distribute it with the NWIS-I software releases.

3. Current Data Systems

With a large number of data systems existing within the Division, it is necessary to identify and analyze those current systems that would contribute data for transfer to NWIS-II. This analysis will focus on the storage, description, and current status of only water-related data, the data indexes, and water data as minimum data requirements for NWIS-II. At this phase of the NWIS-II development, the data designated for transfer is described according to its physical characteristics. This description includes diagrams of the physical data structure, a data dictionary, and a brief narrative of each file. This chapter will not contain mapping of data from the current systems to the high-level logical model of NWIS-II. The information was compiled from communication with the NWIS-I Data Base Managers, reviewing online documentation of the NWIS-I software, and documentation in the National Water Information System (NWIS), Volumes 1 and 2.

3.1 Physical Data Diagram for National Water Information System I

A high-level diagram of the physical data structure of the current National Water Information System (NWIS-I) was constructed as an overview to help describe data transfer (Figure 22). An entity-relationship diagramming technique was used as a documentation tool to show the physical relationships among files in the NWIS-I system. The data entity types shown on the diagram are files. Files containing one record type are shown on the diagram as entities, and files containing more than one record type are shown as entity groups. The physical relationship between files are shown using the arrow notation. The single-arrow notation indicates the files have a one-to-one relationship, and the single arrow/double arrow notation indicates the files have one-to-many relationship. For a complete discussion of entity-diagramming techniques, refer to the data base requirements section of this document.

The diagram illustrates the existing physical relationships among the ADAPS, GWSI, QW, and SSWUDS subsystems and the Site File. The AWUDS subsystem was not included on the diagram because of its relationship as an aggregate of the SSWUDS subsystem, and it does not directly relate to the Site File. The diagram illustrates that the only link among data in the NWIS-I subsystems is through the Site File and that no sharing of subsystem data files occurs. The file names used on the diagram are the common user names for the files, which generally are indicative of the type of data contained in the file. The user names for the files are cross-referenced to the data dictionary tables for the files.

3.2 Data Dictionary

A data dictionary was created to describe the NWIS-I, WATSTORE, MWDI, and WDSD data systems. The data dictionary provides a mechanism for the collection, storage, and retrieval of information about data entity types. The data entity types for the data-transfer data dictionary are files, records, and data elements. The existing data dictionaries for the systems are contained in several publications or online in a text format, or both. The centralization of the data about the data entity types, or metadata, for these systems into one data dictionary is an important tool for coordination and control for data transfer. The data dictionary will provide a complete data inventory, data definitions, and data descriptions. The data dictionary will also function as a data directory, to describe the location of the data in the current systems and how the data can be accessed.

The data dictionary was used to generate two types of reports for the data-transfer documentation for the current systems. An online appendix, **Data Transfer--File Descriptions**, contains descriptions of the files in a table format and another online appendix, **Data Transfer--Data Element Descriptions**, contains glossary entries for the data elements. These appendixes are not included with this requirements document. The metadata for files included in the tables are:

- the user file name,
- the software system name,
- a brief description,
- a list of the data elements as they occur in the file.

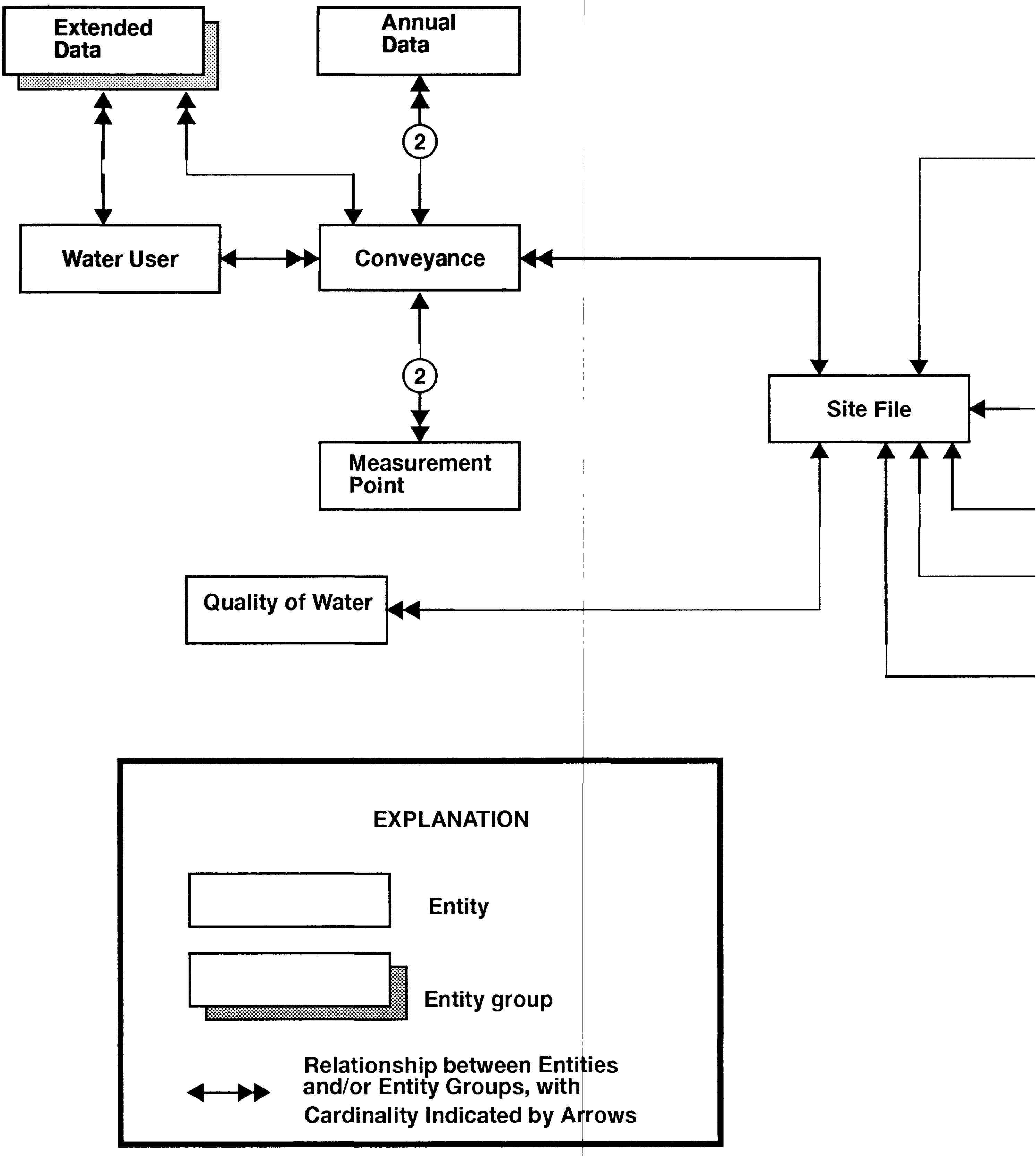
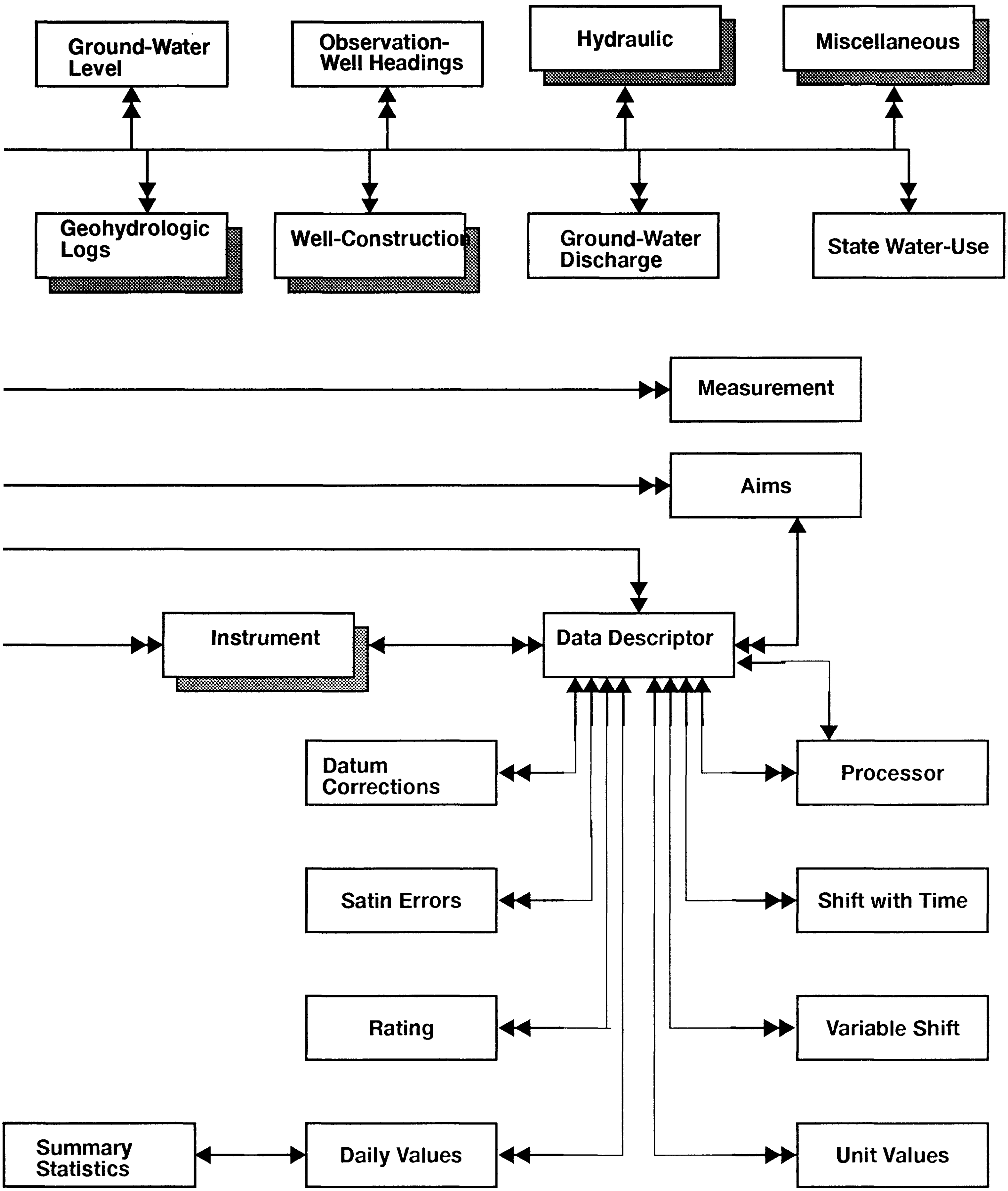


Figure 25. – Physical data diagram for NWIS-I.



Ground-Water Level
Observation-Well Headings
Hydraulic
Miscellaneous
Geohydrologic Logs
Well-Construction
Ground-Water Discharge
State Water-Use
Measurement
Aims
Instrument
Data Descriptor
Datum Corrections
Processor
Satin Errors
Shift with Time
Rating
Variable Shift
Summary Statistics
Daily Values
Unit Values

The metadata for records in the tables are:

- record names
- primary keys for the record
- record length

The metadata for data elements in the tables include:

- data name, as referenced by the program and the data dictionary glossary entries
- 24-character descriptive name
- the format
- length

The data elements in the tables can be cross-referenced to the data dictionary glossaries by the data name for further description. Data dictionary glossaries were prepared for data elements contained in the NWIS-I subsystems, Site File and support files, WATSTORE, and NAWDEX's Master Water Data Index (MWDI) and Water Data Sources Directory (WDSD) files. Data elements in the glossaries are identified by the data name, sorted alphabetically, and include a brief description of the data element as contained in the data dictionary.

3.3 Water Data Systems

The WRD maintains two forms of water data. The first form includes the indexed water data, which summarizes information available from the WRD and other Federal and non-federal agencies. The second form is hydrologic data collected at sites across the Nation, included in the NWIS-I and WATSTORE data systems. The following section provides additional information for the indexed water-data files, the NWIS-I files, and the WATSTORE data files, which have been reviewed to facilitate the transfer of data into NWIS-II.

3.3.1 Data Indexes - Master Water Data Index and Water Data Sources Directory

NAWDEX maintains two main indexing data bases, the MWDI and the WDSD. The data bases are designed to be used independently or in conjunction with one another. The MWDI contains information on the identification and location of sites for which water data are available, the type of data-collection sites, the organizations collecting data at each site, the current status of each site, the types of data available, the period of time for which data are available, the major water-data parameters for which data are available, the frequency at which these parameters are measured, and the media in which the data are available (Perry and Williams, 1982). The WDSD contains information about organizations that collect, store, and disseminate water data and water-related data. This includes: the type of each organization; the major orientation of water-data activities conducted by each organization; the names, addresses, and telephone numbers of offices within each organization from which water data may be obtained; the types of data held by each organization and the geographic locations within which these data have been collected; alternate sources of an organization's data; the designation of liaison personnel in matters related to water-data acquisition and indexing; the volume of water data indexed for the organization, and the information about other types of data and services available from the organization that are pertinent to

water-resource activities (Edwards, 1982). A few components are common in both data bases, allowing retrieved information to be cross-referenced between them.

The MWDI data base is managed and maintained through a hierarchical Data Management System called System 2000. All the data about a single major item comprises a logical entry in the data bases. Individual pieces of information, such as a drainage area or a name of an organization, are known as data elements. Each data element has a unique component number and name in the file. The data are logically grouped into blocks called schema records. A logical entry is composed of one or more schema records, each of which is composed of one or more data elements. A fundamental aspect of a schema record is that the data it describes can occur once, many times, or not at all. The record length is variable and the primary key of the MWDI is the NAWDEX identification number. The schemas contained in the MWDI file include:

- Surface-water site data
- Ground-water site inventory data
- Water-quality site data, including biological, physical, sediment, and chemical data
- Projects data
- Networks data
- Site funding data
- Funding data
- Other source data
- Source information
- Meteorological data

The WDSD was converted from the System 2000 hierarchical data base design to a relational data base design to run on a personal computer. The data base contains 16 files and 4 support files. The primary key linking the files together is the NAWDEX agency code. The 16 data base files include:

- WDORG and WDWRD-- information about the water-related activities of the organization
- WDOFCO--information about the offices of the organization
- WDOFCSD--information about the geographic area covered by the office
- WDOCNTY--information about the counties for which the office has data
- WDOCOM--general information about an office and its data holdings
- WDOSD--information about the number and types of sites operated by the organization
- WDCNTY--identifies the counties in which the organization operates data-collection sites
- WDOS--information about other sources of the organization's data
- WDOSCOM--general information about an other-source organization and its data holdings
- WDMLO--information on individuals within an organization for consultation
- WDLSTAT and WDLNUS--information about geographic areas in which liaison official has jurisdiction
- WDLCOM--general information about the liaison activities
- WDMWDI--information about the number of sites an organization has stored in the MWDI
- WDMCNTY--identifies the counties indexed in MWDI for an organization

The support data base files include the following:

- WDPARAM--cross-reference of parameter codes and their names
- WDSTATE--cross-reference of State codes and their names
- WDCNTRY--cross-reference of country codes and their names
- WDDAT--cross-reference relating agency, State code, and type of site

3.3.2 Water Data - National Water Information System I

The National Water Information System I (NWIS-I) has the major capability for storing and retrieving the most accurate and up-to-date water data collected within the WRD. The NWIS-I is a distributed data system in which data can be processed over a network of minicomputers. The current implementation of the NWIS-I system uses a vendor-supplied software package called MIDASPLUS, the enhanced Multiple Indexed Data Access System, for its file management. With the MIDAS component, data are updated, deleted, and retrieved on the basis of data elements that are specified as key elements. The Command Procedure Language (CPL) feature primarily provides for communication between the computer operating system and user-developed programs. The user-developed programs are written using the FORTRAN 77 (F77) programming language.

The NWIS-I files designated for data transfer are discussed in the following section. The files include:

- Support files
- Site File
- ADAPS files
- GWSI files
- QW files
- SSWUDS and AWUDS files

3.3.2.1 Support Files

The NWIS-I software utilizes eight support files for validating certain data elements. The support files are common to the Site File and subsystems and are utilized during processing. The main support files include the following files:

- Agency Codes
- Aquifer or Geologic Unit Codes
- FIPS State and County Codes
- Hydrologic Unit Codes
- Parameter or Statistics Code
- Taxonomic
- Fixed Values
- Algorithm

Several variations of these files exist; modified at the district level or modified for the subsystem's software. The primary location for these files is on the headquarters Prime computer under the WATSTORE>SUPPORT directory. This directory would be the primary source of data for these files.

The relationships among the support files and the Site File, ADAPS, GWSI, QW, and WUDS are shown with the discussion of the Site File and each subsystem. An entity-relationship diagramming technique was used to show the relationships among the files.

3.3.2.2 Site File

The Site File contains all the primary site information including geographic location, basin information, use of site information, and well information. The file stores data for ground-water, surface-water and meteorological sites. The file contains 1 record type, and is 550 characters in length. The first 20 characters define the primary key for the record, the 5-character agency code and the 15-character site identifier. The acceptable agency codes are contained in the agency support file. For ground-water sites, the site identifier is a 15-digit identification number assigned to the site, containing no blanks or alphabetic characters. Although the site identification number is formed initially from the latitude and longitude and a 2-digit sequence number, the number is an identifier and not a locator. The latitude and longitude data elements are used to update latitude and longitude values. For surface-water sites, the first 8 to 14 digits are the downstream order number for the onstream sites where records are systematically collected. The remaining positions are left blank when the identifier is less than 15 characters. The site identifier is the primary internal control number and links the ADAPS, GWSI, QW and WUDS subsystems together. The relationship between the Site File and the support files is shown in Figure 26.

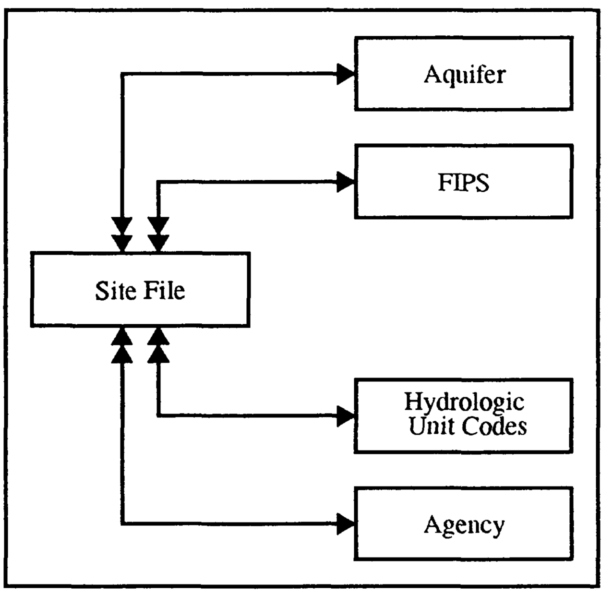


Figure 26 -- Site File and associated support files.

3.3.2.3 Automated Data Processing System

The Automated Data Processing System (ADAPS) allows for processing continuously recorded water data, primarily surface water (Dempster, 1990). However, the subsystem also allows processing of water-quality and ground-water data. Water data stored in ADAPS result from processing of data collected or recorded at field installations operated at the district level. A large majority of the field data are recorded in digital form on punched paper tapes or recorded by a data collection platform and sent to the computer via satellite telemetry. The relationship between the ADAPS subsystem and the common area support files in shown in Figure 27.

The ADAPS processing files reviewed for data transfer were divided into two types of files: the ADAPS support files, which are key to defining and processing water data; and the time-series related files, which include the main data files. The three ADAPS support files reviewed for transfer include:

- Instrument File
- Data Descriptor File
- Processor File

INSTRUMENT FILE: The data contained in the Instrument File define the types of data-sensing equipment installed at the site. The Instrument File contains two record types:

- Automatic data recorder (ADR)
- Data collection platform (DCP)

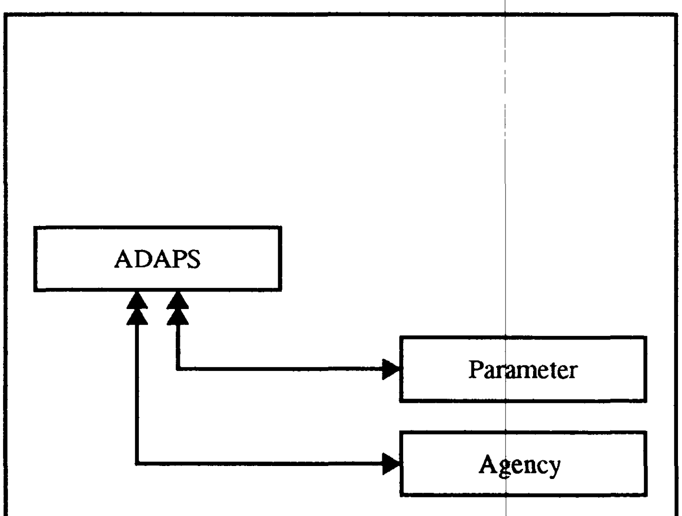


Figure 27 -- Automated Data Processing System and associated support files.

The instrument file is the only file in ADAPS that contains more than one record type. The first 100 characters in the Instrument File are common to both record types. The ADR record contains information about the instrument channel or sensor for automatic data recorders. The DCP record contains information about the instrument channel or sensor for data collection platforms. The Instrument File containing DCP records is functioning under the present release of the ADAPS software, but will be replaced by the Device Conversion and Delivery System (DECODES) processing before NWIS-II is implemented. DECODES files will be reviewed by data transfer when the NWIS-I software revisions are completed.

DATA DESCRIPTOR FILE: The Data Descriptor File is central to ADAPS processing. The Data Descriptor File contains water data parameter and statistic code information for each sensor. The file holds the basic definition of a unique site record in the ADAPS processing. A unique data-descriptor four-character number is assigned to parameter, or sensor data, at a given cross section and depth location for a single station. The information serves to separate data of the same parameter collected at the same site but different locations, the same parameter collected from different sources, and to separate the same parameter collected or computed for different purposes, such as field collected or model generated. A full site identification key is formed by the concatenation of the agency code, station identifier, and data-descriptor number. This site identification is used to locate data in other ADAPS files. The data-descriptor record also contains the primary information about parameter codes and statistic codes that describe the data. A data descriptor must exist for the following records to be stored:

- Processor
- Rating
- Datum Corrections
- Satin Errors
- Shift with Time
- Variable Shift
- Unit Values
- Daily Values
- Summary Statistics

PROCESSOR FILE: The Processor File contains data output conversion information, such as the form of primary output, the processing threshold and base values, and the auxiliary gage information. Using the site identification from the data descriptor, the processor record defines the processing schema and parameters necessary to compute unit and daily values. The processor record information describes unit-values computations involving the particular data descriptor, the daily-values statistics to compute, and the data validity screening thresholds to use.

The following files are related to the processing of time-series collected data:

- Measurement
- Rating
- Datum Corrections
- Shift with Time

- Variable Shift
- Unit Values
- Daily Values
- Summary Statistics

MEASUREMENT FILE: The Measurement or Crest-Stage Gage File contains discharge or other measurement data. The Measurement File relates directly to the Site File. The agency code, site identifier, measurement number, and date of measurement uniquely identify each record in this file. The file contains one record type of fixed length.

RATING FILE: The Rating or Conversion File contains stage-discharge relation data or other tabular look-up or rating data used to convert data from one parameter or type to another. The agency code, site identifier, data descriptor identifier, rating type, and rating identifier uniquely identify each record in this file. Each rating belongs to one data descriptor, and a data descriptor may have zero, one, or many ratings. The file contains one record type of variable length. The number of input and output rating values determine the length of the file. A maximum of 100 rating value pairs are possible for one record.

DATUM CORRECTION FILE: The Datum Correction File contains data to correct changes in gage datum due to settlement or upheaval of the gage or to correct for an instrument being set incorrectly in the field. Each record contains datum correction values for a water year arranged by date, time, and value. Actual datum corrections used in computations are computed by linear interpolation from one datum correction value to the next. The agency code, water year, station identifier, data descriptor identifier, and type uniquely identify each record in the file. The file contains one record type of variable length. A maximum of 100 time-of-year and value pairs are possible for one record.

SHIFT FILE: The Shift with Time File contains data to apply the shifting control method of computing water-data records on the basis of time. Each record contains shift with time values for a water year arranged by date, time, and value. Actual shift with times used in computations are computed by linear interpolation from one shift with time to the next. The agency code, water year, station identifier, data descriptor identifier, and type uniquely identify each record in the file. The file contains one record type of variable length. A maximum of 100 time-of-year and value pairs are possible for one record.

VARIABLE SHIFT FILE: The Variable Shift File, or Shift by Stage File, contains data to apply the shifting control method of computing water-data records on the basis of stage, or to make an adjustment to a value prior to or after a rating table lookup. The variable-shift procedure is sometimes referred to as a Vee (V) diagram. Each record contains variable shift values for a water year stored in a table arranged by date, time, and V diagram. Each V diagram is a set of three input value/shift pairs. Actual variable shifts used in computations are computed by linear interpolation from one V diagram to the next, and by linear interpolation with the V diagrams from one value/shift pair to the next. The agency code, water year, station identifier, data

descriptor identifier, and type uniquely identify each record in the file. The file contains one record type of variable length. A maximum of 100 time-of-year and value pairs are possible for one record.

UNIT VALUES FILE: The Unit Values File contains data collected or computed more frequently than daily and at discrete fixed or varying time intervals. Each unit-value record contains all the unit-values data for a particular date, a data descriptor, and edited or computed data type. The data are stored in a table of values, times, and flags. The agency code, station identifier, data descriptor identifier, type, and date uniquely identify each record in the file. The file contains one record type of variable length. A maximum of 1,440 unit values, time, and flag pairs are possible for one record. The Unit Values Index File identifies the unit-values subfile in which a site's data are stored. The record format of the unit-values subfile, UVnn.DATA, is identical to the Unit Values File, where nn is a sequential number assigned by the subsystem to permanently store the data.

DAILY VALUES FILE: The Daily Values File contains data observed on a daily basis or numerically reduced to a daily basis from data observed on a more frequent than daily basis, usually unit values. Each record contains a water year's daily value for a single site, data descriptor, and statistic code. The agency code, water year, station identifier, data descriptor identifier, and statistic code uniquely identify each record in the file. The file contains one record type of fixed length. The Unit Values Files and the Daily Values File are the primary data files in ADAPS.

SUMMARY STATISTICS FILE: The Summary Statistics File contains discharge data descriptor summary statistics for the period of daily values record . The agency code, water year, station identifier, data descriptor identifier, and statistic code uniquely identify each record in the file, the primary key from the Daily Values File. The file contains one record type of fixed length.

Support files that are used by the ADAPS software, but do not contain data that have been designated for data transfer include the node configuration file, user file, group file, control file, and security file. Other processing files and output files, including status files, error files, meta files, application files, and temporary files will not be transferred to the NWIS-II data base.

3.3.2.4 Ground-Water Site Inventory

The Ground-Water Site Inventory (GWSI) subsystem contains descriptive data elements about sites where ground water is accessed either from wells, test holes, springs, tunnels, drains, ponds, or other excavations (Mathey, 1990a). About 300 data elements, or components, comprise the descriptive ground-water data. The ground-water data elements are contained in eight GWSI data files and the Site File. The Site File primarily contains ground-water data elements, which are identification parameters, physical and political descriptors, and data-collection methods at the sites. The relationship between the GWSI subsystem and the support files is shown in Figure 28.

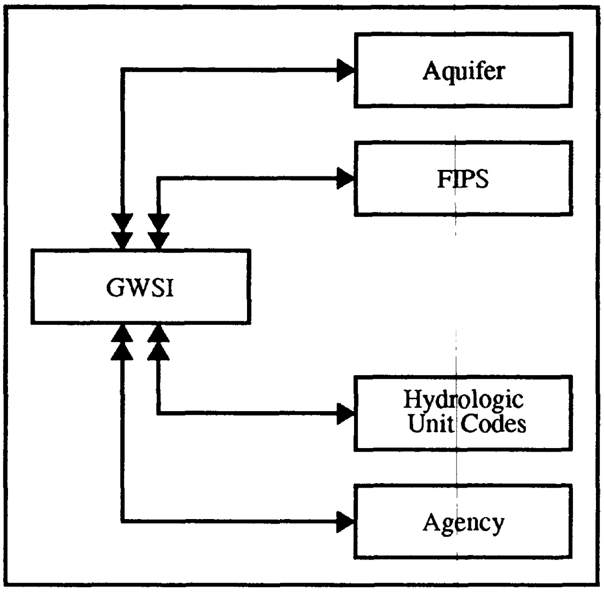


Figure 28. -- Ground-Water Site Inventory subsystem and associated support files.

The eight GWSI data files reviewed for data transfer contain the following data types:

- Well-Construction
- Ground-Water Level
- Ground-Water Discharge
- Miscellaneous
- Geohydrologic Logs
- Observation-Well Heading
- Hydraulic
- State Water Use

WELL-CONSTRUCTION FILE: The Well-Construction File is used to store data elements related to the construction of the well. The file contains eight record types, or record overlays. The records in the Well-Construction File are 160 characters in length. The first 35 characters are common to each record type, the remaining characters vary according to record type. The following is a list of record types and a description of the data contained in that record type, in the Well-Construction File:

- LIFT - lift, major pump, and standby pump data
- CONS - basic construction data
- HOLE - hole data
- CSNG - casing data
- OPEN - openings data
- REPR - minor repairs data
- SPNG - spring data
- MPNT - measuring-point data

GROUND-WATER LEVEL: The Ground-Water Level File stores water-level data. The file contains one record type. The agency code, site identifier, water-level data and time uniquely identify the water-level measurement. Codes referring to the status, methods, references, and accuracy further describe the water-level data.

GROUND-WATER DISCHARGE: The Ground-Water Discharge File stores water-level and discharge data used to estimate well performance for both flowing and pumped sites. The file contains one record type. The agency code, site identifier, record sequence number and discharge date uniquely identify the record. The record sequence number is mandatory for storing the well-production data.

MISCELLANEOUS FILE: The Miscellaneous File is used to store data elements that do not relate specifically to the other data categories. The file contains 11 record types. The first 35 characters are common to each record type, the remaining characters vary according to record type. The following is a list of record types and a description of the data contained in the record type, in the miscellaneous data file:

- OWNR - owner's name data
- OTID - other-identifier data
- OTDT - other-data-available data
- VIST - site-visits data
- QUAL - field water-quality data
- LOGS - geophysical logs data
- NETW - network data
- SPEC - special-cases data
- MSVL - miscellaneous-values data
- COOP - cooperator's data
- RMKS - remarks data

GEOHYDROLOGIC LOGS FILE: The Geohydrologic Logs File stores geohydrologic data about the site. The file contains two record types. The records in the Geohydrologic Logs File are 200 characters in length. The first 38 characters are common to both record types, the remaining characters vary according to record type. The record types contained in the file are:

- Geohydrologic units record, GEOH, which includes the aquifer description and depth interval data
- Aquifers record, AQFR, which includes the water level and contribution data

The aquifers record is a lower-level record within the geohydrologic units record. Data are not stored in the aquifers record if any mandatory entry in the geohydrologic unit record is not present.

OBSERVATION-WELL HEADING FILE: The Observation-Well Heading File is used to specify headings for producing tabular water-level reports. The file contains one record type. These data are used to produce output report headings specific to NWIS-I, and the information probably will not be transferred into NWIS-II.

HYDRAULIC FILE: The Hydraulic File is used to store data that relates to the hydraulics of the aquifer. The file contains two record types. The records in the Hydraulic File are 120 characters in length. The first 38

characters are common to both record types, the remaining characters vary according to record type. The record types contained in the file are:

- Hydraulic record, HYDR, which includes the aquifer and test interval data
- Coefficients record, COEF, which includes the aquifer coefficients data

The coefficients record is used to record the hydraulic coefficients determined by the test data. The record is a lower-level record within the hydraulic record.

STATE WATER-USE FILE: The State Water-Use File is used to store water-use information. The agency code, site identifier, and State water-use record number uniquely define the records in this file. The file contains one record type and is fixed in length.

The GWSI software performs edit validation and logical data checks. The software program checks code validation against lookup tables, reasonable value checks, proper date fields, and proper numeric values. The edit tables may be used for data validation during the transfer process. Other GWSI software specific files, such as error files, definition files, and prompt files, will not be reviewed for data transfer.

3.3.2.5 Water Quality

The Water-Quality (QW) subsystem is a water-quality data storage and retrieval system (Maddy, and others, 1990). All the data in QW is contained in one water-quality data file (QWFILE). In addition to the water-quality data file, the system also accesses the Site File, and five support files. The relationship between the QW subsystem and the support files is shown in Figure 29. The QW subsystem also maintains a lab accounting file, called the LABACCT File. The information contained in the lab accounting file is periodically deleted. The information contained in the file has not been reviewed for data transfer, as the NWIS-II software will probably handle the lab accounting information in a different format.

The QWFILE contains the water-quality parameters and values. The file is a keyed-index MIDAS file, where a record number uniquely identifies each record. The record number is generated by the software. The data elements that must exist for the record number to be generated are the agency code, data category, station number, medium code, sample date, and time. Other secondary keys in the file include project number, geologic unit code, and district processing status. The file contains one record type, and is variable in length. The maximum length of a single record is 4,200 bytes. The length of the record is determined by the data element, QWSETS. The data element contains the parameter code, value, and remark code for a water-quality parameter. A maximum of 250 occurrences for this data element is allowed. The number of parameters stored for the record is contained in the QWNPARM data element.

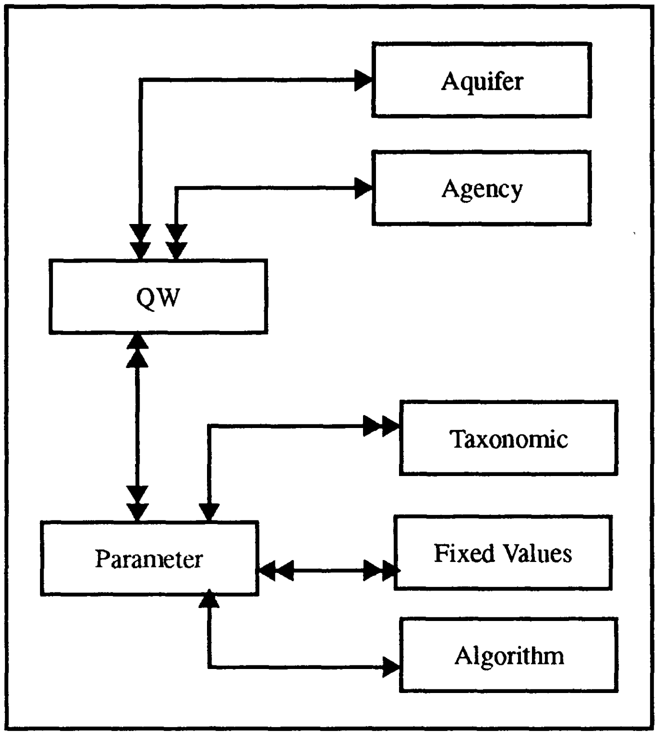


Figure 29. -- Water-Quality subsystem and associated support files.

3.3.2.6 Water-Use Data System

The Water-Use Data System (WUDS) comprises two water-use subsystems, Site-Specific Water-Use Data System (SSWUDS) and Aggregate Water-Use Data System (AWUDS). The SSWUDS subsystem is a system for the storage and retrieval of site-specific water-use data (Mathey, 1990b). Data in SSWUDS can be extracted and aggregated by county, hydrologic basin, and aquifer for the eventual entry into AWUDS. The relationship between the WUDS subsystem and the support files is shown in Figure 30.

The SSWUDS files are keyed files and the keys provide a link from one file to another. Water-use data are contained in five types of files in SSWUDS, which include:

- Water User
- Measurement Point
- Conveyance
- Annual Measurements
- Extended Data

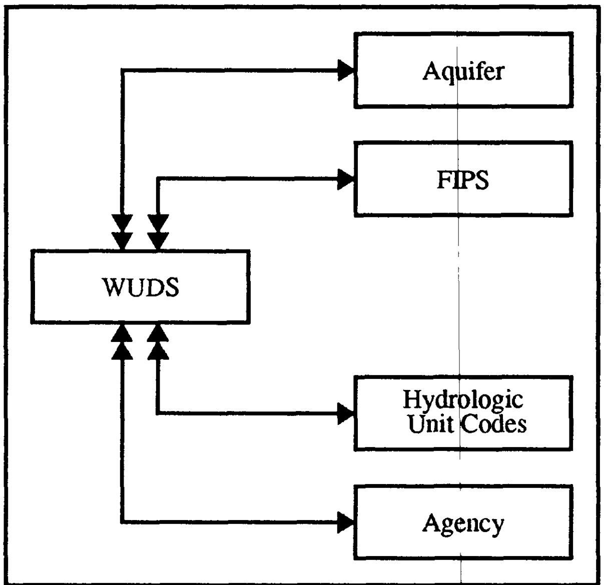


Figure 30. -- Water-Use Data System and associated support files.

WATER USER FILE: A water user is an installation, institution, corporation, organization, or individual that uses water. Each water user is assigned a unique water-user identifier, which is the most important data element in the files, as it is used to reference every other type of data. Water-user data, such as name and address of facility, are stored in the Water-User File. Although SSWUDS is designed to be a site-specific data base, some districts have entered water-use data for a category in a county, hydrologic basin, or other subarea, and have assigned these aggregate users water-user identifiers. Information about domestic, commercial, or industrial purchasers of water from public suppliers may also be represented in the data base as water users. The file contains one record type of fixed length.

MEASUREMENT-POINT FILE: A measurement point is the site or location at which data are collected for water withdrawals, deliveries, releases, or returns. A site-specific measurement-point identifier must be a standard NWIS-I identifier--either a latitude/longitude/sequence number combination, or a downstream order number. Each site-specific measurement point must have a valid corresponding record in the NWIS Site File. Measurement points representing data aggregated on any basis other than well field are flagged as aggregate sites and do not have a corresponding record in the Site File. The measurement-point identifier, also referred to

as the source/destination identifier, is the critical data element that links SSWUDS to the other NWIS-I subsystems. The file contains one record type of fixed length.

CONVEYANCE FILE: A conveyance is the transfer of water from measurement point to measurement point, and tracks the flow of water through a water-use system. Conveyance data are stored in the Conveyance File. The primary internal function of the Conveyance File is to provide internal links from the Water-User File to the Measurement-Point File, and from the Measurement-Point File to the Annual-Data File. Although the Conveyance File does store some data collected for the system, its primary role is in tracking water movements. It also directly links measurement points to the Site File.

ANNUAL-DATA FILE: Annual data are the amounts of water measured at any measurement point. A separate Annual Data File is created for each year of water-use data. Monthly and annual withdrawal amounts are stored in the WUAMXX (XX=year) Annual Data File.

EXTENDED-DATA FILE: The information in the Extended-Data File supplements the Water-User File by providing a more detailed picture of how the water is used. The file is linked to the Water-User File by the water-user identifier, and to the Conveyance File by the source/destination identifier. Data elements common to the four record types include water-user identifier, year, SIC code, data code, and measurement-point identifier. The data code identify the data elements in the remainder of the record. The Extended-Data File contains the following types of records:

- Irrigation crop data (EDIR), including acres irrigated and amount of water applied, by crop type
- Public-supply and waste-treatment data (EDPS) on connections served by type
- Production data (EDIN)
- Power data (EDPW), including power produced monthly and generating capacity.

Reference files used only by the SSWUDS subsystem include a data dictionary file, an error code file, a multiple data-base index file, batch code file, and a user file. These files are specific to the SSWUDS software and do not contain data that will be transferred directly into the NWIS-II data base. SSWUDS and AWUDS both utilize lookup tables for State codes, county codes, and hydrologic basins. The lookup tables are generated from larger, common area support files. The common area support files have been designated for data transfer but not the look-up tables specific to individual subsystems.

The AWUDS subsystem contains data that have been aggregated from SSWUDS or entered by the user. Two data files exists for each year of data contained in AWUDS, a county file and an 8-digit hydrologic unit file. The names of the files are unique for each area, year, and State. The generic names for the files are:

- DATA.CO.YY.SS
- DATA.H8.YY.SS

where YY equals the last two digits in the year, and SS is the two-character abbreviation for the State. The format of the data elements stored in the files is the same for county and hydrologic unit code data files. Three data elements in each file define the State, year, and code for the area. The remaining data elements in the file contain user-entered water-use data, and software calculated water-use data, by water-use category. The

indexes through INDEX168 are produced and stored in ASCII format by the software. The remaining indexes are calculated indexes and are not stored values. An aggregated aquifer data file will also be transferred with the AWUDS data.

3.3.3 Water Data - National Water Data Storage and Retrieval System

Most of the data contained in the National Water Data Storage and Retrieval System (WATSTORE) have comparable data in the NWIS-I data system. The WATSTORE files designated for data transfer that do not have comparable data in the NWIS-I data system are:

- Peak Flow File
- Streamflow Basin Characteristics Files

PEAK FLOW FILE: The Peak Flow File (WRD.PEAKV) contains peak flow values for surface-water stations. The primary key of the file is the agency code, station identifier, and the water year. The first 68 characters are fixed for the record, and contain information about the maximum annual discharge and the corresponding gage height. A record may contain two additional record segments.

The first additional record segment contains information about the annual peak stage. Entry of this part of the record indicates that the peak stage actually occurred at a different time from the peak discharge for that year. Whether or not this record segment exists in the file is determined by reading the data element, PFR_#_PEAK_STAGES, held in bytes 41-42 in the record. The value for this data element is either zero or one. If the value is one, the 12 bytes associated with an annual peak stage entry are present. The information contained in the 12 bytes includes annual peak stage, month, day, and qualification codes. A value of zero indicates that these 12 bytes do not appear in the record.

The second additional record segment contains information about partial peaks for the station and water year. The number of 16-byte partial peak occurrences for a record is contained in the data element named PFR_#_PARTIAL_PEAKS, held in bytes 43-44 of the record. A maximum of 30 occurrences of partial peak data are possible for one record. The information contained in the 16 bytes include month, day, and qualification codes for partial duration peak discharge and partial duration peak stage.

The streamflow basin characteristics data are contained in two main files. The files are:

- Streamflow Basin Characteristics File (WRD.SBCHAR)
- Streamflow Basin Characteristics Auxiliary Name File (WRD.SBNAMES)

STREAMFLOW BASIN CHARACTERISTICS FILES: The WRD.SBCHAR File contains information about the station, including the FIPS Code, the District code, a descriptive name, the data values, and whether the values were observed or computed. The WRD.SBCHAR File contains one record type and has a 878-byte fixed length. The station identifier is the primary key of the file. The data values are stored as a 200-element float (6) array. The position of a value in the array corresponds to an array position in the WRD.SBNAMES file.

The WRD.SBNAMES File contains the name, units, and state of collection of the data value. The WRD.SBNAMES File contains three record types, and each record has a 1,600-byte fixed length. Each of the three records is set up as an array. The first record type contains a 200 element array. Each element of the array contains an eight-character name of the data value, for example AREA or SLOPE. Some array positions are blank. The second record type contains a 200-element array. Each element of the array contains an eight-character unit of measure of the data values, for example CFS or FT. Some array positions are blank. The third record type contains a 100-element array. Each element of the array contains a 16-character State name, spelled-out in full. The array number position corresponds to the FIPS code number for the State name contained in the element.

DAILY VALUES FILE: The WATSTORE Daily Values File is a general-purpose file for the storage of water data collected or measured on a daily schedule, and is very similar in content to the NWIS-I Daily Values File. The data contained in the WATSTORE Daily Values File will be transferred for those stations and water years that do not have corresponding data in NWIS-I. The primary key of the file is the agency code, station identifier, parameter code or statistic code. Information contained in the WATSTORE daily-values record includes the cross-section locator, sampling depth, and parameter code associated with the values. This is different from the NWIS-I daily-values record, which does not store the locator and parameter data directly. Instead the data are stored with the associated data-descriptor record in NWIS-I.

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SYSTEM REQUIREMENTS SPECIFICATION FOR THE U.S. GEOLOGICAL SURVEY'S NATIONAL WATER INFORMATION SYSTEM II

CHAPTER 6. SYSTEM PERFORMANCE

J.C. Briggs and G.D. Rogers

INTRODUCTION

Performance requirements for a distributed-information system are a critical part of the design phase. By developing performance requirements, the users have a means to express needs and expectations with respect to data base transaction rates. Performance requirements bring to the designer a benchmark against which they can test the data base during the development process. Thoughtful performance requirements can make the difference between a satisfactory or unsatisfactory design. Productivity can be greatly enhanced by extensive performance testing before the data base is released.

What is considered a satisfactory transaction rate may be quite subjective among users and be dependent on their experience with computer interaction. Therefore the question--how do you define performance requirements and how explicit should you be? Charles Martin (1989), attempts to answer the question by discussing four subject areas: (1) the number of users, (2) data base size, (3) interactive response times, and (4) function processing rates.

1. Number of Users

Software designers need information on the number of personnel having access to a planned system and their locations to design a large, distributed-information system. The number of users, both current and expected during the life of the system, allows the designer to make plans for such needs as training materials, terminal support, contention problems, and user interfaces. This number should reflect the number of users who can have access at any time, not the number who can simultaneously use the system. Knowledge of the users locations will allow the designers to anticipate possible time-sharing demands at the distributed-system nodes and to design the system to maximize efficiency.

Table 10 shows the number of users for the entire Water Resources Division based on various activities for the collection and analysis of hydrologic data (R.M. Hathaway and J.M. McNellis, written commun., 1989). More than 3,800 employees in the Division, located at 175 locations throughout the United States and abroad, have access to the NWIS-I system on 50 Prime computers. The number of personnel accessing the system in the near future likely will be near the 1989 figures, so those numbers are a possible estimate of the number of users for NWIS-II.

Assumptions for estimating use of NWIS-II include the following:

- Existence of a national data base that consists of a periodic aggregation or update of distributed data bases.
- Greatly expanded capability of online storage.
- The data elements of the national data base that are a subset of the distributed data base.
- The number of users will remain relatively constant.
- Increasing demand for data, especially in machine-readable format. Cooperators and general public will have online access to the data.
- The types and formats of data collected will increase with time.

This analysis gives an estimate of the total number of personnel and time spent on various activities but does not provide any information on number of users per location in a distributed data base system. With the implementation of the DIS-II workstations, many new locations will have computer equipment with the implication that NWIS-II software will be installed at more locations.

Table 11 shows locations and numbers of computer users in 1990. The locations having a Prime computer and operational NWIS-I software are in bold type. This analysis did not include headquarters or regional offices since these offices do not have NWIS-I software for normal operations on their computers. Under each bold listing are the locations currently served by that Prime computer. Figures for number of personnel in the 162 locations were obtained from October 1990 payroll information. This list is organized by location; if more than one office was at a particular location, the numbers of personnel were summed and only one office was listed at that location. The office listed likely would provide the computer support at that location. Also for each location, the number and types of personnel were obtained from an internal Division personnel directory. Five categories of users were established for this analysis. These categories give some indication of the types of duties of the personnel and types of NWIS-II software they would use. The categories are:

- Scientific professional--Includes hydrologists, geologists, chemists, botanists, biologists, and other personnel with titles that indicate a connection to the collection and analysis of hydrologic data as an integral function of their duties.
- Scientific nonprofessional--Includes hydrologic technicians, field assistants, and others who collect and process hydrologic information.
- Computer professionals--Includes computer programmers, analysts, and specialists whose duties are associated with computer hardware and software maintenance and less associated with the collection and analysis of hydrologic data.
- Computer nonprofessional--Includes data processing clerks, computer assistants, and others.
- Others--Includes administrative officers, editors, clerks, and secretaries who are not actively involved in the collection, processing, or analysis of hydrologic data.

This breakdown is arbitrary but was selected to give an indication of who would be collecting, processing, and analyzing the data within each office, as well as who would be available to maintain the software and data files within an office.

The information in the two tables provide an estimate of the types and amount of data transactions that have occurred in NWIS-I and could possibly occur in NWIS-II. It gives the NWIS-II software developers a basis from which to work. Simulations of the estimated number of users accessing similar data within NWIS-II simultaneously will likely prove to be important for performance testing. The importance of the location information is related to whether NWIS-II is implemented as a distributed data base environment, rather than a central national data base system, and the technological feasibility of implementing a truly distributed environment with appropriate response times.

Table 10. -- Estimates of the number of users within Water Resources Division of the NWIS software for nine categories of data activity (R.M. Hathaway and J.M. McNellis, written commun., 1989).

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year		Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		Manually entered			*1988*		*Automatically entered*		
District	170	185,540	2,230	330		170	69,580	2,230	125
Research and headquarters	4	11,440	440	110		4	6,900	440	65
Analytical Services Laboratory	1	10,740	70	1,230		0	0	0	0
					1992				
District	170	185,540	2,230	330		170	81,170	2,230	150
Research and headquarters	4	9,200	440	90		4	11,400	440	100
Analytical Services Laboratory	1	5,600	70	650		1	5,600	70	650
					1997				
District	170	185,540	2,230	165		170	301,500	2,230	270
Research and headquarters	4	6,860	440	70		4	27,460	440	120
Analytical Services Laboratory	1	1,820	70	200		1	9,650	70	1,100
		Standard computation			*1988*		*Data Synthesis*		
District	170	237,900	2,230	425		170	69,600	2,230	125
Research and headquarters	4	11,440	440	105		4	9,200	440	85
Analytical Services Laboratory	1	12,500	70	225		0	0	0	0
					1992				
District	170	210,100	2,230	350		170	139,150	2,230	125
Research and headquarters	4	10,200	440	100		4	18,300	440	90
Analytical Services Laboratory	1	12,500	70	225		0	0	0	0
					1997				
District	170	196,700	2,230	300		170	139,150	2,230	125
Research and headquarters	4	9,150	440	90		4	22,880	440	95
Analytical Services Laboratory	1	12,500	70	225		0	0	0	0
		Data Validation			*1988*		*Data-base maintenance*		
District	170	149,800	2,400	245		70	18,200	70	200
Research and headquarters	4	11,400	440	115		4	1,040	4	200
Analytical Services Laboratory	1	15,500	70	520		1	260	1	200
					1992				
District	170	324,500	2,400	270		135	54,600	210	200
Research and headquarters	4	27,460	440	120		4	2,600	10	200
Analytical Services Laboratory	1	15,500	70	520		1	260	1	200
					1997				
District	170	349,400	2,400	295		170	182,000	700	210
Research and headquarters	4	27,460	440	120		4	7,800	30	210
Analytical Services Laboratory	1	15,500	70	520		1	260	1	210
		Data archiving			*1988*		*Facilitating access to data*		
District	70	2,340	70	85		70	364,000	70	520
Research and headquarters	4	8	4	5		4	2,080	4	520
Analytical Services Laboratory	0	0	0	0		1	520	1	520
					1992				
District	135	15,750	210	150		135	109,200	210	520
Research and headquarters	4	50	10	10		4	5,200	10	520
Analytical Services Laboratory	0	0	0	0		1	520	1	520
					1997				
District	170	52,500	700	150		170	364,000	700	520
Research and headquarters	4	150	30	10		4	15,600	30	520
Analytical Services Laboratory	0	0	0	0		1	520	1	520
		Retrieval of data			*1988*				
District	170	600,000	2,400	125					
Research and headquarters	4	127,600	440	145					
Analytical Services Laboratory	1	140	70	1					
					1992				
District	170	1,200,000	2,400	125					
Research and headquarters	4	255,200	440	145					
Analytical Services Laboratory	1	280	70	1					
					1997				
District	170	1,765,000	2,400	125					
Research and headquarters	4	375,300	440	145					
Analytical Services Laboratory	1	410	70	1					

Table 11. -- Location of Water Resources Division offices and number of personnel by location that have access to operational NWIS software.

[Offices shown in bold type have a Prime computer system. Those offices following access that computer system via GEONET. For a particular location, several offices may be combined; for example, the District Office in Anchorage includes the Subdistrict Office for Anchorage. Source: Number of personnel is based on October 1990 payroll information. The breakdown by occupational type came from an internal directory for 1990. The numbers will not agree.]

		Occupational types				
	Number of	Scientific		Computer		
Office and location	Personnel	Prof.	Non-prof.	Prof.	Non-prof	Other
District Office - Anchorage, AK	**42**	**16**	**10**	**1**	**1**	**11**
Subdistrict Office - Fairbanks, AK	9	4	2	0	0	1
Subdistrict Office - Juneau, AK	4	1	2	0	0	1
District Office - Tuscaloosa, AL	**21**	**8**	**8**	**1**	**0**	**5**
Subdistrict Office - Montgomery, AL	14	3	6	0	0	2
Subdistrict Office - Cullman, AL	3	0	4	0	0	0
District Office - Little Rock, AR	**51**	**18**	**21**	**3**	**3**	**7**
Field Headquarters - Ft. Smith, AR	2	0	1	0	0	0
District Office - Tucson, AZ	**86**	**41**	**16**	**3**	**4**	**16**
Hydrologic Data Program, Tempe, AZ	22	8	10	1	0	3
Field Office - Tucson, AZ	36	4	9	0	0	0
Field Office - Yuma, AZ	8	2	5	0	0	1
District Office - Sacramento, CA	**126**	**54**	**23**	**7**	**4**	**34**
Field Headquarters - Eureka, CA	5	1	4	0	0	0
Field Headquarters - Merced, CA	6	1	5	0	0	1
Field Headquarters - Redding, CA	4	1	4	0	0	0
Field Headquarters - Salinas, CA	6	1	6	0	0	0
Field Headquarters - Redlands, CA	9	1	8	0	1	0
Field Headquarters - Santa Rosa, CA	8	2	5	0	0	1
Field Headquarters - Santee, CA	7	1	7	0	0	1
Field Headquarters - Tahoe City, CA	5	1	3	0	0	1
Field Headquarters - San Diego, CA	32	20	4	0	0	7
Field Office - Bakersfield, CA	9	1	6	0	0	1
Subdistrict Office - Menlo Park, CA	4	2	0	0	0	0
District Office - Lakewood, CO	**89**	**39**	**15**	**3**	**3**	**29**
Field Headquarters - Durango, CO	2	0	2	0	0	0
Field Headquarters - Meeker, CO	7	3	3	0	0	1
Subdistrict Office - Grand Junction, CO	11	4	5	0	0	2
Subdistrict Office - Pueblo, CO	20	11	7	0	0	2
District Office - Tallahassee, FL	**57**	**19**	**11**	**4**	**1**	**14**
Wrd Lab. QW Service Unit - Ocala, FL	17	4	8	1	0	1
Subdistrict Office - Miami, FL	**42**	**14**	**12**	**4**	**0**	**8**
Field Headquarters - Ft. Meyers, FL	7	3	3	0	0	0
Field Headquarters - Stuart, FL	6	3	2	0	0	1
Subdistrict Office - Orlando, FL	**44**	**16**	**15**	**0**	**1**	**6**
Field Headquarters - Jacksonville, FL	9	1	3	1	2	1
Subdistrict Office - Tampa, FL	**60**	**26**	**5**	**2**	**2**	**7**
Field Headquarters - Sarasota, FL	2	0	2	0	0	0

Table 11. – Location of Water Resources Division offices and number of personnel by location that have access to operational NWIS software–Continued.

[Offices shown in bold type have a Prime computer system. Those offices following access that computer system via GEONET. For a particular location, several offices may be combined; for example, the District Office in Anchorage includes the Subdistrict Office for Anchorage. Source: Number of personnel is based on October 1990 payroll information. The breakdown by occupational type came from an internal directory for 1990. The numbers will not agree.]

		Occupational types				
	Number of	Scientific		Computer		
Office and location	Personnel	Prof.	Non-prof.	Prof.	Non-prof	Other
District Office - Doraville, GA	**79**	**39**	**25**	**4**	**2**	**8**
Field Headquarters - Albany, GA	3	0	3	0	0	0
Field Headquarters - Tifton, GA	3	0	3	0	0	0
Field Headquarters - Savannah, GA	2	0	2	0	0	0
District Office - Honolulu, HI	**45**	**17**	**18**	**1**	**3**	**5**
Subdistrict Office - Agana, Guam	6	1	3	0	0	0
Field Headquarters - Hilo, HI	2	0	2	0	0	0
Field Headquarters - Kahului, Maui, HI	3	0	3	0	0	0
Field Headquarters - Lihue, Kauai, HI	2	0	2	0	0	0
District Office - Iowa City, IA	**48**	**18**	**14**	**1**	**4**	**6**
Field Headquarters - Council Bluffs, IA	5	1	3	0	0	1
Field Headquarters - Ft. Dodge, IA	3	0	3	0	0	1
Idaho-Nevada District Office - Boise, ID	**52**	**19**	**19**	**4**	**1**	**9**
Field Headquarters - Sandpoint, ID	5	1	2	0	0	0
Field Headquarters - Twin Falls, ID	4	0	4	0	0	1
Project Office - Idaho Falls, ID	24	8	13	0	0	1
District Office - Urbana, IL	**61**	**26**	**12**	**1**	**5**	**10**
Field Headquarters - Urbana, IL	4	0	5	0	0	0
Field Headquarters - Mt.Vernon, IL	7	3	1	0	0	1
Subdistrict Office - Dekalb, IL	8	3	3	0	0	2
District Office - Indianapolis, IN	**57**	**19**	**21**	**2**	**1**	**4**
District Office - Lansing, MI	26	10	6	0	1	5
Field Headquarters - Escanaba, MI	6	0	5	0	0	1
Field Headquarters - Grayling, MI	3	0	4	0	0	0
Field Headquarters - Garden City, KS	7	1	6	0	0	0
Central Plains District - Lawrence, KS	**59**	**13**	**14**	**0**	**4**	**23**
Project Office - Manhattan, KS	15	6	6	0	0	3
District Office - Louisville, KY	**43**	**20**	**8**	**0**	**2**	**4**
Subdistrict Office - Paducah, KY	6	0	2	0	0	1
Subdistrict Office - Williamsburg, KY	5	0	4	0	0	0
Field Headquarters - Prestonburg, KY	1	0	1	0	0	0
District Office - Baton Rouge, LA	**65**	**24**	**27**	**1**	**5**	**15**
Field Headquarters - Ruston, LA	10	0	9	0	0	0
New England District - Boston, MA	**17**	**5**	**0**	**1**	**1**	**12**
Connecticut Office - Hartford, CT	36	15	18	1	0	7
Maine Office -Augusta, ME	22	7	8	0	0	3
Massachusetts Office - Marlborough, MA	37	24	16	0	0	4
New Hampshire Office - Bow, NH	22	15	4	0	0	7
Field Headquarters - Montpelier, VT	4	0	3	0	0	0
Rhode Island Office - Providence, RI	11	6	6	0	0	1

Table 11. – Location of Water Resources Division offices and number of personnel by location that have access to operational NWIS software–Continued.

[Offices shown in bold type have a Prime computer system. Those offices following access that computer system via GEONET. For a particular location, several offices may be combined; for example, the District Office in Anchorage includes the Subdistrict Office for Anchorage. Source: Number of personnel is based on October 1990 payroll information. The breakdown by occupational type came from an internal directory for 1990. The numbers will not agree.]

		Occupational types				
	Number of	Scientific		Computer		
Office and location	Personnel	Prof.	Non-prof.	Prof.	Non-prof	Other
Mid-Atlantic District - Towson, MD	**77**	**30**	**19**	**3**	**3**	**17**
Field Headquarters - Annapolis, MD	2	0	2	0	0	0
Field Headquarters - Cumberland, MD	3	0	3	0	0	0
Delaware Office - Dover, DE	9	4	4	0	0	0
District Office - St. Paul, MN	**44**	**25**	**9**	**0**	**0**	**9**
Subdistrict Office - Grand Rapids, MN	5	0	4	0	0	0
Field Headquarters - Montevideo, MN	2	0	2	0	0	0
District Office - Rolla, MO	**47**	**19**	**13**	**0**	**2**	**8**
Field Headquarters - Independence, MO	6	3	3	0	0	0
Field Headquarters - Olivette, MO	5	0	5	0	0	0
District Office - Jackson, MS	**49**	**18**	**20**	**1**	**1**	**9**
District Office - Helena, MT	**46**	**17**	**19**	**1**	**1**	**7**
Subdistrict Office - Billings, MT	6	1	4	0	0	0
Field Headquarters - Ft. Peck, MT	4	0	4	0	0	0
Field Headquarters - Kalispell, MT	3	0	3	0	0	0
District Office - Carson City, NV	**92**	**37**	**14**	**4**	**2**	**19**
Field Headquarters - Elko, NV	3	1	2	0	0	0
Subdistrict Office - Las Vegas, NV	26	7	13	0	1	2
District Office - Raleigh, NC	**55**	**25**	**15**	**2**	**1**	**6**
Field Headquarters - Winston-Salem, NC	5	0	3	0	0	0
Subdistrict Office - Asheville, NC	4	0	5	0	0	0
Field Headquarters - Charlotte, NC	4	2	4	0	0	0
Field Office - Washington	7	0	4	0	0	0
District Office - Bismarck, ND	**32**	**12**	**10**	**1**	**1**	**10**
Field Headquarters - Dickinson, ND	3	0	2	0	0	0
Field Headquarters - Grand Forks, ND	5	1	3	0	0	0
Nebraska State Office - Lincoln, NE	**32**	**12**	**12**	**0**	**1**	**8**
Field Office - Ord, NE	4	0	4	0	0	0
District Office - Trenton, NJ	**97**	**62**	**22**	**2**	**0**	**16**
District Office - Albuquerque, NM	**72**	**23**	**15**	**0**	**1**	**8**
Subdistrict Office - Santa Fe, NM	12	3	8	0	0	0
Field Headquarters - Carlsbad, NM	4	3	4	1	1	7
Field Headquarters - Las Cruces, NM	3	5	7	1	0	0
District Office - Albany, NY	**62**	**30**	**11**	**2**	**2**	**16**
Subdistrict Office - Ithaca, NY	27	18	6	0	0	4
Subdistrict Office - Syosset, NY	**31**	**25**	**7**	**1**	**0**	**4**
Field Headquarters - Potsdam, NY	3	0	2	0	0	0
District Office - Columbus, OH	**67**	**28**	**13**	**1**	**2**	**10**
Field Headquarters - New Philadelphia,OH	4	0	4	0	0	0

Table 11. – Location of Water Resources Division offices and number of personnel by location that have access to operational NWIS software–Continued.

[Offices shown in bold type have a Prime computer system. Those offices following access that computer system via GEONET. For a particular location, several offices may be combined; for example, the District Office in Anchorage includes the Subdistrict Office for Anchorage. Source: Number of personnel is based on October 1990 payroll information. The breakdown by occupational type came from an internal directory for 1990. The numbers will not agree.]

Office and location	Number of Personnel	Occupational types: Scientific Prof.	Scientific Non-prof.	Computer Prof.	Computer Non-prof	Other
District Office - Oklahoma City, OK	**53**	**16**	**20**	**1**	**0**	**6**
Field Headquarters - Tulsa, OK	7	0	5	0	0	0
Field Headquarters - Woodward, OK	3	0	3	0	0	0
Oregon Office - Portland, OR	**79**	**27**	**27**	**2**	**0**	**10**
Field Headquarters - Eugene, OR	3	2	0	0	0	0
Field Headquarters - Medford, OR	6	1	4	0	0	0
District Office - Harrisburg, PA	**58**	**28**	**14**	**2**	**2**	**13**
Subdistrict Office - Malvern, PA	18	6	9	0	1	1
Subdistrict Office - Pittsburgh, PA	17	7	9	0	1	1
Field Headquarters - Williamsport, PA	4	0	5	0	0	0
District Office - San Juan, PR	**112**	**36**	**39**	**4**	**5**	**27**
District Office - Columbia, SC	**58**	**24**	**15**	**1**	**1**	**9**
Field Headquarters - Myrtle Beach, SC	5	1	4	0	0	0
Field Office - Aiken, SC	4	0	3	0	0	0
District Office - Huron, SD	**25**	**10**	**7**	**1**	**2**	**6**
Subdistrict Office - Rapid City, SD	19	7	7	1	0	2
Field Headquarters - Pierre, SD	3	0	3	0	0	0
District Office - Nashville, TN	**62**	**26**	**34**	**1**	**4**	**11**
Subdistrict Office - Knoxville, TN	11	2	8	0	0	0
Subdistrict Office - Memphis, TN	12	5	6	0	0	0
District Office - Austin, TX	**85**	**28**	**19**	**3**	**1**	**17**
Subdistrict Office - Ft. Worth, TX	16	3	10	0	0	0
Subdistrict Office - Houston, TX	21	8	11	0	0	2
Subdistrict Office - San Angelo, TX	9	2	6	0	0	0
Subdistrict Office - San Antonio, TX	20	8	6	0	0	1
Subdistrict Office - Wichita Falls, TX	6	1	5	0	0	0
Field Headquarters - El Paso, TX	1	1	0	0	0	0
District Office - Salt Lake City, UT	**64**	**28**	**20**	**2**	**2**	**8**
Subdistrict Office - Cedar City, UT	4	0	5	0	0	0
Field Headquarters - Moab, UT	5	0	5	0	0	0
Virginia Office - Richmond, VA	**45**	**25**	**9**	**3**	**3**	**6**
Subdistrict Office - Marion, VA	4	0	4	0	0	1
Field Headquarters - Charlottesville, VA	4	0	4	0	0	0
Pacific NW District Office - Tacoma, WA	**85**	**42**	**25**	**2**	**2**	**19**
Project Office - Vancover, WA	32	16	7	1	0	8
Field Headquarters - Pasco, WA	6	0	6	0	0	0
Field Headquarters - Spokane, WA	6	0	6	0	0	0
District Office - Madison, WI	**81**	**24**	**16**	**1**	**7**	**23**
Field Headquarters - Merrill, WI	3	0	2	0	0	0
Field Headquarters - Rice Lake, WI	3	0	4	0	0	0

Table 11. – Location of Water Resources Division offices and number of personnel by location that have access to operational NWIS software–Continued.

[Offices shown in bold type have a Prime computer system. Those offices following access that computer system via GEONET. For a particular location, several offices may be combined; for example, the District Office in Anchorage includes the Subdistrict Office for Anchorage. Source: Number of personnel is based on October 1990 payroll information. The breakdown by occupational type came from an internal directory for 1990. The numbers will not agree.]

Office and location	Number of Personnel	Occupational types: Scientific Prof.	Scientific Non-prof.	Computer Prof.	Computer Non-prof	Other
District Office - Charleston, WV	**16**	**9**	**4**	**1**	**1**	**4**
Subdistrict Office - Morgantown, WV	6	3	3	0	0	0
District Office - Cheyenne, WY	**42**	**23**	**4**	**1**	**2**	**11**
Field Headquarters - Casper, WY	8	3	4	0	0	0
Field Headquarters - Riverton, WY	8	2	4	0	0	1

2. Data Base Size

This section discusses sizes of the national and district data bases.

2.1 National Data Base

The size of the data base to be supported must be available to the designers. The size should be expressed by the record type, the record volume or number of records to be stored, and an estimate of data base growth through the life of the system. The record volume should be expressed in number of records; not only in number of bytes it currently takes to store all the extant records. This is because designers have a number of different storage alternatives. Hence, records in a data base with a smaller occurrence of records may be stored differently than in a data base with a large number of record occurrences.

The Water Resources Division currently maintains seven data bases that contain hydrologic information. They are:

- Header File--site location information.
- Daily-Values File--data collected or reduced to daily measurements.
- Unit-Values File--data measurements collected more frequently than daily.
- Ground-Water Site Inventory--inventory data on ground water sources.
- Water-Quality File--chemical, physical, biological, and radiological characteristics of surface and ground water.
- Peak Flow File--annual maximum stream flow and gage height values
- Basin Characteristics File--an inventory of basin characteristics

An additional file, the Master Water Data Index, is maintained by the NAWDEX program office. These national data bases are stored on the Division's Amdahl mainframe computer at USGS headquarters in Reston, Virginia. The five largest and most active data bases in WATSTORE currently contain nearly seven million records and have an annual growth rate of more than 325,000 records a year. WATSTORE was designed to allow users to input, edit, retrieve, and analyze hydrologic data. Its most important function is to provide one source of hydrologic data for the entire Nation. Table 12 and Table 13 provide information on the WATSTORE files and data bases based on information (M.D. Edwards and others, written commun., 1983) on both size of the files in kilobytes and number of records. By late 1990, there were more than 4 gigabytes of data in these files, increasing by nearly 200 megabytes of data each year.

Table 12. -- Major WATSTORE data bases and files showing current size and growth rate in kilobytes since 1983

[Source: The 1983 data are from M.D. Edwards and others (written commun., 1983). K-Bytes, kilobytes]

	Based on 1983 report						
	Size in 1983 K-Bytes	Est. Annual Growth rate K-Bytes	Projected Size 1990 K-Bytes	Actual Size 1990 K-Bytes	Fixed Record Size Bytes	Est. Record Size Bytes	Actual Annual Growth Rate K-Bytes
Header File	56,830	6,100	99,530	314,640	152		36,830
Daily Values File	1,040,000	104,000	1,768,000	1,210,754	1,600		24,393
Unit Values File	305,100	100,000	1,005,100	383,556		370	11,208
Ground Water Site Inventory	599,016	60,000	1,019,016	833,568		838	33,507
Water Quality File	748,700	60,000	1,168,700	1,082,026		340	47,618
Peak Flow File	35,900	3,580	60,960	75,810		143	5,701
Basin Characteristics	13,000	400	15,800	19,950	878		993
Master Water Data Index	207,000	10,000	277,000	289,803		596	11,829

Table 13. -- Major WATSTORE data bases and files showing current size and growth rate in records since 1983

[Source: The 1983 data are from M.D. Edwards and others (written commun., 1983).]

	Based on 1983 report				
	Est. Number Records	Est. Annual Growth rate Records	Projected Size 1990 Records	Actual 1990 Records	Actual Annual Growth Rate Records
Header File	373,882	40,132	654,803	871,444	71,080
Daily-Values File	650,000	65,000	1,105,000	756,721	15,246
Unit-Values File	824,595	270,270	2,716,486	1,036,637	30,292
Ground-Water Site Inventory	714,816	71,599	1,216,010	994,329	39,930
Water-Quality File	2,202,059	176,471	3,437,353	3,182,428	140,053
Peak Flow File	251,049	25,035	426,294	529,753	39,815
Basin Characteristics	14,806	456	17,995	16,849	292
Master Water Data Index	347,315	16,779	464,765	486,057	19,820

With the release of NWIS-I software in the mid 1980's, entry and processing of hydrologic data shifted from the central WATSTORE system to about 50 sites across the Nation. As the data were processed locally, the NWIS data were to be loaded into the WATSTORE System on a regular, monthly schedule (J.F. Daniel, written commun., 1987). However, more data records have been generated at local nodes than can be uploaded into WATSTORE. Hence, the local NWIS-I nodes contain more records in their subsets of NWIS-I than in the mainframe (Table 14). The Aggregated Water-Use Data System and the Site-Specific Water-Use Data System data bases are also maintained only outside WATSTORE on the local nodes, and together these contain an additional 1.7 million records (Table 15).

Table 14. -- Estimate of the total number of records in major files that exist on both WATSTORE and NWIS.

[Estimated percentage of records transferred is based on survey of NWIS data files. Estimated number of unique records and estimated current growth of records would reflect the numbers for a new national data base.]

	WATSTORE		Estimated percentage of records transferred from NWIS to WATSTORE	Estimated number of unique records	Estimated current annual growth rate records
	Actual 1990 records	Actual annual growth rate records			
Header File	871,444	71,080	70	968,371	90,465
Daily-Values File	756,721	15,249	70	777,515	19,408
Unit-Values File	1,036,637	30,292		unknown	
Ground-Water Site Inventory	994,329	39,930	50	1,105,246	62,113
Water-Quality File	3,182,428	140,053	69	3,381,586	179,885

Table 15 .-- National Aggregated Water-Use Data System and Site-Specific Water-Use Data System data base size and growth rates based on 23 districts using the system.

[AWUDS, Aggregated Water-Use Data System; SSWUDS. Site-Specific Water-Use Data System; K-Bytes, kilobytes]

	Total Hydrologic Records	Total Space K-Bytes	Average Annual Growth Records	Average Annual Growth K-Bytes	Maximum Annual Growth Records	Maximum Annual Growth K-Bytes
SSWUDS Estimate	760,379	305,060	11,8612	28,880	215,045	51,400
AWUDS Estimate	1,030,454	22,410	1,030,454	22,410	1,020,454	22,410

2.2 District Data Bases

To provide information on the size of individual data bases currently on the NWIS-I system, District data bases for California and Arkansas are shown in Table 16. California is the largest location in number of personnel served by one Prime computer. It should be representative of a large office data base. Arkansas was selected because it is approximately the median size of office locations.

Table 16. -- Major NWIS data bases and files showing current size and estimated growth rate for two example districts.
[K-Bytes, kilobytes]

File	Number of Records	Size of files in K-Bytes	Estimated annual growth rate in Records	Number of Records	Size of files in K-Bytes	Estimated annual growth rate in Records
	California			**Arkansas**		
Site File	60,636	47,800	400	19,160	19,998	1,000
QW File	177,063	114,800	4,000	104,485	66,872	300
GWSI File	56,075	146,638	350	35,000	46,952	500
ADAPS DV File	59,661	450,600	1,500	12,328	30,770	750
ADAPS UV File	1,630,505		600,00	847,188	305,850	140,000
Water Use Files				232,114	80,798	80,000

3. Function Processing Rates and Interactive Response Times

Function processing rates will depend on the number of simultaneous users, frequency of various types of retrievals, and whether the data base is distributed or centrally located. The software designers, as NWIS-I users, are experienced with the existing systems and are aware of the processing times that would be acceptable to users.

Interactive response time is the time required from entering information via a key stroke or mouse click until the software has taken an action and provided the user with a new possibility of action. Users understand and expect that many of the processes in the NWIS-II software may be done in background or batch mode; they do not want their terminal tied up by a job. They are willing to have a process running in a window as long as they can be using other windows on their workstation for another task. The multitasking capability of the computer platform upon which NWIS-II is based will provide the functionality desired by the users.

Interactive sessions of most concern to users are those when pieces of information are entered and they must wait for this information to be accepted and processed before the next piece of information is entered. Users had various answers to the question of what is an appropriate interactive response time. Some suggested that processes that allow only interactive mode should respond within 5 seconds and should take no longer than 1 minute to complete. Others have stated that the response time should be sufficiently rapid to accept normal typing speed in filling query or screen entry forms. Response time should be acceptable and consistent regardless of the physical location of the data and software.

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SYSTEM REQUIREMENTS SPECIFICATION FOR THE U.S. GEOLOGICAL SURVEY'S NATIONAL WATER INFORMATION SYSTEM II

CHAPTER 7. DESIGN CONSTRAINTS

J.C. Briggs, S.M. Trapanese, G.D. Rogers, and J.D. Christman

This chapter discusses items that will affect the design of NWIS-II. These items may limit full implementation of the requirements listed in the previous sections and will also have an impact on the course of the data base design work. The constraints are organized into five subject areas: hardware environment, software environment, organizational environment, implementation standards, and policy questions. The hardware platform for which NWIS-II is being designed is a 32-bit UNIX workstation, included in the DIS-II contract. The contract includes file servers and storage modules but does not include digitizers, large plotters, image scanners, and bar-code readers. Software also is included in the DIS-II contract. DIS-II supplied software includes text editors, an electronic report processing package (ERP), a statistical package, a relational data base management system, and a spreadsheet software package. All software packages are dependent on the operating system and limited by the problems associated with machine computations. To address the needs of users not met by commercial software, WRD written software will be produced by the Office of the Assistant Chief Hydrologist for Program Coordination and Technical Support, the Branch of Instrumentation, the Branch of Administrative Management Systems, the National Water Quality Laboratory, the Applications Assistance Unit within DIS, and others. NWIS-II software will be developed to provide for efficient corrective, perfective, and adaptive maintenance. Training, support, and documentation will be developed to facilitate the operation of NWIS-II by all users. Implementation standards will be followed to ensure software quality assurance. Policy questions that may have an impact on the design of NWIS-II are discussed in the last section of this chapter.

1. Hardware Environment

The hardware environment for NWIS-II will be the equipment included in the DIS-II contract. A complete listing of this equipment is available in the contract document. The following summarizes the equipment provided by the contract.

1.1 Workstations

NWIS-II will be designed to work on a platform of 32-bit UNIX workstations. A workstation is a desktop computer with a bit-mapped, high-resolution screen, mouse and keyboard. The DIS-II contracted 32-bit UNIX workstation, the Data General AViiON Model 300C workstation, is supported by the Data General DG/UX operating system, an implementation of the industry-standard UNIX operating system. The DG/UX system can support large files, recovery mechanisms, and symmetric multiprocessing. The workstation has a 16.67 (17) MHz 88100 processor and is rated as 17 million instructions per second. In the benchmark tests, the Data General workstation ran faster than

a Prime Model 9955, but a bit slower than a Prime Model 6350. The AViiON workstation is configurable from 8 megabytes (MB) to 28MB of memory. A minimum of 12MB of memory is recommended for each workstation.

A workstation can support up to seven small computer subsystem interface (SCSI) peripherals. Peripheral housing units are required to hold the seven devices. Each housing unit has 1.5 slots for full-height 5.25 inch devices. That is, one unit can hold three half-height devices.

The workstations can be configured as stand-alone systems, or as diskless nodes in Network File Server networks since their distributed applications capabilities make them ideal for client/server environments. A stand-alone workstation has its own disk for programs and data and does not need a file server. However, a stand-alone workstation can access disks on other workstations or a file server. File servers are anticipated to be used at most sites; however, small sites that will never have more than a few workstations may not install file servers.

1.2 File Servers

While a workstation can function as a file server, a file server cannot be used as a workstation. The DG file server is a rack-mounted computer that uses a terminal entirely dependent on the main computer for processing (dumb terminal) as a console; it does not support the bitmapped screen of a workstation. It is used to store and provide programs and data to other workstations over a local area network. Each server has one built-in serial port and one built-in parallel port.

The 6100 (single CPU) and the 6120 (dual CPU) servers use 19-inch computer racks and they require a combined storage subsystem for mounting SCSI disks. The combined storage subsystem is a chassis for mounting up to four SCSI devices in a standard 19-inch computer rack.

The 5100 server, which uses the same CPU as the 6100 server, includes an office environment rack that has built-in capability to hold SCSI devices. Therefore, the 5100 does not need the combined storage subsystem.

1.3 Disks and Peripheral Equipment

The 322 MB (megabyte) and the 662 MB disks can be attached to either a workstation or a server. A 1-gigabyte (GB) disk is available that can be attached only to servers. The 622 MB SCSI disks at the time of the benchmark had a data transfer rate of 1.5 MB/second. The 1 GB storage module disk had a data transfer rate of 2.6 MB/second. Since the time of the benchmark, the DG/UX operating system has been enhanced and now automatically supports the synchronous interface capability of those same 662MB SCSI disks. In this new "synchronous mode," the 662 MB disks now have a data transfer rate of 4.0 MB/second. Access time also has changed as a result of the synchronous SCSI. The average access time for the 662 MB SCSI disk is now 16.5 microseconds. The access time for the 1 GB storage module disk is 16 microseconds.

The server and workstation cartridge tape drives are identical. The workstation version goes in the peripheral housing unit. The 5100 server version mounts in the office environment rack. The version for the 6100 and 6120 surveyors is a combined storage subsystem.

Other hardware peripherals on the contract include a laser printer, a color dot matrix printer, a scanner, and a line printer. The laser printers are connected to the workstations and servers through RS-232 ports, but can be configured as print servers for other workstations. The scanner connects through an RS-232 port; the line printer connects through a parallel port.

The workstations and servers are connected to the local area network through a local area network controller. A system can be connected to the Geonet through the GS/1 IP router, which connects directly to the local area network.

1.4 Equipment Not Included in the Distributed Information System II Contract

To provide certain functions the users have requested, additional equipment not included in the DIS-II contract will be required. Examples of this type of equipment include large plotters, digitizers, and bar-code readers. During the design phase of NWIS-II, equipment to meet the users' requirements but not included in the DIS-II contract will be identified.

2. Software Environment

Users have requested that the NWIS-II software have close integration with software packages provided on the DIS-II contract or be purchased for general use at all DIS-II installations. To meet the users' needs, the DIS-II software, including spread sheet software and statistics software, will be utilized. Additional third-party software will be procured to allow NWIS-II to meet user requirements not addressed by DIS-II software. The need for specific software will be determined during the design phase of NWIS-II development.

2.1 Software Dependency on Operating System

The use of third-party software (software provided by other than the vendor of the hardware or by USGS) in NWIS-I was limited. The majority of NWIS-I software was developed using software supplied by Prime Computer, Inc., the hardware vendor for DIS-I. The major software dependency for NWIS-I was in the scheduling of upgrades to the Prime operating system. Each upgrade of the operating system required extensive testing of the NWIS-I software to ensure that it would operate correctly in the new operating system environment. During certain operating system releases, the FORTRAN compiler was modified extensively. When this occurred, NWIS-I software needed considerable changes to be compatible with the new compiler.

The dependency of NWIS-II on both third-party software and software provided by the DIS-II hardware vendor affects the management of DIS-II as well as NWIS-II. As in the past, there must be close coordination between the DIS and NWIS offices whenever an operating system update is scheduled. Because of the anticipated heavy use of third-party software within NWIS-II, release of revisions of this software must be coordinated with NWIS.

Ideally, the scheduled release concept would be applied to all software supported by the Division including DIS software, NWIS software, applications software developed by PC&TS, and financial and personnel software developed by Operations. Using a scheduled release, all revised software would be released as an extensively tested

package on a fixed schedule, such as monthly, quarterly, or twice yearly. All users would be required to update their machines with a complete set of software revisions within a fixed time period.

2.1.1 Potential Problems Associated with Machine Computation

Most numerical computations are not exact due to several problems, including: 1) inaccuracies in input data as a result of measurement or round-off of measured data; 2) inaccuracy resulting from storing input data in machine's floating-point real-number format; and 3) errors introduced during numerical computations on the data.

Most problems occur because the computer stores and computes numeric values using registers of a finite length. For example, most computers have 32 bits available to store a single-precision floating-point number which provides only 6 or 7 decimal digits of precision. The result of each arithmetic computation (add, subtract, multiply, or divide) also must be contained within the 32 bits.

Consider the following example where 2-digit decimal values are converted to 6-bit binary numbers:

Decimal	Binary
.00	.000000
.01	.000001
.02	.000001
.	.
.	.
.	.
.99	.111111

There are 100 distinct decimal numbers that must be converted to one of only 64 binary numbers. Thus, in some cases one binary number must represent two decimal numbers. When converting from decimal to binary, the conversion may not be exact and rounding to the closest binary equivalent must be done. When converting from binary to decimal, there may be ambiguity as to which of two decimal numbers is correct.

Floating-point numbers are stored in a computer in a form of scientific notation. That is, some number of bits are used to store the exponent and the remaining bits are used to store the fraction. For example, in a 32-bit machine, 8 bits will contain the exponent while 24 bits contain the fraction. In some computers, Prime for example, the sign of the number is in the first bit of the fraction, leaving just 23 bits of precision for storing the value. In the fraction part of the number, each bit represents the value of 2 raised to a power corresponding to the bit's position in the register. For example, the first bit has the value 2^{-1}, the second bit has the value 2^{-2}, the third bit has the value 2^{-3}, (the values are 1/2, 1/4, 1/8), and so forth. The exponent indicates placement of the binary point. In the Prime computer, the decimal value .1 is stored as the binary value 0.11001100110011001100110 times 2^{-3}, or 1/16 + 1/32 + 1/256 + 1/512, and so forth. However, if this binary value is converted back to decimal, the result is 0.099999994. Thus, some accuracy has been lost in merely storing the value.

The problem may be compounded each time a computation is done. Because of the loss of accuracy, computer arithmetic does not necessarily follow the associative laws of mathematics. In general, $A+(B+C) \neq (A+B)+C$.

The same is true, of course, for arithmetic computations other than addition. The growth, or accumulation, of round-off errors depends primarily upon three things: 1) word length (available precision), 2) computational procedure (order of calculation), and 3) size of problem (number of calculations, especially multiplications).

2.1.1.1 Methods of Control

There are several techniques that can be used to minimize the problems associated with floating-point arithmetic: 1) Use fixed-point arithmetic, 2) Use multiple-precision floating-point arithmetic, 3) Optimize order of calculation, and 4) Adjust calculated floating-point values by arbitrary small amounts to force agreement between computer-produced values and "true" values. These methods are discussed below:

Fixed-point arithmetic: Numeric values may be stored in computers without loss of accuracy by storing as character strings, integer values, or packed decimal values. There are advantages and disadvantages associated with each of these methods.

Character strings may be used to store numeric data. Data are generally entered in the computer as character data and information produced by the computer is generally converted to character strings before transmission to some output device, such as a terminal or printer. However, most internal computations cannot be done with character strings as most computers do not provide hardware capabilities for arithmetic manipulation of character data. The data must be converted to another form, usually floating-point, before computations may be done. Furthermore, each decimal digit requires one byte (8 bits) of computer memory, so other storage formats are generally more efficient.

Numeric data which are strictly integer may be stored in integer numeric variables, which can generally contain any integer value between -2,147,483,648 and 2,147,483,647. No loss of accuracy occurs in storage or in processing (as long as results fall within the range specified). Integer variables are efficient for storing data. The major drawback is that only integer values may be stored or calculated, and most real-world data are not in integer form.

Many computers provide a packed decimal capability for storing and manipulating decimal data. A packed decimal number consists of one byte containing a sign and one decimal digit. A variable number of additional bytes, each containing two decimal digits, may be included. The placement of the decimal point is arbitrary and must be managed by the programmer. For example, a 4-byte packed decimal number can contain the exact representation of any 7-digit value between -9,999,999 and +9,999,999. Packed decimal variables are quite efficient for storing numeric values relative to the other formats. Although the computer hardware will support the normal arithmetic computations, there is usually no software capability for trigonometric conversions or transformations such as logarithms or exponentials. Thus, for most scientific calculations, the packed decimal values must be converted to floating-point for processing. Another major problem is that many higher-level computer languages, notably FORTRAN, do not support packed-decimal variables.

Multiple-precision floating-point arithmetic: Floating-point computing and storage can be made more accurate by extending the length of the word--to use multiple-precision variables and processing. For example, double

precision on a 32-bit machine will have 48 or 56 bits available for representing the fraction portion of the number. (Some machines, such as Prime, will expand the exponent to 16 bits in double precision, others retain just 8 bits). However, there are a couple of drawbacks to using multiple precision. First, obviously more storage space is required. If multiple precision is used only for internal computations, the expanded memory use will probably not be a serious problem. Second, the time required for multiple-precision computing is roughly proportional to the square of the degree of precision. For example, double precision requires approximately four times as much time to complete as single-precision. However, with modern hardware, this may not be too significant. Even with multiple precision, the internal representation of many values will not be exact and some adjustments will be necessary when those values are presented to the user.

Optimize order of calculation: A loss of accuracy frequently occurs when numbers of like magnitude are subtracted. After subtraction, the result is shifted left (normalized) until the first bit is non-zero. This shifting can cause any round-off errors present at the extreme right (low importance) of a number to be moved toward the left (high importance).

Floating-point numbers are not uniformly spaced. They are more abundant near zero. For example, in a 3-decimal floating-point numbering system, there are as many numbers between $0.100*10^{-3}$ and $0.999*10^{-3}$ as there are between $0.100*10^{3}$ and $0.999*10^{3}$. In either case, 900 numbers are available, but the first group contains a range of only 0.000899, while the second contains a range of 899. In the real numbers of mathematics, an infinite number of numbers are contained in either group. Thus, grouping calculations to keep results as near to zero as possible will help to maintain accuracy by minimizing the use of available computer bits to represent the magnitude of a number and maximizing the use of bits to represent precision. Thus, a long series of additions and subtractions can be alternated (for like magnitudes) to keep the intermediate results small.

Adjusting floating-point values: Before floating-point values are transmitted to an output device, they must be converted to character strings. This will probably involve rounding. Values may also be rounded before storage in floating-point format. Since the internal representation of a floating-point value is generally slightly different (slightly less with Prime computers) than the "true" value, an arbitrarily "small" adjustment must be made to the value when rounding. The question is, how large should this adjustment value be? The following procedure is incorporated in the rounding program used in the NWIS-I ADAPS and GWSI systems:

First, the floating-point number is converted to the scientific notation character string S0.xxxxxxxxEsee; where S is the sign of the number, xxxxxxxx is the fraction, s is the sign of the exponent, and ee is the exponent. This conversion, using Prime operating system conversion routines, will round the number in the right-most position of the fraction string. Then, the string is tested to determine if, upon rounding, the number of digits will change. That is, a test is made if the number is close (from below) to one of the "threshold" values of .0, .1, 1, 10, 10...0. The test is made by creating a test value .99...95 where the number of 9's is equal to the accuracy desired. If the number is greater than or equal to the test value, the number is set equal to the threshold value.

After the threshold test is complete, the number is converted to another character string in the form S0.xx.xxEsee, where the number of x's is equal to the accuracy desired. This will cause rounding to occur in the right-most significant digit.

The resulting character string is then converted to an appropriate string of the form: [sign] [integer-part] [decimal point] [zeros] [fraction] where one or more of the elements in [] may not be required.

2.1.1.2 Recommendations

Recommendations are provided in three areas: (1) storage of input data, (2) internal computation, and (3) storage of results of computations.

Storage of input data. Input data should be stored as character strings or as packed decimal. With packed decimal it also would be necessary to include a variable indicating the accuracy (number of significant figures) of the input data. Use of one of these methods is the only way to ensure that the exact value of input data is maintained.

Internal computation. There is no satisfactory alternative to using floating-point variables and arithmetic for internal computations. However, the following measures can be employed to minimize loss of accuracy: (1) Use multiple precision whenever a series of calculations (especially multiplication) must be performed, and (2) Order calculations to keep intermediate results as near zero as possible.

Storage of results. As with input data, results should be stored in an exact form to the degree of accuracy warranted by the accuracy of variables used in computation. That is, results can be no more accurate than the least accurate element of a computation. For computations involving values of widely-different magnitudes (for example, subtracting water levels from surface altitude) this restriction may have to be relaxed. The results of computation should be rounded to the appropriate accuracy (probably including adjustment by adding or subtracting a "small" amount) and the results stored in some exact form such as character string or packed decimal (with indicator of accuracy also stored if packed decimal). At this time, the values need not be further rounded to some standard specification, such as publication standards. Such rounding can be done when the values are retrieved for output. As long as numbers are stored in some exact form, rounding can be done consistently and accurately.

2.2 Commercially Available Software

The DIS-II contract application software runs within a graphical window-based environment and can be divided into two categories, standard and optional. Standard software, provided for use in building application software, includes: ANSI FORTRAN and ANSI C programming language compilers, the IMSL statistics library, an ANSI Graphics Kernel System (GKS) library, a high-level graphics library, and a source-level debugger. Standard software also includes several programming and data editors, including a Unix version of the EMACS text editor, and a full suite of Unix utilities for text processing and file management. Optional software includes a software PC emulator (that allows PC applications to run on the DIS-II workstations); an expert system shell; computer assisted

software engineering (CASE) software; and several additional programming languages, including PROLOG, LISP, BASIC, PL/1, COBOL, PASCAL, and an object-oriented programming language.

2.2.1 Software Supplied by Distributed Information System II

The following software will be supplied by the Distributed Information System II:

2.2.1.1 Text Editors

A number of text editors will be available in DIS-II. These include FrameMaker, a powerful program for word processing and electronic report processing, described below; a simple mouse-oriented editor called xedit; two full-screen editors, vi and emacs; and two line-editors, ed and ex. In addition to these interactive editors, UNIX provides a large number of text manipulation programs, which can be linked together with "pipes," where the output of one program is fed directly into the input of another to provide very powerful text editing capability within the operating system itself.

The editors ex and vi are actually line-oriented and full-screen modes for the same program. The standard editor available on all UNIX systems is vi. The emacs provided by Data General is GNU emacs, an implementation that is equivalent but not identical to the version currently available on Prime. Xedit is a simple mouse-based editor, a standard tool on systems that support X Windows. The editor called ed is a limited, simple editor used almost entirely within other programs. It is terse, responding to all errors with a single character, "?".

2.2.1.2 FrameMaker

FrameMaker provides word processing, graphics, layout, composition of equations, and hypertext. FrameMaker is a "what-you-see-is-what-you-get" (WYSIWYG) package, which means that what you see on the screen is exactly what you will get when the document is printed. This includes symbols, super- and subscripting, bold-facing, mixed font sizes and styles, as well as graphics. The interface is mouse-driven, with pull-down menus for all commands. In addition, there are keyboard equivalents for all menu options. Multiple FrameMaker documents can be open at the same time, and text, formats, and graphics can be cut and pasted between documents.

In support of graphic applications, FrameMaker can import scanned images, selected areas of a screen-dump, Postscript, and computer graphics meta files (CGM). It also can import documents in the following formats; ASCII, troff, WordStar, WordPerfect, WordMarc, document interchange format (DIF), and document content architecture (DCA).

FrameMaker has a paragraph-oriented editor that can modify, catalog, and apply format characteristics for a paragraph. Each paragraph has a tag associated with the format characteristics in use on that paragraph. Changes can be applied to a single paragraph, all paragraphs with a given tag, or all paragraphs in a document. Paragraph format characteristics include: indentation (first, right, and left), space above and below a paragraph, leading (space between lines), text justification and hyphenation, font size type and style, automatic

paragraph numbering for list or chapter items, tabs (right, left, center, and decimal), and word and letter spacing.

FrameMaker uses templates (called style guides in some packages) that can be customized so authors can produce nearly camera-ready copy without having to concern themselves with any of the details of formatting. The Application Assistance Unit (AAU) at National Headquarters will be collecting and distributing templates with the eventual goal of providing templates for all WRD publications series, as well as for standard forms such as requisitions, memos, and travel vouchers.

FrameMaker includes a spelling checker. For each flagged word, this checker provides a list of possible spellings of the intended word that nearly always includes the correct spelling. It also offers options to ignore all subsequent occurrences of that word, and to add the word to a user's local dictionary.

2.2.1.3 Statit

Statit is a statistical package that meets the statistical requirements specified in the DIS-II contract specifications. In addition to supporting a large number of statistical analyses, Statit provides graphics capabilities that are integrated with the DIS-II windowing environment.

Statit is easy to use through a simple command interface, similar to that provided by the statistical package called Minitab. Statit also provides an X-windows-based "point-and-click" menu interface. Statit is similar to Minitab in the way that it handles data; all data are stored in "columns" or "variables" in a Statit workspace. Direct support for data tables and tabular file management is not available.

Statit provides a programming language that allows user-developed procedures to be created and integrated with the Statit system. Procedures are written using Statit commands and various standard programming constructs such as if-then-else constructs, do loops, arguments, and temporary variables. Once written, the procedures are compiled and then used the same as any other Statit command, and may be installed in such a way that they are available to everyone.

2.2.1.4 INGRES

INGRES is a general-purpose relational data base management system (RDBMS) that consists of a set of integrated tools. INGRES tools allow users to perform numerous functions including data-base creation, maintenance, data input, update, query, display, and print. There are different levels of user interaction with INGRES tools designed to accommodate new users, end users, more experienced users, and application developers. INGRES is a true multiuser RDBMS that provides concurrent handling and a dynamic data dictionary.

INGRES has three basic components--user interface, query language, and data manager. The user interfaces provide a means for users to generate instructions that are passed to the data manager to accomplish specific tasks. User interfaces fall into three categories: 1) forms-based, 2) system-level, and 3) embedded-query language. A forms-based interface provides a simple, easy to use, end-user interface to INGRES tools that

perform powerful tasks. Users at every level of expertise are likely to use INGRES tools that are based on the forms-based interface. Users see the forms-based interface on the screen as a menu of available functions along with some type of form, such as a data record form or report form. The system-level interface allows more experienced users to issue query language statements directly to the data manager. Embedded-query language allows the applications developer to incorporate INGRES data base instructions within host language programs. INGRES applications may be embedded within FORTRAN and C programs.

INGRES provides the ANSI Structured Query Language (SQL), which passes instructions to the data manager from the user interfaces. The data manager performs all basic INGRES tasks, such as data updates, retrievals, concurrent handling, and data dictionary management. Users and the data manager interact by way of user interfaces.

The applications developer has several tools available to help generate custom INGRES systems. The Visual-Forms-Editor allows developers to generate forms to be used in a customized forms-based system. The applications-by-forms allows developers to use INGRES system language to write, compile, and link programs that contain INGRES instructions and tools.

2.2.1.5 TACTICIAN

TACTICIAN is a general-purpose spreadsheet software package, similar in functionality to the 20/20 spreadsheet software currently used on the DIS-I Prime computers. In addition to the ability to support standard spreadsheet computations and graphics, TACTICIAN can interface directly to several RDMS's, including INGRES. TACTICIAN can be used within the X-window environment, or on a dumb terminal connected to a workstation.

This package supports a wide variety of graphic output devices including various graphics terminals, Hewlett-Packard model 7475 and 7559 plotters, PostScript laser printers, QMS model PS-810 and PS-2200 laser printers, and Hewlett-Packard Laserjet printers. TACTICIAN can output graphics in ANSI standard computer graphic meta (CGM) files, which can be edited and incorporated in reports using the DIS-II electronic report processing software, FrameMaker.

TACTICIAN includes a translation utility (tlate) that can be used to translate files to either the TACTICIAN or 20/20 spreadsheet file formats. The source data formats recognized by tlate include: Lotus 123, Multiplan, 20/20, and Data Interchange Format (DIF) files. DIF files can be created by many commercial spreadsheet software packages and by the INFO, P-Stat, and OUTWAT software packages used on the DIS-I Prime computers.

2.2.2 Other Procured Software

Follow-on procurements are planned for interactive charting, interactive graphic editing, and geographic information system (GIS) software. The interactive charting software will provide a capability similar to the currently provided TELLAGRAF, but will be easier to use. The interactive graphics editing package will provide capabilities for creating publication-quality illustrations and high-quality presentation graphics. Graphics can be created from scratch or, more commonly, by editing graphics created by other DIS-II (or Prime) software. The

follow-on, Survey-wide contract for GIS software for UNIX workstations, including DIS-II, will allow enhanced site location and areal data analysis in NWIS-II. Until the GIS contract is awarded and the software is installed, a limited number of ARC/INFO licenses are being transferred to the DG platform.

2.3 Interface to Software Written by WRD

User requirements not addressed by commercial software will be addressed by application software developed within WRD. This section describes the integration of software written by WRD into the NWIS-II. The different WRD units with responsibilities for developing software applications are: Office of the Assistant Chief Hydrologist for Program Coordination and Technical Support, the Branch of Instrumentation, the Branch of Administrative Management Systems, the National Water Quality Laboratory, and the Applications Assistance Unit within DIS.

2.3.1 Application Software Developed by the Office of the Assistant Chief Hydrologist for Program Coordination and Technical Support (PC&TS)

The offices of SIM/NWIS and PC&TS each have responsibilities for developing application software to support the WRD mission to store, process, and disseminate hydrologic data. In NWIS-II, the office of PC&TS will develop NWIS-II applications that are appropriately in its purview, and NWIS-II personnel will be responsible for providing access to the application and, in selected cases, graphical output from the application (see Figures, section 7.3 of Chapter 3).

The first sections list the roles in application development as seen by the office of PC&TS on February 22, 1990. Minor modifications to the original listing are ***italicized.*** The second section lists additional NWIS-II requirements that should be addressed by the office of PC&TS. The last section lists those items for special consideration.The following two items describe NWIS-II's responsibilities to the users of PC&TS applications.

(1) NWIS-II has the responsibility to provide users access to run PC&TS applications while inside NWIS-II. NWIS-II shall allow the use of the multiwindow and multitasking environment of DIS-II for PC&TS applications without any direct effect on the NWIS-II software.

(2) NWIS-II also has the responsibility to provide the PC&TS applications a means to retrieve and store data in the RDBMS. PC&TS applications would use the NWIS-II data retrieval function to specify the type and amount of data to be retrieved and would use the output function to obtain these data in a format described in Supplied Interchange Formatted Files, section 7.5.1 of chapter 3. (Since NWIS-II allows users to define "scripts" and run them in an interactive or non-interactive mode, PC&TS applications could submit the NWIS-II retrieval and output tasks in a background or batch mode of operation.) PC&TS applications would also use the NWIS-II input and edit and verification functions to store data in the data base.

2.3.1.1 PC&TS Stated Application Responsibilities

PC&TS responsibilities fall under the topics of: basic data computations, graphics, statistical analyses, data QA/QC processing, hydrologic process models, spatial data analysis, decision support systems for calibrated models, surface/ground/quality process modeling linkage, data base interfaces, and applications tool box for PC&TS software. Each function developed by PC&TS shall be seamlessly accessible from within NWIS-II, i.e., the users should notice no difference between the "look and feel" of functions developed by PC&TS and the "look and feel" of functions developed by NWIS-II personnel. Specific PC&TS functions are listed below by topic.

BASIC DATA COMPUTATIONS

- slope-area indirect measurement of peak flow
- 1-D unsteady flow model (BRANCH) for flow computations
- culvert rating, indirect measurement of peak flow
- processing channel cross-section data and computation of hydraulic properties

GRAPHICS

- x-y, logx-y, x-logy, logx-logy ($\log_{10}$ and natural log)
- computations for probability plots
- computations for time-series plots
- computations for duration hydrographs
- *overlaid multiple x-y plots*
- rating plots
- channel cross-sections
- network diagrams (schematics)
- box plots
- whisker plots
- Collins diagrams
- frequency histograms
- bar charts
- pie charts, *with a maximum of 9 slices*
- piper diagrams
- stiff diagrams
- irrigation (salinity hazard) diagrams
- point-value mapping with boundary overlays
- area shading with boundary overlays
- point location mapping with boundary overlays
- choropleth diagrams (maps) with boundary overlays
- display of geophysical logs
- diagrams of geologic cross sections *to include fence diagrams*
- hydrographs from water-use facilities or other water users

STATISTICAL ANALYSES PLUS APPLICABLE DISPLAYS

- generalized least squares for regional analyses
- network analysis
- WRC Bulletin 17B flood frequency analysis
- Stedinger/Cohn maximum likelihood frequency analysis
- computation with national flood frequency equations
- low-flow correlation and record extension
- record extension by Allen/Burns/Hirsch method
- seasonal Kendall Tau trend analysis
- flow (concentration or loads) duration analysis
- n-day hi/low flow to include concentrations and loads
- log-Pearson Type III frequency analysis of n-day hi/low annual series *plus appropriate tables*
- plain-Pearson frequency analysis
- monthly/annual *daily value* (instead of just flow) statistics
- annual reservoir storage-yield analysis
- reservoir storage frequency
- load computation with seasonal terms, bias correction for transport curves
- descriptive statistics for censored data
- Tobit analysis for regression with censored data
- trend analysis using smooths and graphical interface
- LOWESS smoothing routine
- P-value for contingency table analysis
- statistics subroutine library by Hirsch, Slack, Heisel, and Kirby
- general time-series data transformations
- kriging and interpolations
- extended streamflow prediction (ESP-NWS)
- stochastic climate generator
- national flood frequency program (NFF)

DATA QA/QC PROCESSING

- water quality
- surface water
- basin characteristics
- ground-water site inventory

HYDROLOGIC PROCESS MODELS

Surface Water

- RRM (A634,G824,E784) Rainfall/Runoff Model
- DR3M Distributed Rainfall/Runoff/Routing Model
- HSPF Hydrologic Simulation Program- FORTRAN

- PRMS Precipitation Runoff Modeling System
- Inmann/Sauer dimensionless hydrograph model
- WSPRO Water Surface Profile program
- XHYDROP cross-section hydraulic properties
- NCALC n-verification - indirect measurements
- BRANCH 1-D flow model
- HYDRAUX 1-D flow model
- FESWMS 2-D horizontal flow model
- CONROUT convolution unit response routing
- A697 reservoir downstream-upstream routing
- DAFLOW unsteady flow diffusion analogy
- HYSEP baseflow separation
- ground-water/surface-water interactions (J349)
- 3-D flow model
- sediment transport and alluvial channel morphology (GFLUVIAL, GSTARS)

Water Quality

- BLTM Branch Lagrangian Transport Model
- HSPF-qual basin point-nonpoint runoff, transport, budget model
- DR3M-QUAL urban watershed nonpoint model
- QUAL2e steady-state water quality
- PHREEQE mass transfer for geochemical reactions
- WATEQF element specification and mineral saturation

Ground Water

- MODFLOW 3-D modular finite difference
- MODFE 2-D finite element
- MOC 2-D transport
- STRA 2-D finite element transport
- MODPATH particle-tracking
- GW transport analytical solution
- aquifer test analysis
- VS2D variable saturated fluid flow
- HST3D 3-D ground-water flow, heat, and solute transport
- RADFLOW radial symmetric flow to a well

SPATIAL DATA ANALYSIS

- raster and image processing (ELAS, GRAS)
- basin delineation software
- surface modeling
- preprocessor to ground water, riverine, lacustrine, estuarine modeling
- AML's for ARC/INFO in coordination with WA&DC and SIM
- GIS interfaces to GW modeling

DECISION SUPPORT SYSTEMS FOR CALIBRATED MODELS

SURFACE/GROUND/QUALITY PROCESS MODELING LINKAGE

- develop designs, procedures, data bases, and shells

DATA BASE INTERFACES

- NWIS-II to applications data bases--*(application data base interface(s) to NWIS-II)*

APPLICATIONS TOOL BOX FOR PC&TS SOFTWARE

- system user interface
- applications data bases
- graphics tool box

2.3.1.2 Additions to PC&TS from NWIS-II User Requirements

The NWIS-II team has attempted to list or reference those functions desired by the user groups that are in the purview of PC&TS but, as far as the NWIS-II team knows, have not been considered by PC&TS. The organization of this section parallels the prior section.

DATA COMPUTATIONS AND MANIPULATIONS

- Computation of sediment discharge
  (1) Empirical method (See Empirical Sediment Discharge, section 6.3.8.4.5, in Chapter 3,.)

  (2) Flow duration--Not all sediment records are computed on a daily basis. Where daily values are neither desired nor obtainable, a common approach to computing suspended-sediment records for a year or some other designated period of time is described by Ringen (1980). The sediment rating curve-flow duration method combines sediment transport techniques with flow duration techniques and is a useful tool for estimating sediment discharge see Provide several methods to estimate missing sediment record, Requirement 6.3.8.5-1 in chapter 3.

  (3) Group averages method

  (4) Daily Accumulation method

  (5) Bedload and bed-material formulas
- Flow routing--Simplified flow routing method for estimating missing surface-water record
- Nonlinear interpolations between x-y data pairs (see Provide the ability to interpolate between X-Y pairs, Requirement 6.2.4-4 in Chapter 3) and any time adjustments not described in Manipulation of Time-Series data, section 6.2.2 in Chapter 3.
- Automated techniques for handling special data qualifiers (Table 3 in Chapter 3) for NWIS-II retrieval, computations, and output. Some of these procedures needed for the treatment of data below the reporting limit have been outlined in a BSA Technical Memorandum.

- A preprocessor that would apply data compression techniques to NWIS-II input data from PC&TS application software. More specifically, there may not be a need to store all values from a simulation to describe the input when only a few are statistically significant or necessary.
- Advanced Biological Calculations and Interpretations:

  NWIS-II will provide a basic suite of computational routines to perform most biological calculations as specified in the TWRI. Certain TWRI determinations and methods of determination not contained in the TWRI and not addressed by NWIS-II should be software developed by PC&TS.

  (1) Oxygen-curve method for estimating primary productivity and community metabolism in streams (see Diel Oxygen-Curve Method for Estimating Primary Productivity and Community Metabolism in Streams, section 6.3.10.10.5 in Chapter 3).

  (2) Oxygen-curve method for estimating primary productivity and community metabolism in stratified water (see Diel Oxygen-curve Method for Estimating Primary Productivity and Community Metabolism in Stratified Water, section 6.3.10.10.6 in Chapter 3).

  (3) Species richness determinations on analyses that may not have a taxonomic classification to the species level.

  (4) Percent dominance

  (5) Community structure of some type of diversity measure

  (6) Percentage of times a taxon has occurred at a station

  (7) Total number of taxa summed per station and the average number of taxa collected at a station.

  (8) Percent of total taxon by gender, larval stage, or age.

  (9) Total number of individuals for biomass determinations.
- Hydrologic event notification:

  There are useful ways to analyze probable flood events by comparing telemetry discharge data against district flood priority plans, historical extremes, and flood frequency data. PC&TS shall provide software for statistical analyses and comparisons of data, which will automatically generate summaries that will be stored in NWIS-II. NWIS-II will provide the capability to automatically compare the summaries with current data and provide notification. For example, telemetry gage-height values could be checked against the gage-height values that correspond to discharge at selected probabilities of exceedance using the districts version of their present stage-discharge relationship.

  Another aspect of hydrologic event notification is to compile a report to district flood coordinators that shows date and time, and values of stage and discharge that are observed at streamflow-gaging sites along with historical and flood frequency data. This would be helpful for coordinating data-collection activities, informing senior staff of high streamflow events, and for putting out news releases (examples provided to PC&TS; source code available from Rob Moffat, NWIS). Similar

computer programs using different data comparisons and statistical analyses could be written to assist district and regional surface-water specialists in evaluating low-water or regional drought conditions.

GRAPHICS AND STATISTICS

- color separation of overlaid plots

  The ability to visually separate overlaid plots through the use of contrasting colors is needed by the users. When plots are overlaid in the same window, it is helpful to visually separate them with different colors.

- display/output of water-use octopus diagrams
- 3-D perspective charts and plots
- 3-D similarity trees
- durov diagrams
- rotation of a graphical screen image

  The ability to rotate a graphical screen image shall be provided. Geographic and other spatial data are often better understood when rotated from their original screen display position.

- well strips (symbolic logs)
- lithologic sections
- Theis curves for determining transmissivity
- structure contour map
- structure thickness map
- 3-D surfaces
- cluster analysis
- ordination figures
- multivariate plots
- sediment grain-size distribution statistics
- statistics to determine extremes: peaks above base and troughs
- recurrence interval statistics
- mean population density
- percent of total for species compared at multiple locations

HYDROLOGIC PROCESS MODELS

Water Use

- IWR-MAIN forecasting of urban water use
- water budget model
- aquifer pumpage estimation
- retrieve water-use data from NWIS-II and link to a digital, defined model grid

QA/QC PROCESSING FOR WATER USE

- assessment of coefficients applied to an area
- assignment of accuracy to aggregated data based on method of acquisition and/or data source
- descriptive statistics
- comparisons of results from different data years

OTHER DATA BASE AND SYSTEM INTERFACES

- Interface between WRD sediment laboratories:
  (1) notification to lab of scheduled sampling
  (2) importation of sampling information from EFN's (electronic field notebooks)
  (3) reading and storage of scanned images, such as paper field notes, samples bottles, text, or bar codes
  (4) notification from lab of scheduled lab work
  (5) notification from lab of reruns
  (6) transmission of analyses results and updates
  (7) requests to the lab for specific QA/QC checks
  (8) notification from lab of QA/QC checks
  (9) notification from lab of updates
- Derive standard input forms for non-WRD laboratory data for water quality, sediment, and biology

2.3.1.3 Special Considerations

Although PC&TS has agreed to supply all graphical needs of NWIS-II users, certain graphical displays are critical to the input, verification, and derivation/computation of NWIS-II basic data. As a minimum, NWIS-II plans to supply its users with the ability to display simple linear and logarithmic x-y data plots (see Figures, section 7.3 in Chapter 3). These graphical representations are critical to data input and verification (see Graphical Input and Editing, section 4.7 in Chapter 3). In addition, NWIS-II plans to provide its users with a graphical curve-fitting tool, as described in Interactive Graphics, section 6.2.6 in Chapter 3.

The NWIS-II user groups described some functions that may be the responsibility of either PC&TS or NWIS-II. These are:

- The calculation of data summaries for the water-use octopus diagrams (see Octopus Diagrams, section 6.3.9.5.3 in Chapter 3).
- The printing or display of preprinted hydrograph forms (see Requirement 7.3-3, Provide the ability to output preprinted forms, in Chapter 3).

The NWIS-II user groups described a help function that is not the responsibility of either PC&TS or the NWIS-II: Provide technical information in an electronic form accessible by the NWIS-II help system (see Requirement 1.3.2-2, Provide help from several sources, in Chapter 3). The SPG will assign the responsibility for the development of these functions. The publications specifically requested by the user groups to be available electronically are listed below.

- WRD Publications
  (1) Estimating Pumping Time and Ground-Water Withdrawals Using Energy-Consumption Data WRIR 89-4107 [GW]
  (2) Analytical methods
  (3) TWRI's
  (4) explanation of algorithms
  (5) technical bulletins
  (6) Water Supply Papers
- Non-WRD Publications
  (1) Material safety data sheets (MSDS)
  (2) U.S. EPA health advisories
  (3) U.S. Federal Register Regulations

2.3.2 Branch of Instrumentation (BOI) Software

Historically, the Branch of Instrumentation (BOI) and NWIS have coordinated the development of software to read, transport, convert, and input field-recorded data into the NWIS data bases. This has been a productive partnership that has overseen the development and continued enhancements of SATIN and DECODES. NWIS expects this coordination shall continue during development and maintenance of NWIS-II and beyond.

2.3.2.1 Responsibility

The BOI will be responsible for the development and testing of software to read, decode, transport, and convert DCP, EDL, Telephone, and line-of-sight radio relayed instrumentation data from the field into a standard input format to be subsequently entered into the NWIS-II data base.

2.3.2.1.1 SRS Requirements to be Fulfilled by BOI Software Development

The BOI shall satisfy the following requirements as specified in the SRS by developing new software or modifying existing software.

(1) All requirements in section 4.1.1.2, Electronic Data Loggers, in Chapter 3, Functional Description.

(2) All requirements in section 4.1.1.3, Portable Field Computers, in Chapter 3, Functional Description.

(3) All requirements in section 4.1.1.5, Satellite Relayed Data, in Chapter 3, Functional Description.

(4) All requirements in section 4.1.1.6, Telephone Relayed Data, in Chapter 3, Functional Description.

(5) All requirements in section 4.1.2, Reading and Decoding Data, in Chapter 3, Functional Description.

(6) All requirements in section 4.1.3, Transforming Instrumentation Data to Engineering Units, in Chapter 3, Functional Description.

(7) Requirement 4.1.4-1, Transfer preprocessed data into NWIS-II standard format, in Chapter 3, Functional Description.

(8) All requirements in section 8.2.1, Monitoring Instruments, in Chapter 3, Functional Description.

Presumably, items 1 through 7 above shall be satisfied by modification or redesign of the DECODES and SATIN software, and item 8 shall be satisfied by modification or redesign of the Automated Instrument Monitoring System (AIMS) software.

Although the following requirements technically fall under the responsibility of BOI, they have historically been the responsibility of NWIS and shall continue to be the responsibility of NWIS:

(1) All requirements in section 4.1.1.1, Analog-to-digital Recorders, in Chapter 3, Functional Description.

(2) All requirements in section 4.1.1.4, Analog Recorders, in Chapter 3, Functional Description.

2.3.2.2 Coordination

2.3.2.2.1 Personnel

The BOI personnel involved in the development of the above-specified requirements shall coordinate work with the Preprocessing and Data Base Design teams of the NWIS-II Data Base and Software Design and Development Unit.

2.3.2.2.2 Software Interfaces

The software interface format used to enter data into NWIS-II from field instrumentation shall be a modified version of the Standard Input Forms (SIF) as used currently among DECODES, SATIN, and NWIS-I. The use of the current SIF will provide near compatibility with existing systems and shall make conversion of the existing DECODES, SATIN, and AIMS software easier. The current SIF will have to be modified to accommodate the NWIS-II data base design, which is significantly different from the NWIS-I data base.

The DECODES software shall be ported to the DIS-II platform and shall be integrated into the NWIS-II navigation paths to facilitate a seamless "look and feel" to the users for entering and processing data.

The satin software shall be ported to the DIS-II platform, if deemed necessary by BOI (SATIN may reside on 386 or 486 PC's).

- **DECODES, SATIN, AIMS, and any other software developed by BOI to read, decode, and convert field instrumentation data (if ported to the DIS-II platforms) shall be integrated into NWIS-II menus by use of the user interface management system (UIMS) in use by NWIS-II.**

  Links between DECODES and the NWIS-II data base shall be provided to facilitate the development of programming scripts and instrument configuration files to be used to program DCP's and EDL's for data collection and for decoding the field instrumentation data into SIF. These links shall provide information to include but not be limited to USGS site, sampling point, measurement methods, and parameter ID information. If a benefit to users, DOI, and/or NWIS can be demonstrated, DECODES or SATIN data structures shall be integrated into the NWIS-II data base.

2.3.3 Branch of Administrative Management Systems Software

The Branch of Administrative Management Systems is developing a new Administrative Information System (AIS), which will be the repository of information that users have requested be accessible through NWIS-II. Information about projects (project number, description, and such definitions as purpose, scope, sites, and study areas) will be essential to the various input and edit and verification functions of NWIS-II. Information about the qualifications, experience, and training of the personnel involved in obtaining data must be accessible to the project chief and project reviewer. Likewise, information about the equipment and supplies used in obtaining the data should also be available. Project information concerning optimized workloads and timelines, as well as reports of project status, purchasing, billing of samples, and supply inventories should also be accessible from within NWIS-II. Coordination must be maintained between NWIS-II and AIS to make this information accessible to authorized individuals and to maintain the privacy of individuals, as mandated by the Privacy Act.

Coordination must be maintained among the development teams of AIS, NWQL, and NWIS-II for development of an integrated sample management system. AIS will have the following responsibilities of the sample management system found in Chapter 3, Functional Description:

- Requirement 8.1-1, Provide the ability to plan sampling activities and laboratory analyses
- Requirement 8.1-2, Provide the ability to update project sampling schedules
- Requirement 8.2.3-1, Provide the ability to monitor NWQL charges against project funds

2.3.4 National Water Quality Laboratory Software

The National Water Quality Laboratory (NWQL) is developing a new Laboratory Information Management System that will be fully integrated with NWIS-II and AIS. NWIS-II users will have the full functionality of an automated sample management system, such as sample-load assessment and scheduling, sample tracking, transmittal of analytical results and associated quality-control data, project-defined and lab-defined verification checking, and rerun requests. Responsibilities for the development of the NWIS-II sample management system have been divided among the development teams of AIS, NWQL, and NWIS-II. Coordination must be maintained in designing the common RDBMS and to ensure that all the applications for the sample management system are completed without redundancy. The NWQL shall have responsibility for the following requirements or enumerated parts of the requirement found in Chapter 3, Functional Description:

- Requirement 8.1-3, Provide the ability for districts to define a suite of laboratory analyses
- Requirement 8.2.3-2, Provide ability to monitor the status of NWQL samples
  (1) condition of shipment when received at the NWQ
  (2) bottle location within the NWQL
  (3) sample bottle disposition schedule
  (4) schedule status
  (5) reporting group status
  (6) test identifier status
- Requirement 8.2.3-3, Provide the ability for notification of samples received by the NWQL
- Requirement 8.2.3-4, Provide the ability to enter NWQL analyses results
- Requirement 8.2.3-5, Electronic transfer of NWQL analyses to districts
- Requirement 8.3.2-1, Provide the ability to check NWQL analytical results that exceed water-quality alert limits
- Requirement 8.3.2-4, Provide the ability for appropriate routing of alert notifications through NWQL personnel to appropriate personnel

2.3.5 Software Supported by the Applications Assistance Unit of the Distributed Information System

The distributed spatial data library (DSDL) will be a WRD-supported repository of spatial data and spatial data-processing programs to be used in hydrologic investigations. The AAU is responsible for this effort, which is in the planning phase. The design and implementation phases should occur in the next few months. NWIS-II will utilize this library in several ways. The spatial data (thematic maps) will be used as a visual aid to orient the user to the geographic features in the area surrounding the NWIS-II site(s) of interest. This visualization will serve as a guide when inputting, editing, and retrieving NWIS-II information. The thematic maps will also be used to automatically populate the geographic type attributes in the NWIS-II data base (e.g., state, county and hydrologic unit names; elevation; river reach number), thus eliminating the need for users to determine and type in the attributes. The spatial data-processing programs will be used in NWIS-II whenever possible. The functions of these programs have not been determined at this time. Coordination must be maintained between NWIS-II and AAU to avoid duplication of programming for requirements in the following sections of Chapter 3, Functional Description:

- 4.7.2, Site-Location and Attribute Information
- 5.1.5, Geographic Information System Checks
- 7.3, Figures

The AAU is developing ERP templates for some publication-quality tables and for some standardized report formats, such as the annual-report manuscript. Coordination between AAU and NWIS-II must be maintained so that NWIS-II users may enter NWIS-II data into AAU report templates. See requirements in the following sections of Chapter 3:

- 7.1, Manuscript Preparation
- 7.2, Textual Data
- 7.4, Tables

Users also want online or near-online access to various publications such as WRD TWRI's. Depending on the decisions of the SPG, DIS or AAU may be responsible for these documents, and NWIS-II must then provide access to these documents from within NWIS-II (Requirement 1.2.2-1, Provide Help From Several Sources, in Chapter 3).

3. Organizational Environment

The organizational environment is another factor affecting the final design of NWIS-II. The design will be affected by the planned maintenance policy, the needs for software documentation, and training and support.

3.1 Maintenance Policy

The maintenance function has been discussed earlier in this document. The purpose of this section is to specify requirements for the development of NWIS-II software that will ensure the software is maintained at a reasonable cost after initial release. Often the cost of maintenance far exceeds the cost of the initial development of the software.

Software maintenance is a combination of activities resulting in changes to the software. The most familiar is the corrective maintenance where an error must be fixed. A second type is perfective maintenance, which adapts the software to changes in the needs of users within the Water Resources Division. New functionality is added to the software with this type of maintenance. Another major software maintenance activity is adaptive maintenance, which modifies the software to accommodate changes in computer hardware, the operating system, or third-party software.

3.1.1 Software Documentation and Traceability

The functions within a program or module must be traceable back to the requirements. Maintenance personnel must be able to see the intent of a program and why certain actions were taken. These comments may be included with the code but, by use of structure design tools, these requirements should be traceable, through development specifications back to NWIS-II requirement specifications. Testing is one method that ensures traceability.

There are three levels of testing of primary importance to developers of the software. These are system testing, integration testing, and unit testing. Unit testing is often broken into program and module testing. For each level of testing, test data sets need to be developed, added to with new test cases, documented, and maintained.

A written test plan addresses each of these levels of testing, solidifies decisions, and communicates these decisions to all members of the development and maintenance staff. The plan provides a measure of progress and is available for review/sign-off, revision, and reuse. Completion of items in the test plan indicates when the software is ready for acceptance testing.

Testing at the different levels should be automated as much as possible. Tests should be run, compared with previous tests, and the differences highlighted. Baselined test runs would provide assurances that modifications to the software have not changed the results in an unanticipated way. Satisfactory results would then be baselined for future tests. Test data sets, plans, and procedures should be complete prior to the acceptance of the software by the maintenance personnel.

Change control is a set of formal procedures that provide orderly control of change in a dynamic environment. Changes go through all the stages of the life cycle. Change management documents the change, ensures that the change meets the requirements, and publicizes the status of the change to other developers or maintenance personnel.

The configuration management system is a combination of administrative procedures, change controls, and automated version controls. This is being established for NWIS-II under the leadership of the Quality Assurance and Configuration Management Unit. All software and documentation for NWIS-II must be functional under the configuration management system developed prior to its acceptance by maintenance personnel.

3.1.2 Implementation Standards

The Software Quality-Assurance Plan for the National Water Information System-II (Dempster and Merk, 1990, written commun.) describes the implementation standards required for each phase of the life cycle. The documentation of these standards is a joint effort of development personnel, maintenance personnel, quality-assurance personnel, and in some cases, the users. The Software Quality-Assurance Plan must be completed and agreed upon within NWIS. The documentation required for each phase of the life cycle must be completed prior to major work being initiated in the next phase.

Implementation standards are essentially documentation of the four cornerstone activities of quality assurance described in Dempster and Merk (1990, written commun.). These activities are standards and procedures; reviews, inspections, and walkthroughs; testing; and configuration management.

Standards and procedures consist of a four-level hierarchy. Policies are directives that originate with management. Standards describe what makes products acceptable and how to measure product quality. Procedures describe methods for proceeding or steps to accomplish tasks. Guidelines are a set of instructions that describe the procedural methods but are optional and serve as guides. Formal documentation of standards and procedures are required.

Reviews, inspections, and walkthroughs are formal and informal evaluations and audits to alert management and development personnel regarding actual or potential problems in meeting goals for software quality. The reviews and inspections are formal and are held at strategic points during the software life cycle, usually at the end of a life-cycle phase when specific products are finished and become input to the next or another phase. Walkthroughs are usually held informally as needed throughout the life cycle. Walkthroughs are usually held as peer reviews or in small groups to communicate, integrate, and assign work tasks throughout the life cycle. Both the procedures

used in formal reviews and inspections, as well as detailed acceptance criteria, must be documented prior to the initiation of any work for that phase of the life cycle.

Testing begins at low-level (unit and module) and works outward toward integration and system testing and finally to acceptance testing of the entire system. Different testing techniques are used at different points in the life cycle. Developers and users conduct low-level software tests while an independent test group conducts the high-level acceptance tests. Test sets and test cases are developed, documented, added to, and maintained throughout the life cycle. Criteria for acceptance testing must be developed and documented early in the life cycle so that developers and users who perform the acceptance testing agree on common goals.

Configuration management is a set of activities developed to manage change throughout the software life cycle. Items that compose all information produced as part of the software development effort are collectively called a software configuration. As development progresses, the number of configuration items grows rapidly. Each life-cycle phase spawns additional items to create a hierarchy of information. The four main tasks of configuration management are identification of all items, providing a mechanism for change control, configuration auditing for review and inspections, and status accounting or reporting to provide answers to "what, who, when, and what else is affected" questions.

3.2 Training and Support

The largest demands for training and support will come with the initiation of NWIS-II which will be new to all users. The software application is new which means there is a likelihood for more software problems than would be found in an established application. As the software matures with subsequent releases, expertise increases at every node, which will result in lower demands for both training and support. Also, the types of training will change as NWIS-II matures.

3.2.1 Support

The current NWIS-I system has four data base managers who provide telephone, electronic mail, and bulletin board (continuum) support for users. This support is provided by hydrologic discipline because the four parts of the current system are organized by discipline. As an integrated system, NWIS-II support will be provided by what appears to users as one source. One phone call or one electronic message would be all that is required to obtain assistance. During the initial period of installation and use of NWIS-II software, the support facility will require heavy staffing to meet the needs of the users. The user support shall not consist of NWIS-II developers; this would be difficult to handle in addition to their other tasks.

Support should be available during core working hours (9 a.m. to 3 p.m.) for most locations. Personnel who provide the support should be able to immediately answer simple questions on installation and use of the software. More difficult problems will be referred to special NWIS-II support personnel. Users will receive an acknowledgment of their problem and an estimate of when their problem will be resolved within 1 working day. Problem reports will be tracked electronically to ensure that each problem is resolved and to provide management information on problem areas within the software.

3.2.2 Computer-Based Training

New users of the system should be able to use an online tutorial that would explain how to use NWIS-II. The tutorial should be tied to online help messages so that the new users could receive additional or more thorough information by pressing a button. Users have used hypertext as an example of the way they would like to see the tutorial work. The tutorial should be sufficiently complete so that new users could use the system to do a simple input, edit, and retrieval of data.

Tutorials shall be arranged so that individuals may learn to use those parts of the system they need for their work. The tutorial should consist of at least seven independent parts. Six parts would include entering, processing, and retrieving surface-water, water-quality, ground-water, water-use, biological, and sediment data. The seventh part of the tutorial would explain how to use the system as an integrated whole. Using discipline-specific tutorials does not defeat the purpose of an integrated software system, but it does facilitate the training of users whose duties are in only one of the disciplines.

3.2.3 Formal Training Sessions

Formal training must be provided on the installation and use of the software, and the maintenance required for the data base and associated files. With the introduction of the software, there will be the need for intensive training, particularly on the installation and use of the software. As the software matures, the need for training on use and installation decreases, but there will be increased need for training on managing the NWIS-II software. Non-WRD user training will be provided where applicable.

3.2.4 Training for Initial Release

With the release of the software, training will be provided to DBA's on how to install the software, how to transfer data from NWIS-I and WATSTORE, and how to use NWIS-II. Other selected personnel will also be provided training on how to use NWIS-II. Many of the training materials will be developed during presentations to user group representatives and review group members during walkthroughs and reviews of the NWIS-II software. Those attending the early courses will need strong computer backgrounds and have a thorough knowledge of the hydrologic data. These individuals should be used to help with subsequent training.

Initial training will probably be on a node-by-node basis as NWIS-II is tested at each node. The first sets of software will be installed by NWIS-II development or maintenance personnel. After the initial software installations and testing, training courses can be set up for training on site, regional office, and/or headquarters. Users attending these sessions would then return to their own offices and train their personnel on the use of the NWIS-II software. During these first training sessions, recommendations will be made on maintenance of the software and data bases.

3.2.5 Training After Initial Release

After the initial installation of NWIS-II software, formal training sessions will be held periodically at the National Training Center to train new personnel, cooperator personnel, or others in the use of the software. Use of the

training center facilities would allow users to practice and experiment with the NWIS-II without the potential of destroying real data. NWIS-II Users Groups could also be established, and semiannual meetings could be held within each Region, facilitated by the Regional Computer Specialists.

As the NWIS-II software is installed and experience with the software is gained, another training course will be developed for those individuals maintaining the software and data at a node. This course for data base administrators (DBA's) will standardize the way the data bases are administered.

Users have requested separate training courses on the computational methods used by the NWIS-II software. Since the computational methods used in NWIS-II software are based on standards developed in the discipline offices within WRD (Office of Surface Water, Office of Ground Water, and Office of Water Quality), these offices should have the lead in providing these courses. The computational methods used within NWIS-II should be taught, along with the computational methods used by application software developed by the office of PC&TS.

3.3 Documentation

Documentation will be written for users, DBA's, site administrators, and system/application programmers. All documentation will be stored electronically, accessible through the user interface, and indexed. An ancillary, online guide to printed documents shall be provided that lists the names of the NWIS-II manuals and the WRD technical documentation, and how to obtain printed copies from a contact(s). The contact's name, telephone number and address shall be provided. At each release of a new version of NWIS-II software, new documentation will describe installation instructions and changes to NWIS-II since the last release.

3.3.1 User Documentation

User documentation will describe programs and systems in nontechnical terminology to guide users in the preparation of data input and retrievals and in the interpretation of data output. This documentation will be called the NWIS-II User's Manual. For Cooperative or non-WRD personnel, a user's manual or technical sheet describing NWIS-II will be available. The NWIS-II User's Manual will include the following:

- a description of NWIS-II software help text files
- a description of the logical system design (system concepts)
- a description of the operation and use of programs and applications
- copies of default input and output forms
- examples of output products
- an indexed list of user-defined problems
- case studies that provide examples of coding, data input, and retrieval
- a list of all system errors and a detailed description on how to resolve each error.

In addition to the User's Manual, a NWIS-II commands reference guide and a software release guide will be available. The NWIS-II commands reference guide will provide an alphabetic listing of commands and menu entries that explain options and consequences. A software release guide will list available software for the current version of the system with an explanation of what is in each package/module. An alphabetical and subject oriented index will be available with the software release guide.

3.3.2 Data Base Administrator Documentation

Data base administrator documentation will be written at the level of an average computer user. The documentation will be contained in the NWIS-II Operations Manual, which will include sections describing the data base, software, and operational environment. The first section, the data base, will address the concerns of the DBA and include, but not be limited to the following:

- a description of data-base protection operations
- a description of the operation of data-base software and maintenance programs
- a description of regular data base maintenance procedures

The last two sections of the Operations Manual will provide information for the site administrator, who may or may not be the data base administrator.

A data base conversion manual will be available that specifies the approach and details of the conversion of the current data bases to NWIS-II.

3.3.3 Site Administrator Documentation

Site administrator documentation is provided by the last two sections of the Operations Manual and will include instructions on:

(1) fine-tuning the data base,
(2) recompiling, linking, or binding the software system
(3) optimizing a computer installation,
(4) interfacing hardware, and
(5) locating data within the local area network.

The NWIS-II Installation Manual and Version Description Document also will provide relevant documentation for site administrators. These documents are discussed in Release Documentation, section 3.3.5 of this chapter.

3.3.4 System and Application Programmer Documentation

System and application-programmer documentation will be written with the advanced computer user in mind and is called the System Maintenance Manual. The System Maintenance Manual explains the structure of the software system so that a programmer can support or modify the system. The documentation will include:

- a description of the structure of the software system
- standards for programming
- a description of the organization of existing programming modules
- a detailed description of how to use and access each programming module
- procedures for creating customized input and output forms
- installation instructions for local applications and customized forms.

3.3.5 Release Documentation

Release documentation describes software modifications, lists known errors, and gives instructions for installing new releases or versions of NWIS-II. Release documentation will be written in two parts. Part one, the Version Description Document (VDD), will be written for the general computer user and will include a description of software modifications and known bugs. Part two, the Installation Manual, will be written for the site administrator and will include specific installation instructions. The VDD will include the following:

- a description of software modifications since the last release (what's fixed and what's broken)
- a description of known bugs
- software version number and date installed
- suggestions about how to navigate around known software on an interim basis
- a description of programming efforts to be completed for the next release
- references to manual changes/updates

3.3.6 Data Base Documentation

Data base documentation consists of the Data Base Design Specification and the Data Dictionary, which describe the structure and physical characteristics of the data base. The Data Dictionary will be designed for use by users, administrators, and programmers. In addition to electronic and hard-copy documents, information in the Data Dictionary will be accessible through data base retrievals and help queries within NWIS-II. The Data Base Design Specification and the Data Dictionary will include the following:

- definitions and domains of entities (files)
- definitions and domains of attributes (data elements of a file)
- a description of the physical data structure (entity and attribute format)
- a description of all activity rules (entity relationships and constraints on these relationships)
- security assignments (locks) on entries and attributes (user views and access rights to the data).

3.3.7 Format and Distribution of Documentation

User, DBA, site administrator, system/application programmer, and release documentation will be available in the following formats: hard copy, electronic, and online (interactive). Hard copies of documentation will be distributed upon request. Documentation in electronic form will be readable and printable using software and hardware commonly available at every node. The online documentation will be in the form of help files, which will match electronic and hard-copy documentation. Documentation will be updated to reflect the operation of NWIS-II prior to the software distribution. Electronic documentation will be updated and will supersede any previous electronic documentation.

Updates of hard-copy and interactive (help files) documentation will be generated from electronic documentation. Electronic documentation will be updated prior to updating hard-copy documentation or help files. Information in the electronic documentation will then be used to update (re-create) hard-copy documentation and help files.

Update packages will be available for hard-copy documentation. Update packages will allow individuals to update specific pages of documentation without the need of reprinting an entire document.

3.3.8 Training

User training is a continuous process. Training materials are needed to assist data base administrators in local training efforts and for presenting information to groups as well as individuals.

Training materials such as handouts, overheads, slides, and hands-on work sessions created for national or regional NWIS-II training courses will be made available to nodes on request.

A self-paced tutorial that teaches the basic operation and function of the NWIS-II will be available. The tutorial will be updated to reflect changes prior to the distribution of a new release. The tutorial will be written for the novice as well as the advanced computer user.

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Appendix A: Glossary of Terms

accepted method - The usual, proper, and approved procedure for obtaining a result.

access-level tracking - The process of monitoring the access rights of a user for different projects and data bases.

access rights - The authority to make use of or view software or data.

access-violation tracking - The process of monitoring, intentional or unintentional, unauthorized attempted use of software or data.

activity rule - An explanation of the inherent relationship between two entities, which implies a direction and ownership or usefulness.

Administrative Information System (AIS) - The computerized system used by WRD for managing administrative information and the related events such as funding, project, personnel, purchasing and other administrative events. Currently consists of software such as AFIMS, MIS, and property control.

alert limit - A criterion which, if exceeded, requires special action. For example, if a specific conductance value of a tidal stream exceeds an alert limit, additional fresh water is required to be released by reservoirs upstream of the monitoring point.

alphanumeric check - A verification of information to ensure that only valid alphabetic and numerical symbols are contained within the information.

application software - Software specifically produced for the functional use of a computer system; for example, software for navigation, gunfire control, payroll, general ledger. Contrast with system software (Software Engineering Technical Committee, 1983, p. 9). This software is documented so the user can easily use the application software and so other application software developers can easily use the software in their applications.

application toolbox - A set of application software that aids in the development of additional application software.

approval authority - Permission granted to an individual to perform some task, such as authority to release data to the public.

approved status - See data aging.

archival - The process of preserving data. The data can be preserved on computer media, such as magnetic tapes, CD-ROM, WORM, or paper.

argument list - A series of data, sometimes optional, used in computer software.

asynchronous - Occurring without regular time relationship.

asynchronous transmission - A method of electrical transfer of data in which the sending and receiving units are synchronized on each character, or small block of characters, usually by the use of start and stop signals. Synonymous with start/stop transmission.

attribute - A characteristic of a data entity that should be maintained by the software application. Attributes become data items when data dictionary information is compiled (Martin, C.F., 1988, p. 289).

automatic data recorder - A device, such as an ADR, BDR, or data logger, used to continuously monitor and store information on a feature or facility.

automatic electronic notification - Computer-generated alert that criteria have been met. This alert may require user interaction, such as a flood event or loading paper in a printer.

automatic entry of data - The electronic transfer of data from one form to another so that it may be stored in the NWIS-II data base. This transfer occurs without operator intervention.

automatic logging - Automated entry of data history information. See data history.

automatic scale selection - The default selection of a maximum and minimum value for the axes of a plot, based upon the data to be plotted.

azimuth - The horizontal angular distance from a fixed reference direction to an object or position usually measured clockwise in degrees from due north.

background data-base process - A computer program executed by the computer, minimally interfering with the normal interactive processing done by a user.

backup - Provisions made for the recovery of data files or software, for restart of processing, or for use of alternative computer equipment after a system failure or a disaster.

backup log file - An inventory of tapes, software, materials, and equipment used during a backup; and what data and software resides on each backup tape.

backward compatibility - The ability to have new computer software run against old data files.

basin delineation software - Computer-processed algorithms used to either automatically map or aid in mapping of the aerial extent of a watershed.

bearing - The orientation of the long dimension of a feature in degrees from north, read clockwise.

bias correction - A modification to data to correct for a consistent under or over estimation of a result. This estimation error is inherent in the method.

Boolean - Any of various algebraic systems based on mathematical forms and relationships borrowed from the symbolic logic of George Boole. Examples are the *and*, *or*, and *exclusive or* logical operators used in computer software.

bottom-up data analysis - Development of a data base description starting with a complete set of data items and then combining these into normalized record types and data aggregates. (Martin, C.F., 1988, p. 289)

bounded area - A legal, political, physical, or imaginary area with defined limits (boundaries) and attributes at a specific point in time, that may be used in GIS to tag an item.

breaks in data - Periods of time during which data are missing.

calculated value - A data value not stored but rather computed from stored values of other constituents.

card-image format - A computer format corresponding to the IBM 80-column punch card.

cardinality - The maximum number of instances of some relationship type that an object type is permitted to have (Ross, 1988, p. 213).

chain of custody - A record of the handling of a sample, including dates, people, and locations involved.

changed (edited) value - a user-supplied corrected value. The original value would not be altered or erased but would be maintained in the data base.

character recognition - The ability of computer software to take a scanned image and convert that image to alphanumeric characters.

checklist - A grouping of data used to verify inputs into computer software.

checks - Tests of accuracy, comparison or standard of comparison, or verification of data and procedures.

chemical abstract - A computerized library of chemical information used as a method of identifying water-quality constituents and their properties.

Chemical Abstract System (CAS) - A computerized library of chemical information on most chemical compounds.

choropleth map - Map depicting areas differing by the range of a data value.

classified record - Information requiring a special clearance to access.

cluster analysis - A statistical procedure to categorize groupings of data based on the similarity of given characteristics. Sometimes used to analyze sites and samples.

code - A short group of alphanumeric characters used to replace a large description. Some examples of codes are: event codes, FIPS codes, aquifer codes, geologic codes, hydrologic unit codes, water-use codes, Standard Industrial Classification codes, and stream reaches.

color-aided identification - Use of colors and shading in graphics to aid in the distinguishing of features.

combined data analysis - The development of a data base description by doing a top-down analysis followed by a bottom-up data analysis.

common file - A computer file shared by a group of users.

common unit - A single unit of measure shared by a particular data type.

comparable records - A list of data that can be used to estimate missing data at a site, also includes the expected quality of estimation.

compatibility - With respect to a computing environment, the ability to use programs, data, and/or devices of one computer system on another computer system without change.

compiled code - Computer software of a higher order language, such as C and Fortran, that has been translated into its relocatable or absolute machine code equivalent.

composite sample - A sample that is created by combining several other samples. For example, a whole-body biological composite sample is a sample created by taking a given number of individual specimens and combining their bodies by some method, such as grinding, to form one sample.

computational blocks/structure - A section of computer software designed to perform a specific computation.

computational operators - Mathematical, Boolean, and symbolic logic operators used in a computation.

computational script - See script

computed value - A value computed from a primary, edited, corrected, or other computed value.

Computer Graphics Metafile (CGM) -A standard computer file used to transfer graphical data between different computer software packages.

computer mail system - An electronic system developed for the purpose of sending and receiving messages, typically over a WAN or LAN.

computing environment - The enterprise-wide combination of computer hardware and software used to run application software.

concurrency - Simultaneous occurrence; coincidence; in a computer data base environment several users all accessing the same object, such as a data base table.

configuration - A relative disposition or arrangement of parts, the interrelationship of system elements.

configuration management - The control over and authorization of changes to and releases of computer software.

connectability - The ability to network different types of computer hardware to form a heterogeneous computer environment.

consistency check - A test of the relation of two or more values for control purposes.

constant correction - A number whose magnitude remains unchanged over time and used to adjust a series of values.

constituent - A physical, chemical, or biological element, compound, or material.

constituent identification system - A set of procedures and definitive information about a constituent measured or sampled at a site, including the name, the units of measure, phase, matrix, and accuracy of the results.

context-sensitive help screen - A computer function allowing for differing levels of help depending upon the users' ability.

continuous data -Used by WRD for time-series data.

continuous monitoring - The collection of information about an entity over a period of time without interruption.

control field - A fixed portion of a data item or record where information for control purposes is placed; for example, account numbers used for sequencing or transaction codes used for identifying the types of operations to be performed on input data.

controlled data - Data that have restrictions placed on its availability.

coordinate system - A functionally related set of numbers used in specifying the location of a point on a line in space or on a plane or given surface, such as latitude-longitude, state plane, or UTM.

council of government area - A bounded area defined by a group of governmental agencies.

critical failure - The instance when a subprocess, necessary for completing the whole process, cannot be completed.

critical software fix - A repair to a computer software defect that if left unrepaired would result in erroneous data being entered into or existing data being removed from the data base.

cursor - An indicator that shows the current position on a visual-display screen; not uncommonly, the indicator is an underscore character.

curve construction - The development of a graphical relation of two entities.

curve-smoothing - A statistical procedure to free a graph from irregularities by ignoring random or anomalous deviations.

data access - See access rights.

data adjustment - A factor applied mathematically to a value to make it more representative of the particular time when or place from which the data value was collected.

data aging - The processing of a data value from one status type to another, with the implied goal of release to the public.

data availability index - An inventory of the quantity and types of data available for a retrieval.

data base - A comprehensive, integrated collection of data organized to avoid duplication of data yet permits retrieval of information to satisfy a wide variety of user information needs through a query language.

data base polling - The process whereby an external computer system is queried to determine if that system is available and if the desired data resides on that system.

data collection platform (DCP) - The electronic equipment that records, processes, and transmits data through the GOES satellite to a receive site for satellite data.

data compression - A reformatting of data that reduces the space required to store that data.

data conversion - Changing from one form of representation to another; for example, from decimal to binary, binary to decimal, binary to hexadecimal, binary to octal, decimal to binary, decimal to hexadecimal.

data dictionary - A specialized set of tables containing definitive information about data in the data base. The data dictionary defines the meanings and functions of metadata, establishes relationships between all metadata, lists the organizational and bibliographic sources, defines data types and ranges of data, and defines security and audit trails of the data base.

data element - See data item.

data entity - A person, object, or concept which will be described by data in the application data base. Data entities become record types after compilation of the data dictionary (Martin, C.F., 1988, p. 291).

data exchange - The transfer of data from one computer system to another.

data flow diagram (DFD) - A schematic of a system showing process and the flow of data among those processes.

data history - (1) A chronological record of the development of a data value or entity within the data base. Histories consist of an audit trail describing who, when and why a change was made and a transaction describing what change was made. (2) A summary of the type, occurrence, and frequency of data.

data item - Smallest break out of information in the data base. Attributes of data entities become data items when the data dictionary is prepared (Martin, C.F., 1988, p. 291).

data model - The structured representation of the data requirements of an organization.

data piping -The process of connecting the output of one program to the input of another program, so the two run as a sequence of processes.

data protection - See access rights.

data reliability - The confidence in a data value being correct.

data type - (1) The type of value associated with a data entry, such as text, real, or integer. (2) The discipline (i.e., ground water, surface water, water quality,) associated with a data entry.

decision support system (DSS) - A data-processing system designed to provide assistance directly to managers and other professionals as an aid in decisionmaking.

denormalization - The process of selectively introducing redundancy in a data base to increase the speed of frequently used processes.

desktop environment - A metaphor that relates the computer display screen to a person's desktop: The objects displayed on the screen (windows, menus, and icons) resemble the objects on a desktop (papers, reports, notes, and gadgets).

Device Conversion and Deliver System (DECODES) - A computerized system that takes data files from many different data recorders and standardizes the file formats.

diagnostic report - The results of a process that identifies or determines the existence or nature of a problem.

digitize - To convert data to a discrete form of representation; for example, to a sequence of on-off electrical pulses acceptable as input to a computer.

digitizer - A device used to digitize data, consisting of a puck with cross hairs and a table.

direct read-out terminal (DROT) - A computer that is connected to the LRGS equipment for the purposes of receiving and disseminating data transmitted through the GOES satellite.

discrete data - Data collected at specific point in time and space.

Distributed Information System (DIS) - (1) A series of minicomputers located in offices of the U.S. Geological Survey's Water Resources Division connected by the WAN. (2) The program office within WRD responsible for the maintenance of the DIS network.

distributed information system node - A WRD office containing a computer system connected to the WAN.

Distributed Information System-II (DIS-II) - A series of workstations joined by a LAN that replaces the minicomputer used in DIS.

district - Administrative division of U.S. Geological Survey's Water Resources Division that is composed of one or more state offices.

district workload - The yearly projected NWQL service needs of a District for a fiscal year. Schedules of requests for a project, site, and frequencies of sampling. Projections may be modified throughout the year as projects are funded, terminated, or modified.

Document Interchange Format (DIF) - A standardized arrangement of data allowing the data to be used by many different software packages.

documentation - The supporting references for a piece of software that describes its logical and physical structure.

domain - (1) The set of possible values for an attribute. (2) A set of values whose formation conforms to a common definition (i.e., format or syntax, and meaning). Domains are used as attributes to give properties of entity types and certain other objects (Ross, 1988, p. 214).

edit access - See access rights.

edited values - Values that have been reviewed and adjusted, as necessary, to correct for instrument malfunction or other inconsistencies.

electronic analytical services request (EASR) - The electronic form or report that provides information about samples sent from the District to the NWQL. The EASR states what analyses are requested for a sample, and gives information about the type of sample, the shipment, the project, the hazards and priorities, and the district contacts. The EASR matches a paper report, the Analytical Services Request (ASR).

electronic file - Digital storage of data and images of information, such as paper copies of relevant station documentation (e.g., photographs, maps, newspaper clippings, historical data, discharge measurement note sheets), water-quality data, and remarks.

electronic mail system - A computer system designed to send and receive messages.

electronic notebook - A computer-based device used to digitally store observed information, usually in the form of a free format text or vocal entry.

electronic request form - A computer-generated image used to ask for an item or piece of information.

electronic transmission of data - The sending and receiving of data via telephone, microwave, or satellite method.

empirical computation - A computation with exact conformity to a set of rules learned by observation or experiment.

emulation - A process by which one computer system is made to function like another, to accept the same kind of data, execute the same programs, and achieve the same kind of results.

encryption - The process of transforming text to conceal its meaning.

engineering unit - A unit of measurement; the units of the entity being measured, such as gage height in feet, DO in mg/l, temperature in °C.

enterprise model - A very high-level data model of an organization.

entity - A person, place, thing, or object, physical or conceptual, of significance to the system about which information needs to be known or store; one or more tables in a data base.

entity relationship - A meaningful connection between two entities: one-to-one, one-to-many, or an association entity (many-to-many).

entity relationship diagram (ERD) - A diagram which shows normalized data entities and the relationships among entities (Martin, C.F., 1988, p. 292).

entity type - A thing that exists, or that gives some focal point in understanding or organizing the real world. An entity type is something that is meaningful to the enterprise, about which information is collected and maintained. Entity types may be classified into people, places, things, organizations, concepts, or events (Ross, 1988, pp. 8 and 214).

error range of final value - The possible low and possible high numerical values of a final value.

error-tracking system - An algorithm for tracing mistakes and their corrections.

estimated record - The records of stage, discharge, or other parameters based on indirect methods that involve interpolation, reconstruction of missing gage-height records, the use of records for other stations, power plant generation records, reservoir records, discharge measurements, observers' readings, and weather records. Information created to replace faulty or missing records.

external computation - Computer algorithms performed outside of the NWIS-II system.

external data base - Any data base other than the NWIS-II data base.

extremes - The maximum and minimum values for a constituent. Extremes may be computed for a single year, the period of record, or any other time period.

field note - A written observation during a site visit that documents such information as conditions at the site, tasks performed during the visit, observations made, and experiments performed.

field run - A grouping of stations that constitute the workload for an individual during one data collection visit to the field.

field storage media - The material on which data, collected in the field, are preserved between visits by people.

final value - A checked and reviewed value.

foreign key (FK) - An attribute of an entity that is the primary key of another entity. The foreign key is used to relate two entities.

format - The form or layout of a data field or screen.

fouling correction - An adjustment applied to water-quality minimonitor data. This adjustment rectifies the electronic drift caused by algae growth on the probe.

full backup - To copy all or selected data files on a disk onto a removable media (magnetic tape, WORM). This differs from a partial backup, which is to copy only those data files that have been changed since the last backup.

functionality - The capability to perform a function.

general analytical method - The general method used to analyze a sample for a value. Refers to only the method itself, without reference to matrix, phase, or other types of methods.

general constituent group - The general classification of a group of constituents. May include major inorganics, major organics, nutrients, stable isotopes, radio isotopes, and industrial organics.

general control - Channel features that determine the stage-discharge relation at the gage.

general method - A method used to obtain data. Does not include sample collection, preservation, preparation, or chemical analysis.

Geographic Information System (GIS) - A set of algorithms and procedures, usually computerized, for manipulating thematic maps and their associated data.

geographic information system coverage - See thematic map.

GEONET - The WAN connecting computer systems of the Department of the Interior, operated by the U.S. Geological Survey.

geostationary orbiting earth satellite (GOES) - A satellite orbiting the earth at the same speed as the rotation of the earth making it appear as if the satellite is stationary above a point on the earth's surface.

Geo-Positioning System (GPS) - A device used in conjunction with a satellite to locate a position on the earth's surface.

grammar checker - An applications software that verifies the correctness of word usage and sentence structure.

graphical display - A video display terminal capable of displaying graphical data.

graphics toolbox - A set of application software designed to make the development of graphs easier.

hard copy - A permanent record of machine output in human-readable form; generally, reports, listings, and other printed documents.

hierarchical data model - Data structuring philosophy which explicitly represents a tree-like break out of one-to-many relationships. That is, each record type may have only one one-to-many relationships leading to it (Martin, C.F., 1988, p. 292).

historical data - Data that have been published.

horizontal scrolling - See scrolling.

icon - A symbolic image used to denote a specified closed window in a computer environment.

identifier - A short name linked to a piece or pieces of data for the purpose of identifying that data, such as site identifier, constituent identifier, and equipment identifier.

identity - The collective aspect of the set of characteristics by which a thing is definitively recognizable or known. It can be a taxonomic identity, such as genus species, or a nontaxonomic identity based on a classification determined by habitat, physiology, morphology, or ecology.

importing - To bring in from a foreign source, such as importing data from an external data base.

in review data - Data being examined for correctness.

index - An indicator that guides the user to a data item, points out a data item, or otherwise facilitates the referencing of a subject. Also see Key and NAWDEX indexes.

information - The meaning that a human assigns to data by means of known conventions used in the data representation; processed, or "finished," data.

input - The process of translating paper-punched, electronically stored, or keyed data into the NWIS-II data base.

input access - See access rights.

input screens - The physical layout of the computer screen used to key data into the data base.

instruction - A set of characters that specifies an operation to be performed and the value or location of one or more operands.

interface - In computer systems, a piece of hardware or software used to allow two pieces of equipment, or a piece of equipment and a user, to transfer data between them.

intermediate values - A value on which computations have been made and on which additional computations will be made changing the magnitude of the value.

interoperability - In information processing, a characteristic of software that allows it to be run on more than one type or size of computer and under more than one operating system (NBS 500-152, 1988, p. 130)

INTERNET - A research and development network originally begun as ARPANET (Advanced Research Projects Agency Network), but is evolving to using TCP/IP internetworking technology for router-to-router communications.

IUPAC name of constituent - The name assigned by the International Union of Pure and Applied Chemistry (IUPAC) to identify a constituent.

job scheduling - The process of arranging tasks for the computer in the order they are to be done.

key - (1) One or more characters associated with a particular item or a particular record and used to identify that item or record, especially in sorting, collating or direct input/output operations. Also called a control field. (2) A biological publication that aids in the species-identification of a specimen.

keywords - Strings of characters used to classify information that a user wishes to find in a text field.

laboratory catalog - A catalog of laboratory information about sample analysis, preservation requirements, and supplies.

Laboratory Information Management System (LIMS)- See National Water Quality Laboratory information management system.

less than values - Values that are less than the analytical reporting limit for the given constituent. The given value is reported as the reporting limit value preceded by the arithmetic symbol "<".

local area network (LAN) - A computer network which spans short distances.

local read-out ground station (LRGS) - A site that continuously receives satellite-transmitted data over commercial communications satellites. The transmitted data are received at a traditional satellite downlink site and then transmitted to a direct read-out site via a commercial satellite.

local site software - Commercial or locally-developed software (outside of NWIS-II) available at a particular office.

local supplied list - A list of items, representing the domain of a character variable, supplied to NWIS-II managers by a WRD office.

location - A place or places where something is or could be located; will include both geographic locators (e.g., latitude/longitude) and text fields (e.g., station or laboratory name).

locking - The prevention of another user from editing a relational data base table, page, or row while a first user is editing the table.

logic check - Verification that an entry meets a specific criterion or falls within an allowable range.

logical data model - A data model of an organization, describing only the required data objects and the logical relationships between those objects. It does not describe the physical structure of the implemented data base.

lookup table - A table that serves as a reference, listing codes and explanations.

maintenance program access - Access rights to programs used to manage files that support the NWIS-II data base. See access rights.

matrix spike - A laboratory sample spiked with constituents in a specified matrix to determine percent recovery of the constituents. The spike is put in a sample duplicated by the laboratory.

memory - 1) The power or process of reproducing or recalling what has been learned or retained especially through associative mechanisms. (2) A device in which computer information can be inserted and stored and from which it may be extracted when wanted.

menu - A list of choices shown on a visual-display screen, from which the user selects a command or data to be entered into the computer.

mode - A particular functioning arrangement or condition of computer operations.

modifiable table - A tabular form of output which will be allowed to evolve over time, at the national level of system maintenance.

modifier - A grammatical qualifier. Also lithologic modifier, an adjective modifier in geohydrology needed to describe a rock type. Examples: GREY, SOFT, CHALKY.

module - 1) Any in a series of standardized units for use together. 2) A usually packaged functional assembly of electronic components for use with other such assemblies.

multichannel recorder - A recorder that has more than two paths along which data passes or may be stored.

multitasking -A feature of a computer; performing more than one function at the same time and showing the progress of each function in separate areas, called windows, on the monitor screen.

multiwindow -Term describing multitasking computer software evidenced by several independent subscreens that can be overlaid on one monitor screen.

narrative - A text field that describes an activity, method, or feature.

national data base - A data base that contains approved data from all districts or indexes of all data available, with access paths and procedures.

National Handbook of Recommended Methods for Water-Data - The source of general methods used by the USGS. In some cases these methods are modified for use by the USGS-WRD and then referred to as USGS methods.

National Oceanic Data Center (NODC) - A part of the National Oceanic Atmospheric Administration, with offices in Washington D.C. and Asheville, North Carolina, responsible for the taxonomic lists of freshwater and marine species, the report on marine toxic substances, and the atlas of the ocean.

National Water Quality Laboratory (NWQL) -The WRD laboratory, located in Arvada, Colorado, that receives and analyzes most of the water samples collected by the WRD.

National Water Quality Laboratory LIMS - The WRD National Water Quality Laboratory's internal computer system, which consists of an administrative system; a data system for analytical samples, values, and quality control data; a library system; and a sample management system. The library system and the sample management system are associated with NWIS-II.

navigation path - A series of commands linking consecutive steps for entry and working of basic data, to guide users through a standard process.

NAWDEX indexes - A set of reference lists containing information on organizations that collect and disseminate data; and the geographic locations, type of data collected, and frequency of data collection for sites monitored by those organizations.

near online - A state of easily retrievable data storage, one command removed from direct communication with a computer. The CD-ROM media provides near-online storage.

near real time graphical analysis - A system that dynamically graphs data on a computer screen nearly simultaneously with an event's occurrence.

network data model - Data structuring philosophy which indicates one-to-many relationships among record types. More general than the hierarchical data model, the network model allows any number of one-to-many relationships to lead to a record type (Martin, C.F., 1988, p. 293).

network retransmission request - A repeated request (sometimes made automatically) to a computer or data base to send data across the communications network to the requesting computer, used when the initial request cannot be handled immediately.

noninterpretive curve - An experimental curve created during curve construction that is not saved to document the final interpretation.

normalization - A series of tests and rules for data-base design aimed at eliminating update anomalies. Normalization was originally developed as a theory complementary to the relational model (Ross, 1988, p. 216).

numeric field - A column in a data file or data table in which real or integer numbers are recorded.

observation - A measurement, such as stream velocity or dissolved oxygen, at a point in a vertical along a cross-section of the surface-water body.

octopus diagram - A table with tentacle-like graphics that summarizes, by State, freshwater withdrawals by source and water-use category.

offline media - Means of effecting retrievable storage of electronic data, allowing removal by direct communications with (and storage in) the computer. Magnetic tape is an offline medium.

online storage area - The area in a computer or attached storage device from which data can be retrieved.

oops capability - The capability to undo a command or series of commands.

operating system - Software that supports or complements the hardware of a computer system (as by keeping track of the different programs in multiprogramming).

optical media - Light sensitive devices used to acquire and store information (text or graphic) for a computer.

original data - Data values, measured or observed, prior to any adjustments. Original data are retained permanently.

output - Information in any format output from a computer due to a specific request from a user.

output media - The equipment that captures the data from a computer routine, such as a printer, helical tape, or CD-ROM.

overlaid data - In a GIS, data represented on a thematic map that can be overlaid on a base map.

paper records - Information or data recorded on paper.

parameter - (1) Any list or grouped items having numerical values (such as water-quality constituents). More appropriately used as the numerical values of constants used as a referent for determining other variables, or as the values used in equations or matrices. (2) Identified by WRD as an association among a constituent, a matrix, and a phase. See constituent identification system.

partial backup - A backup of only those data and software files altered since the last backup.

pause and warn - Temporary cessation of a retrieval process, followed by a warning message on the computer screen of anticipated problems.

period of record - Period of record for individual parameters, time span for which there are published records for the station or for an equivalent station; includes publication status (published/

unpublished), record type (e.g., daily value, monthly, seasonal, fragmentary, partial record, discharge, measurements only, published by another agency).

phase - The chemical or physical state of a constituent in a matrix.

polling - See data base polling.

portable field computer - Any of a variety of battery-operated computers light enough to be transported easily from place to place and weather-resistant enough to be safely used outdoors.

positional coordinates - See coordinate system.

postprocessing - A process or process appended to a completed procedure.

postscript - An interpretive computer language that describes how an electronic document will be output to a printer. Includes font definitions as well as graphic objects.

precision data - (1) Data concerning the accuracy (as in binary or decimal places) with which a number can be represented, usually expressed in terms of computer words. (2) The reproducibility of data.

preprocessing - A process or process preceding the start of a major procedure.

preset template format - A previously designed guide for the input of data into a standard form.

primary key - An attribute or set of attributes which uniquely identify a record occurrence of an entity type (Martin, C.F., 1988).

processing navigation path - See navigation path.

programming script - See script.

project viewer - (1) The level of data protection for a group of users giving them access rights to view any and all project data at any stage of completion designated by the project chief. (2) A member of the above designated group of users.

project worker - (1)The level of data protection for a group of users giving them access rights to a) input and view original data, b) edit, view, or change the status of working data, and c) view in-review or approved data for a project, even data restricted from public viewing. (2) A member of the "project worker" group described above.

projection system - A series of algorithms used to transfer a digital thematic map from one geographic coordinate system to another.

proprietary data - Data held under patent, trademark, or copyright by a private person or company.

protection functionality - The functions of protecting the data and information in a computer system from deliberate or accidental alteration through the use of access restrictions on the data base and associated software.

pseudo-binary - A format similar to standard binary used in data-collection platform transmissions.

public access - (1) The level of access to Government data guaranteed by the Freedom of Information Act. (2) The public viewer level of protection for computerized data.

public survey area - An area of the Public Land Survey System (PLSS) established by public, private, or combined surveys.

public viewer - (1) The level of data protection for a group of users giving them access rights to view approved data, and any working or in-review data designated by the project chief that are not restricted. (2) A member of the "Public Viewer" access group described above.

punctuation checker - Software that proofreads an electronic document for mistakes in punctuation, highlighting errors.

push button - (1) A small button or knob that when pushed operates something, especially by closing an electric circuit. (2) A visual representation of a push-button or icon on a computer screen, used to initiate a process.

qualifier - A word (as an adjective), word group, or special character that limits or modifies the meaning of another work (as a noun), word group, or numerical value.

quality assurance (QA) - All those planned or systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality.

quality control (QC) - The operational techniques and the activities used to fulfill requirements of quality.

query - The insertion, deletion, updating, or retrieval of data in a data base.

raster and image processing - Processes that address graphics/raster interface issues in converting remote-sensed data to usable maps. These processes include data reduction and interpretation of satellite imagery from its original raster format, multisensor data registration and rectification, and spectral classification.

record type - Group of data items, usually assembled in a normal form, which is fully described in a data dictionary (Martin, C.F., 1988, p. 294). See data entity.

recovery - In data base maintenance, recovery involves restoring data base and system files (including software) to the state in which they exist prior to a hardware or power failure. (2) In geohydrology, the rise in water levels in pumping and observation sells at the end of a pumping test.

redundancy analysis - The examination of superfluous repetition for the purpose of its reduction.

reference list - See lookup table.

referential integrity - An integrity constraint in the relational model that prescribes that whenever foreign key values exist, then instances of the object(s) to which they refer (i.e., for which they are determinant values) must also exist (Ross, 1988, p. 217).

relational data model - Data structuring philosophy which represents both data and relationships as tables (Martin, C.F., 1988, p. 294).

release documentation - The provision of documented instructions for the installation of a new version or enhancement of software.

remote monitoring - Monitoring done from a location some distance away from the site, usually via some form of telecommunications.

resolution of latitude or longitude - Ability to store latitude/longitude information at decimal degrees or smaller units.

retrieval - The process of recovering data from a file.

reuse - (1) The use of water more than one time before it passes back to the natural hydrologic system (2) The use of data and software a second time.

revised records - Identifies record revisions and refers to publication in which revision is published; includes publication number of report; revised record type (e.g., maximum, minimum, peak above base, daily value), and publication number of report.

RS-232 interface - An electrical and communications standard for transmitting data.

sample tracking - The process of documenting the location and handling of a sample and sample containers from the time the sample is collected until the sample containers are discarded at a lab.

scan and browse feature - A computer function that allows the user to search tables or other screens of data with only partial search criteria.

scanned image - A visual depiction of data, such as two-dimensional maps, graphs, charts, photos, or text, generated by a scanner.

screen -The video display portion of a computer.

script - A series of computer actions, normally invisible to the users.

scrolling - With respect to a computer-terminal windowing environment, the movement of the text or diagram being viewed to the left or right (horizontal) or up and down (vertical) so that other parts of the text or document appear in the window.

security - The level to which a program, device, or files are safe from unauthorized use.

senior staff - A collective term for the Chief Hydrologist, the Associate Chief Hydrologist, the Assistant Chief Hydrologists and the Regional Hydrologists. The Strategic Planning Group consists of the senior staff with the exception of the Chief Hydrologist and the Associate Chief Hydrologist.

sensitive data - Data considered to have legal or political ramifications. Classified information.

site - The locale at which a measurement is made, sample is collected, or other field event takes place; the location of permanent structures installed for an investigation of natural and human-induced water-resources phenomena. Synonymous with Station. In the NWIS-II logical model, site is a view of the data base that describes such data as the name, ID number, location coordinates, data-collection history, land use, ownership, and purpose of a locale where field events occur. Information about a site is contained in the Activity Location, Feature, and other entities.

site coincidence - The situation in which two sites have the same latitude and longitude.

station history - Chronology of past significant events at a data-collection location.

software - The entire set of programs, procedures, and related documentation associated with a computer system.

software interchange format - A communications standard for transmitting data between different types of software.

software management - The control over the installation of new versions or enhancements of software and the deletion of appropriate outdated files and program.

software tracking system - A method of checking the timely issuance and installation of software releases.

spatial commonality - Location, shape, or relationship attributes in common among or between spatial data.

spatial data - Data about features; used to map the feature.

spatial data coverage - See thematic map.

spell checker - Software that proofreads an electronic document for spelling, and highlights errors.

spike sample - A sample to which known concentrations of specific analytes have been added in such a manner as to minimize the change in the matrix of the original sample.

split screen - A multiwindow alternative in which two windows are aligned adjacent to one another for the purpose of displaying or analyzing different data.

spreadsheet - Commercial computer software for the computation or analysis of data in rows and columns.

stand-alone module - A software module that can function independently.

standard industrial classification codes (SIC) - Four-digit codes established by the Office of Management and Budget and used in the classification of establishments by type of activity in which they are engaged.

station analysis - A narrative description, in a standard format, of the gaging-station equipment, its performance, and methods used to compute the hydrologic record; this is a summary document composed of several paragraphs describing important aspects related to the computation of an annual record at a gaging station. Incorporated into the text are several items from the data base; text should be retained as a separate summary in NWIS-II.

storage media - The computer equipment in which data are kept.

STORET - The system used by the U.S. Environmental Protection Agency to identify and store combinations of constituents, matrices, and phases. Identical to the WRD parameter code system.

stratified random sample - One of a series of samples collected from a part of a feature divided into dissimilar subparts. The number of samples from each subpart is weighted by the relative size (or weight) of the subpart, and samples within a subpart are collected at random.

surrogate - A compound chemically similar to the constituents of a chemical group that is expected to behave similar to the constituents of interest and not expected to be found in the environmental sample.

symbology - The art of expressing a meaning by the use of a conventional sign or diagram.

syntax - The way terms are combined to form phrases and sentences.

system administration - The duties involved in the managing of a computer system that is part of the Distributed Information System.

system-defined reference list - A lookup table whose contents are entered by headquarters staff. See lookup table.

system software - Application-independent software that supports the running of applications software.

system user interface - A designed set of screens from which the user will access NWIS-II.

system-wide check - A check that evaluates data across the entire Distributed Information System.

table - (1) A collection of rows and columns of related information. (2) An object in a relational data base system composed of rows and columns.

tabling package - A software module that formats an output into tabular form consisting of rows and columns.

temperature change flag of sample container - A flag to indicate status of a temperature-change strip placed on a sample container. The strip changes color if a given temperature of the container is exceeded during transit.

template - A pattern or form designed by the user for entry or retrieval of data, text, etc.

thematic map - In a GIS, an image of an area that shows a category of features, such as a system of roads, counties, or topographic relief.

thematic spatial data layer - A thematic map showing information, such as land use or average population density by census tract, rather than physical features. Spatial data layers are typically overlaid on a base thematic map.

third-party software - Commercial software, which is not developed by the system developers.

threshold check - The computerized comparison of a value to stored criteria values and the subsequent report of any exceedance of a criterion.

tickler - A computer program that reminds the user about important upcoming events on a calendar maintained by the user.

time-series data - A set of measured or computed values determined at equal time increments at a site. (The resolution of the time increment typically ranges from seconds to 24 hours and is generally frequent enough to define relevant changes in the measured constituent.)

top-down data analysis - Development of a data base description starting with a data structure diagram and then adding data dictionary detail (Martin, C.F., 1988, p. 295).

transaction - The actual exchange of data into or out of the data base.

transfer - The moving or copying of data from one location to another.

transparent - A computer process, such as communication, that occurs behind the scenes in a way that the user is not aware it is occurring.

transparent link - A computer interface that appears to the user as if there is no link to another module or system.

user-defined - Terms, restrictions, reference lists, and other items defined by the user (e.g., margins for text).

user-defined reference list - A lookup table whose contents are entered by the user. See lookup table.

user group - One of eight discipline-specific WRD committees approved by the Strategic Planning Group with instructions to assess the limitations of NWIS and submit a list requirements for NWIS-II to the NWIS-II design team. The groups are biology, ground water, NAWDEX and national thrust programs, sediment, spatial, surface water, water quality, and water use.

value qualifier - A comment, remark, or code that indicates the reliability of the value.

vertical scrolling - See scrolling.

view access - The right to view the contents of a computer file. See access rights.

wide-area network (WAN) - A computer network that spans large distances.

workstation - A desktop computer that has the speed and power of a minicomputer and includes a large, high-resolution monitor.

worm drive - A computer storage device, upon which one can "Write Once and Read Many" times.

WRD district - A district organization of the USGS, WRD.

x-window system - A technology of network computing, developed at the Michigan Institute of Technology, that permits users to work on many tasks at the same time in a windowing computer environment.

zoom - In computer graphics, to enlarge a section of a graph, map, or other image, thereby making more details visible on the screen, if those details exist in the image.

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Appendix B: Navigation-Path Descriptions

J.D. Christman

This appendix contains the functional details on specific navigation paths identified from the user requirements documents. For clarity and brevity, several subpaths have been identified and documented first. These subpaths are used in most if not all of the navigation paths and are easier to identify and document one time and then refer to them as many times as needed. Subpaths are not navigation paths themselves but are paths of a navigation path. Some subpaths refer to other subpaths as needed. The subpaths will be automatically linked to the navigation paths that use them; the users of the system shall not see the subpaths as separate navigation paths. **These descriptions are exhibits to be used by the NWIS-II software designers to develop the continuous data-navigation paths and are intended to be a general guide on what will be needed for each navigation path. The actual look of the navigation paths shall be decided during design based on extensive prototyping with the user groups, the type of user-interface system available, and the data base design.**

I. Instrumentation Data-Entry Navigation Subpath

Step	Input	Process	Output
A1.	Instrumentation data	Instrumentation preprocessing	Unit data and times Starting and ending unit times Starting and ending watch times Max/min tape indicator readings Intermediate observed unit times Intermediate observed watch times
A2.	Unit data and times Starting and ending unit times Starting and ending watch times Intermediate observed unit times Intermediate observed watch times	Time verification and correction	Time-corrected unit data and times[1] Comments

1. For multichannel recordings this time-corrected unit data and times will include separate output for each sensor channel of the recording instrument.

II. Stage Navigation Subpath

Step	Input	Process	Output
A1.	Completion of the Instrumentation Data Entry Navigation Subpath		
A2.	Level notes Crest-stage notes Discharge measurements Miscellaneous field notes	Forms entry of field notes	Level note data Crest-stage data Miscellaneous notes data Observed gage heights and times High-water marks reading
A3.	Time-corrected unit data Max/min gage indicator readings[2] High water mark readings[2] Observed gage heights and times[2] Verification thresholds Current rating extremes Q-measurements starting & ending gage heights and times Starting and ending gage readings	Unit data verification and editing	Verified and edited unit stage Comments
A4.	Verified and edited unit stages Observed Gage heights and times Level note data	Unit data-correction definition	Computed unit stages or elevations[3] Unit gage height/datum corrections Comments

2. High-water marks and observed readings could come from any of the four note sources.
3. This is an optional data correction applying a datum correction to adjust the gage height to NGVD. Note that the use of stage can refer to stage or elevation.

III. Index Velocity Navigation Subpath

Step	Input	Process	Output
A1.	Completion of the Instrumentation Data-Entry Navigation Subpath.		
A2.	Discharge measurements Miscellaneous field notes	Forms entry of field notes	Observed velocities and times Miscellaneous field notes
A3.	Time-corrected unit velocities Observed velocities and times Verification thresholds Current rating extremes	Unit data verification and editing	Verified and edited unit velocities Comments
A4.	Verified and edited unit velocities Observed velocities and times Miscellaneous field notes	Unit data-correction definition	Computed Unit index velocities Unit index velocity corrections Comments

IV. Miscellaneous Unit-Values Navigation Subpath

Step	Input	Process	Output
A1.	Completion of the Instrumentation Data-Entry Navigation Subpath for specified constituent.		
A2.	Miscellaneous field notes	Forms entry of field notes	Miscellaneous note data
A3.	Time-corrected unit data Max/min tape indicator readings Verification thresholds Starting and ending unit readings	Unit data verification and editing	Verified and edited unit data Comments
A4.	Verified and edited unit data	Unit data-correction definition	Computed unit data Unit data corrections Comments

V. Stage-Only Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath.		
A2.	Corrected unit stages Computation instructions	Primary computations	Computed daily statistics[4] Stage - max, min, mean Computed period statistics Stage - max, min, mean
A3.	Computed unit stages Computed daily-stage statistics Computed period-stage statistics Unit datum corrections Comments	User review of primary . computations	Approved-computed unit stages Approved-computed daily stages Comments

4. Computed daily and period statistics will include maximum, minimum, and mean as default.

I. Ground Water Level Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath.		
A2.	Corrected unit stages Datum correction for NGVD or Datum correction for LSD Computation instructions	Primary computations	Computed unit values Elevation in feet NGVD or Elevation in feet below LSD Computed daily statistics[1] Elevation - max, min, mean Computed period statistics Elevation - max, min, mean
A3.	Computed unit elevations Computed daily-elevation statistics Computed period-elevation stats Unit datum corrections Comments	User review of primary computations	Approved-computed unit elevations Approved-computed daily elevations Comments

1. Computed daily and period statistics will include maximum, minimum, and mean as default.

VI. Tide Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath.		
A2.	Corrected unit stages Computation instructions	Primary computations	Computed daily statistics[5] Stage - high-high, high-low, low-high, low-low Computed period statistics Stage - high-high, high-low, low-high, low-low
A3.	Computed unit stages Computed daily statistics Computed period statistics Unit datum corrections Comments	User review of primary computations	Approved-computed unit stages Approved-computed daily stages Comments

5. Statistics include date and time of occurrence.

VII. Reservoir Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath.		
A2.	Computed unit stages Level-to-contents rating Computation instructions	Primary computations	Computed unit contents[6] Computed daily statistics[7] Stage - max, min, mean, @time Contents - max, min, mean, @time Computed period statistics Stage - max, min Contents - max, min
A3.	Computed unit stages or Computed contents (optional) Computed daily statistics Computed period statistics Unit datum corrections	User review of primary computations	Approved-computed unit stages Approved-computed unit contents Approved-computed daily stages Approved daily contents Comments

6. This is an optional computation and is not used at all reservoir sites.
7. Maximum and minimum statistics include date and time of occurrence.

VIII. Stage-Discharge Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath.		
A2.	Current or user-specified stage-discharge rating Current + last 2 Q-measurements Last used stage-shift curve Computed unit stages	Unit data shift definition	Stage-shift curve(s)
A3.	Computed unit stages Stage-shift curve(s) Selected stage-Q ratings Computation instructions	Primary computations	Computed unit discharges Computed unit shift data Computed daily statistics[8] Stages - max, min, mean Discharge - max, min, mean Shifts - max, min Computed period statistics Stages - max, min Discharge - max, min
A4.	Computed unit discharges Computed unit stages Computed daily-discharge stats Computed daily-stage stats Rating summaries Max and min shifts Q-measurement data for period Computed unit shift data Other selected station data Comments	User review of primary computations	Approved-computed unit stages Approved-computed daily-stage statistics Approved-computed unit discharges Approved-computed daily-discharge statistics Comments

8. Maximum and minimum statistics include date and time of occurrence.

IX. Slope-Discharge Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath for the Auxiliary Gage (AG).		

B1.	Completion of the Stage Navigation Subpath for the Base Gage (BG).		
B2.	Current or user-specified stage-discharge rating(s) Current + last 2 Q-measurements Last used stage-shift curve Corrected BG unit stages	Unit data shift definition	BG stage-shift curve(s) Comments

X1.	AG computed unit stages BG computed unit stages BG stage-shift curve(s) Stage-discharge rating Stage-fall rating Factor rating Computation instructions	Primary computations	Computed unit discharges Computed unit-shift data Measured unit fall Computed Daily statistics[9] AG stage - max, min, mean BG stages - max, min, mean Discharge - max, min, mean Measured fall - max, min Shifts - max, min Q ratio[10] - max, min Computed period statistics Stages - max, min Discharge - max, min Stage shift - max, min Measured fall - max, min
X2.	Computed unit discharge Computed unit AG & BG stages Computed unit-shift data Computed daily statistics Computed period statistics Rating summaries Max and min shifts Q-measurement data for period Comments Other selected station data	User review of primary computations	Approved-computed unit discharge Approved-computed daily-discharge statistics Approved-computed daily-stage statistics Comments

9. Maximum and minimum statistics include date and time of occurrence.
10. Discharge ratio associated with max and min daily discharge.

X. Velocity-Index-Discharge Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath.		
A2.	Current or user-specified stage-area rating Current + last 2 Q-measurements Last used stage-area shift curve Computed unit stages	Unit data shift definition	Stage-area shift curve(s) Comments

Step	Input	Process	Output
B1.	Completion of the Index Velocity Navigation Subpath.		
B2.	Current or user-specified Index-velocity rating Current + last 2 Q-measurements Last used index-velocity shift curve Computed unit index velocities	Unit data shift definition	Index-velocity shift curve(s)

C1.	Steps B1 through B2 are repeated for each additional velocity meter at site.

Velocity-Index-Discharge Navigation Path, continued

Step	Input	Process	Output
X1.	Computed unit stages Computed unit index velocities Stage-area shift curve(s) Index-velocity shift curve(s) Stage-area ratings Index velocity/stream velocity ratings Stage-velocity factor ratings Computation instructions	Primary computations	Computed unit data Discharges Stage shifts Area Stream velocity Velocity factors Index velocity shifts Computed Daily statistics[11] Stages - max, min, mean Discharge - max, min, mean Shifts - @ max & min stage Stream *v* - mean, max, min Index *v* - mean, max, min Area - mean, max, min Velocity factor - max, min Computed period statistics Stages - max, min Index velocity - max, min Stream velocity - max, min Velocity factor - max, min Area - max, min Discharge - max, min Stage-area shift - @ max and min of index velocity Velocity-index shift - @ max and min of index velocity

11. Maximum and minimum statistics include date and time of occurrence.

Velocity-Index-Discharge Navigation Path, continued

Step	Input	Process	Output

X2.	Stage unit data
	Max and min shifts
	Computed unit data
	  Discharge
	  Stream velocity
	  Index velocity shift
	  Stage shift
	  Velocity factor
	Computed daily statistics
	Computed period statistics
	Rating summaries
	Q-measurement data for period
	Other site data as selected
	Comments
		User review of primary computations	Approved computed unit discharges
			Approved computed daily discharge statistics
			Comments

XI. Rate-Of-Change in Stage-Discharge Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath.		
A2.	Current or user-specified stage-discharge rating Current + last 2 Q-measurements Last used stage-shift curve Computed unit stages	Stage-shift definition	Stage-shift curves Comments
A3.	Computed unit stages Stage-shift curves Selected ratings Stage-discharge Stage vs factor or Storage correction Computation instructions	Primary computations	Computed unit data Discharge Shifts dh/dt $1/VS_c$ or storage adjustment Computed daily statistics[12] Stages - max, min, mean Discharge - max, min, mean Shifts - max, min Computed period statistics Stages - max, min Discharge - max, min
A4.	Computed unit data Discharge Stage Dh/dt $1/VS_c$ Storage correction Storage shifts Computed daily statistics Discharge Stage Shifts Rating summaries Q-measurements for period Other-site data as selected Comments	User review of primary computations	Approved-computed unit data Discharge Stage Approved-computed dailystats Discharge Stage

12. Maximum and minimum statistics include date and time of occurrence.

XII. Structures Navigation Path

Step	Input	Process	Output
A1.	Completion of One of the Other Discharge Navigation Paths (optional).		
A2.	Completion of the Stage Navigation Subpath for Headwater Gage(s).		
A3.	Completion of the Stage Navigation Subpath for Tailwater Gage(s)		
A4.	Completion of the Miscellaneous Unit-Values Navigation Subpath for Tainter Gate Opening(s).		
A5.	Completion of the Miscellaneous Unit-Values Navigation Subpath for Turbine(s).		
A6.	Existing computation parameters	Editing of computation parameters	Modified computation parameters
A7.	Corrected unit headwater stages Corrected unit tailwater stages Corrected unit gate openings Corrected unit turbine readings Corrected unit discharges f/others	Primary computations	Computed unit discharges; All intermediate discharges Structure discharge
A8.	Computed unit discharges Computed daily stages Computed daily discharges Computed daily stages Rating summaries Max and min shifts Q-measurement data for period Comments	User review of primary computations	Computed unit discharges Computed daily discharges Computed daily stages Computed daily stages

XIII. Branch Model Navigation Path

Step	Input	Process	Output
A1.	Completion of the Stage Navigation Subpath.		
B1.	Step A1 is repeated for each additional stage site used in model.		
X1.	Existing model parameters	Editing of model parameters	Modified model parameters
X2.	Computed unit stages Unit datum corrections Unit stage-shifts Selected ratings Q-measurement data for period	Primary computations	Computed unit discharges Computed daily discharges Computed daily stages Max and min shifts
X3.	Computed unit discharges Computed daily stages Computed daily discharges Computed daily stages Rating summaries Max and min shifts Q-measurement data for period Comments	User review of primary . computations	Computed unit discharges Computed daily discharges Computed daily stages Computed daily stages

XIV. Water-Quality Monitor Navigation Path

Step	Input	Process	Output
A1.	Completion of the Instrumentation Data-Entry Navigation Subpath		
A2.	Field notes	Forms entry of field notes	Field measurements
A3.	Time-corrected unit values Field measurements Verification thresholds Starting and ending readings	Unit data verification and editing	Verified and edited unit values
A4.	Verified and edited unit values Field measurements	Data adjustments	Computed QW unit values Unit data adjustments
A5.	Computed QW unit values Unit data adjustments	Primary computations	Computed QW unit values Computed QW daily values
A6.	Computed QW unit values Computed QW daily values Comments	User review of primary computations	Approved computed QW unit values Approved computed QW daily values
X1.	Steps B1 through B4 are repeated for each channel of the water-quality monitor.		

XV. Suspended-Sediment Navigation Path

Step	Input	Process	Output
A1.	Completion of One of the Discharge-Computation Navigation Paths		
A2.	Misc. suspended sediment field notes	Entry of field notes	Misc. field notes for suspended sediment data
A3.	Suspended concentration Particle size distribution	Forms entry	X-section sediment concentration Point sediment concentrations Single vertical sediment conc. Particle size distribution
A4.	Single Point sediment conc. Single vertical sediment conc. X-section sediment concentrations Unit Discharge	Cross-section concentration coefficient analysis	Cross-section concentrations coefficients
A5.	Historical & current suspended sediment concentration Historical & current sediment concentration coefficients Historical & current unit water discharge	Development of correlation to estimate concentration coefficients	Concentration coefficients
A6.	Point Sediment concentrations Cross-section coefficients Unit Discharge	Development of continuous concentration curves (using unadjusted or adjusted concentration values)	Unit sediment concentrations Unit concentration coefficients
A7.	Unit water discharge Unit sediment concentration	Primary computation	Unit sediment discharge Mean daily sediment concentration Daily sediment discharge
A8.	Measured daily suspended sediment concentration or discharge Water discharge	Estimate missing suspended sediment values using transport curves, etc.	Estimated daily suspended sediment discharge

XVI. Suspended-Sediment Navigation Path, continued

Step	Input	Process	Output
A9.	Unit-sediment discharge Unit-sediment concentrations Mean daily-sediment concentratior Mean daily-sediment discharge Computed unit-stream discharge Concentration coefficients Miscellaneous field notes Suspended sediment concentrations Particle-size distributions Correlation curves Transport curves Comments	User review of primary computations	Approved computed unit-sediment discharges Approved computed daily-sediment discharges Comments

XVII. Bedload Navigation Path

Step	Input	Process	Output
A1.	Completion of One of the Discharge-Computation Navigation Paths		
A2.	Miscellaneous bedload field notes	Entry of field notes	Misc. field notes for bedload data
A3.	Bedload sample lab analysis	Entry of bedload data	Bedload concentrations
A4.	Miscellaneous field-notes data Bedload discharge computed empirically Bedload particle size distribution	Adjust bedload discharge according to collection bag mesh size	Bedload particle-size distribution
A5.	Historical & current bedload discharges (unit or daily) Historical & current water discharges (unit or daily)	Development of correlation to estimate bedload discharge (transport curves)	Unit or daily bedload discharge Correlation curves
A6.	Unit bedload discharge	Primary computations	Daily bedload discharge
A7.	Instantaneous bedload discharge Unit bedload discharge Daily bedload discharge Misc field notes data Bedload particle-size distribution Correlation curves Comments	User review of primary computations	Approved-computed daily bedload discharge Comments

XVIII. Type-1 Total Sediment-Discharge Navigation Path

A1.	Completion of the Suspended-Sediment Navigation Path (by particle size).		
A2.	Completion of the Bedload Navigation Path.		
A3.	Misc. total sediment-discharge field notes	Entry of field notes	Misc. field notes for total sediment discharge data
A4.	Daily bedload discharge	Adjust bedload discharge for overlap in sediment sample	Adjusted daily bedload discharge
A5.	Daily suspended-sediment discharge Adjusted daily bedload discharge	Primary computation	Total daily-mean sediment discharge
A6.	Daily suspended-sediment discharge Daily bedload sediment discharge Total daily-mean discharge Adjusted daily bedload discharge Miscellaneous field notes Daily-total sediment discharge Daily-mean water discharge Comments	User review of primary computations	Approved daily-total sediment discharge

XIX. Type-2 Total Sediment-Discharge Navigation Path

A1.	Completion of the Suspended-Sediment Navigation Path.		
A2.	Empirically computed bed-material discharge data	Forms entry of data	Daily bedload discharge
A3.	Misc. total sediment-discharge field notes	Entry of field notes	Miscellaneous field notes for total sediment-discharge data
A4.	Daily bedload discharge	Adjust bedload discharge for overlap in sediment sample	Adjusted daily bedload discharge
A5.	Daily suspended sediment discharge Adjusted daily bedload discharge	Primary computation	Total daily-mean sediment discharge
A6.	Daily suspended sediment discharge Daily bedload sediment discharge Total daily-mean discharge Adjusted daily bedload discharge Miscellaneous field notes Daily-total sediment discharge Daily-mean water discharge Comments	User review of primary computations	Approved daily-total sediment discharge

XX. Water-Quality Load Discharge Navigation Path

Step	Input	Process	Output
A1.	Completion of one of the Discharge-Computation Navigation Paths		
A2.	Misc. water-quality field notes	Entry of Field notes	Misc. field notes for water-quality data
A3.	Water-quality concentration Particle-size distribution	Forms entry	X-sec. water-quality concentration Point water-quality concentrations Single vertical water-quality concn Particle-size distribution
A4.	Point water-quality concentrations Cross-section coefficients Unit Discharge	Development of continuous concentration curves (using unadjusted or adjusted concentration values)	Unit water-quality concentrations Unit concentration coefficients
A5.	Unit water discharge Unit water-quality concentrations	Primary computation	Unit water-quality discharge Mean daily water-quality concn Daily water-quality discharge
A6.	Measured daily water-quality concentration or discharge Water discharge	Estimate missing water-quality values using transport curves, etc.	Estimated daily water-quality discharge
A7.	Unit water-quality discharge Unit water-quality concentrations Mean daily water-quality concn Mean daily water-quality discharge Computed unit stream discharge Concentration coefficients Miscellaneous field notes Water-quality concentrations Particle-size distributions Transport curves Comments	User review of primary computations	Approved computed unit water-quality discharges Approved computed daily water-quality discharges Comments

XXI. General Navigation Path

Step	Input	Process	Output
A1.	Completion of the Instrumentation Data Entry Navigation Subpath		
A2.	Field notes	Forms entry of field notes	Field measurements
A3.	Time-corrected unit values Field measurements Verification thresholds Starting and ending readings	Unit data verification and editing	Verified and edited unit values
A4.	Verified and edited unit values Readings from field note	Data adjustments	Computed unit values Unit data adjustments
A5.	Computed unit values Unit datum corrections	Primary computations	Computed unit values Computed daily values
A6.	Computed unit values Computed daily values Comments	User review of primary computations	Approved computed unit values Approved computed daily values

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Appendix C: Input Forms

L.C. Trotta and J.D. Christman

This appendix contains Input form descriptions and figures of "form flow" during input/editing sessions. It is intended to itemize the input/edit forms the user requirements groups have specified and to show graphically how a user would move through a specific input or edit session. Each table contains a list of items in an input/edit form to be entered or edited by the user. Each list item contains a field name, type of data, mandatory field indicator, and description of the field. The 'type of data' columns using the following codes; Integer = integer number, Number = real number, Date = date and time field, Text = text, Ref. List = field selected from another input form in this appendix or a reference list being designed, Spatial = data related in geographic space, Y/N = yes or no. The mandatory field indicator is an "M" and is displayed after the type of data field only on fields that are mandatory entries. Items marked as mandatory within tables are mandatory for the completion of the table. Mandatory items sometimes apply only to a particular discipline and, in this case, will be qualified with an asterisk (M*) and explained in the description of the field (e.g., * = ground water only). While these forms are still in development, user groups may request changes to the "mandatory" determinations within a table. Criteria for making an item mandatory include: 1) absence of a value renders the record useless or very difficult to handle, 2) pre-existing policy requires entry of the item, 3) entry of the mandatory value is easy and accurate, and 4) the total number of mandatory items efficiently meets district or Division needs without being burdensome to the users. For integer and number types, the description of the field will include units of storage as converted from units of user input.

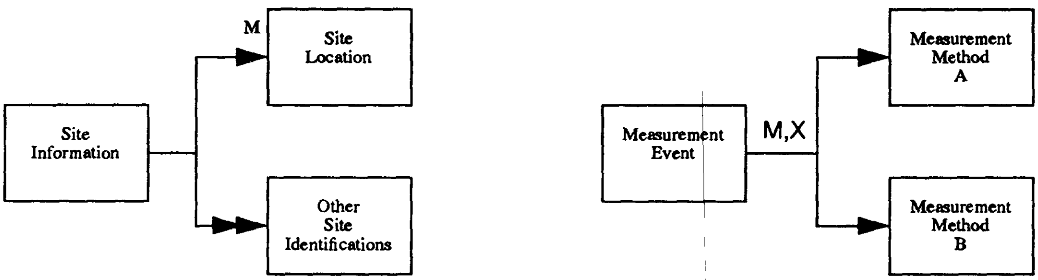
Sometimes there is a parent/child relationship between the information being entered and another associated form. If a parent table is mandatory, it will be noted as such in the forms flow figure that follows each section of tables. Each forms flow figure describes the order and flow of the input forms a user will see as the user's input or edit session progresses.The basic structure of the forms flow figures are the box, representing a form described in a table, and the line and arrows, indicating the order in which forms are seen and used by the user. The different representations are best described graphically in Figure 31.

This appendix is divided into eight sections, each explaining a specific type of input. Figure 32 shows the relationship of the eight types of input forms. The first five forms are site-specific forms, that is, the user selects one specific investigation site and then inputs or edits the desired data for that site. The main components in this appendix are the input/edit table descriptions and the forms flow figures. The general attributes of both of these components are described below to help the reader understand the concepts contained in this appendix.

These forms and forms flow are exhibits to be used by the NWIS-II software designers to develop the input/edit forms and are intended to be a general guide as to what will be needed on each input form. The actual look of the input forms shall be decided during design based upon extensive prototyping with the user groups, the type of forms development system available, and the data base design.

BASIC DESCRIPTION

MUTUALLY EXCLUSIVE



Basic description

1) Site information form is entered first.
2) Site location form is entered automatically since it is a mandatory form as indicated by the "M".
3) Other Site identification form is entered optionally by the user and is a form that can be used multiple times, one for each occurrence of other site identifications as indicated by the double arrows.

Mutually exclusive

1) Measurement event form is entered first.
2) Since the "M" flag is on the next form used is mandatory and since the "X" flag is on also the user must select either Measurement Method A or Measurement Method B form to enter data. the "X" indicates the two forms are mutually exclusive.

Figure 31. -- Examples of form-flow figures.

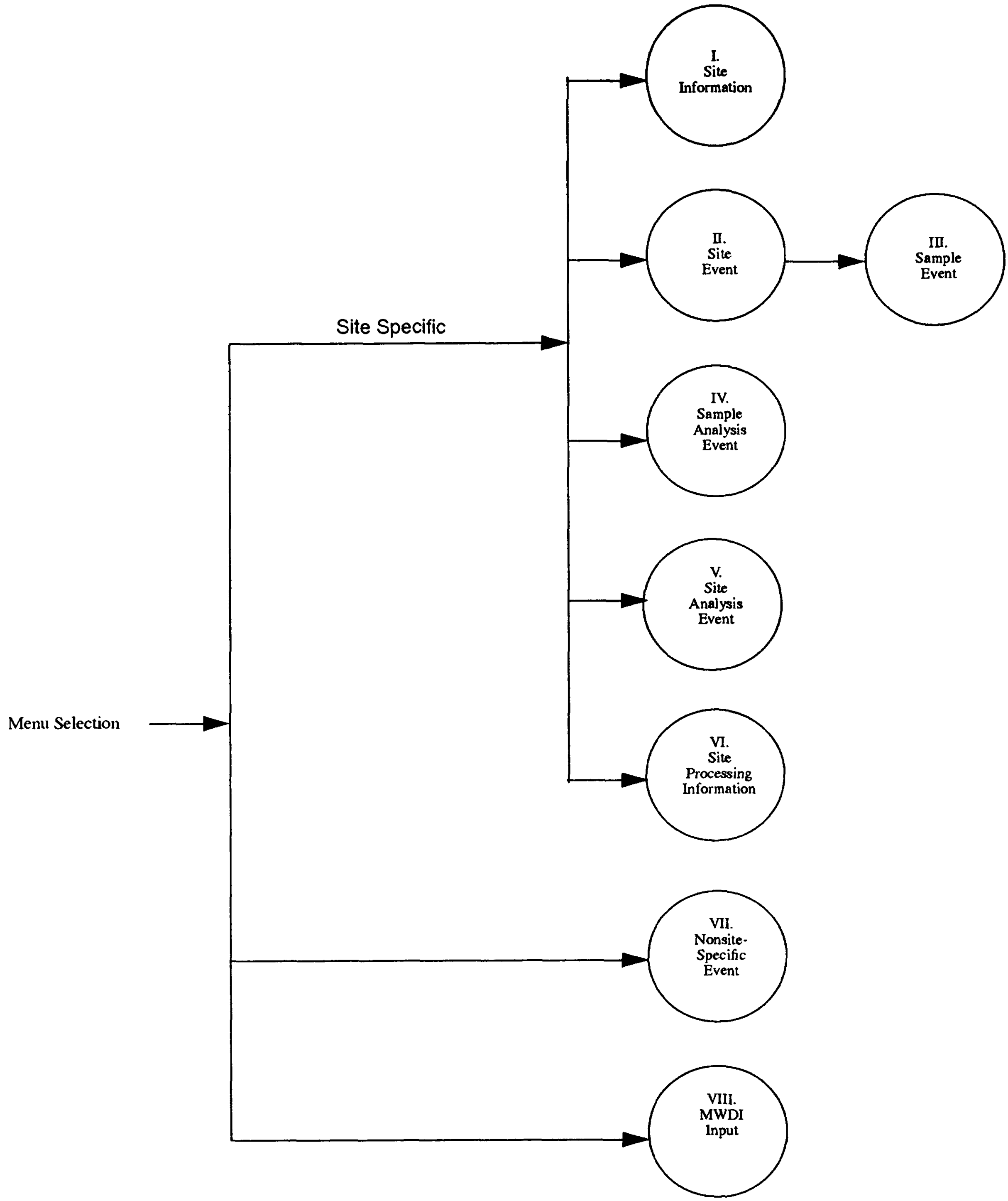


Figure 32. -- Forms flow for input and edit functions.

I. SITE INFORMATION INPUT AND EDIT FORMS AND FORMS FLOW

Site information input and edit forms are the forms used to enter or edit basic site description data, such as site names, locations, topographic settings, and facilities such as wells, and gage houses. This section is arranged in seven sections: General information, Marsh-swamp-atmospheric sites, Ground-water wells, Ground-water springs, Water-use facilities, Conveyance sites, and Stream-reservoir-lake-estuary sites.

A. GENERAL SITE INFORMATION INPUT FORMS

Table 17. -- Components of the input form for site information.

Item	Type		Description
Site number	Number	M	USGS identification number assigned to the site
Site Name	Text	M*	Site Identification name (* = not mandatory for ground-water sites)
Site type(s)	Ref. List	M	Keyword(s) that describes the type of site or feature
Narrative on site type	Text		Further comments describing the site type
Date established or inventoried	Date		Date that this site was established (or reactivated) or first time it was inventoried, sampled, or measurements were taken.
Date terminated	Date		Date that site is terminated or destroyed
Reactivation	Y/N		Do above dates apply to a reactivation of a formerly terminated site? (default = No)
Site permit existence	Y/N	M	Does a permit exist for use of site or water at site?

Table 18. -- Components of the input form for other-site identification.

Item	Type		Description
Other-site identification	Text	M	A different site identification other then the USGS ID.
Other-site identification agency	Ref. List	M	Agency assigning a different site identification

Table 19. -- Components of the input form for grouping of sites (within or across project groups).

Item	Type		Description
Site Group I.D.	Number/Spatial	M	A representative Site number, lat/long, or GIS areal outline of entire group of associated sites
Site number	Number	M	USGS identification number of component site
Percent contribution	Number		Percent contributed by component site (constituent contributed depends on purpose in assigning unique group ID)
Start date	Date		Date when group configuration began
End date	Date		Date when group configuration ended; if null, percent valid to current date
Group purpose remarks	Text		Remarks on purpose for associating sites and common constituent

Table 20. -- Components of the input form for source of site information.

Item	Type		Description
Site information source	Ref. List	M	Source type of information for site

Table 21. -- Components of the input form for agency source of site information.

Item	Type		Description
Site information source agency	Ref. List	M	Agency responsible as source of information
Site information source agency office	Ref. List	M	Agency office for source of information
Site information source agency person	Ref. List		Person in agency for source of information
Original provider	Ref. List		Provider of information (for credit purposes) before USGS modification

Table 22. -- Components of the input form for person source of site information.

Item	Type		Description
Site information source person	Ref. List	M	Person who is source of information
Site information source address	Ref. List	M	Persons office or home address

Table 23. -- Components of the input form for publication source.

Item	Type		Description
Reference title	Text	M	Title of publication referencing data
Author	Text	M	Last name, First name, Initial
Date	Date	M	Date of publication
Pages	Text	M	Page range separated by hyphen

Table 24. -- Components of the input form for site location.

Item	Type		Description
Site country	Ref. List	M	Country where site is located (USA default)
Site state	Ref. List	M	State where site is located
Site district	Ref. List	M	USGS district office responsible for site data
Site county	Ref. List	M	County where site is located
Site town	Text		Name of nearest town, city, etc.
Site congressional district	Ref. List	M	Congressional district where site is located
Site hydrologic unit	Ref. List	M	Drainage basin number as defined by USGS of site
Site drainage basin code	Integer		Number indicating a subdivision of hydrologic unit
Site topographic setting	Ref. List		Defined topology where site is located
Site township & range	Text	M*	Township and range number (* = only where land net exists)
Site township name	Text		Township in which site is located
Site location map	Text		Identification of map used to locate site
Site location map scale	Text		Map scale of location map
Site geographic location (station)	Text		Narrative description of site location(e.g., highway directions, 50 feet from left bank)

Table 25. -- Components of the input form for site latitude and longitude.

Item	Type		Description
Site latitude	Integer	M	Latitude coordinates of site, in degrees, minutes, and seconds
Site longitude	Integer	M	Longitude coordinates of site, in degrees, minutes, and seconds
Site lat/long determination method	Ref. List	M	How longitude/latitude coordinates were determined
Site lat/long determination instrument	Ref. List		Instrument used in determining longitude/latitude coordinates
Site lat/long determination date	Date		Date & time longitude/latitude coordinates were determined
Site lat/long determination accuracy	Ref. List	M	Accuracy of longitude/latitude coordinates
Site lat/long method modification	Text		Modification to the method used to determine longitude/ latitude coordinates
Site person determining lat/long	Ref. List		Individual who determined longitude/latitude coordinates

Table 26. -- Components of the input form for site elevation.

Item	Type		Description
Elevation of land surface	Number	M	Land surface elevation value of site, in feet NGVD
Elevation datum	Text	M	Point from which elevation was measured
Elevation determination method used	Ref. List	M	Method used to determine elevation
Elevation determination date & time	Date		Date and time elevation was determined
Elevation determination instrument	Ref. List	M	Instrument used to determine elevation
Altitude accuracy	Number	M	Number indicating accuracy of elevation, in feet
Elevation method modifications	Text		Modifications to the method used to determine elevation
Person determining elevation	Ref. List		Individual who determined elevation

Table 27. -- Components of the input form for site eco-region.

Item	Type		Description
Eco-region	Ref. List	M	EPA classification for ecological region
Eco-region determination date & time	Date	M	Date and time eco-region was determined
Person determining eco-region	Ref. List		Person making eco-region determination

Table 28. -- Components of the input form for site surface geologic.

Item	Type		Description
Surface geologic unit	Ref. List	M	Formal name of series, group, formation of surface geology
Geology determination date & time	Date	M	Date and time geology was determined
Person determining geological unit	Ref. List		Name of person making geologic unit determination

Table 29. -- Components of the input form for site physiographic province.

Item	Type		Description
Physiographic province name	Ref. List	M	Physiographic unit name
Province determination date & time	Date	M	Date & time physiographic province was determined
Person determining physiographic	Ref. List		Name of person making physiographic unit determination

Table 30. -- Components of the input form for site soil type.

Item	Type		Description
Soil classification system	Text	M	ASTM, SCS, or other
Soil type	Ref. List	M	Name assigned based on soil classification system
Soil Type determination date & time	Date	M	Date & time soil type was determined
Person determining soil type	Ref. List		Name of person making soil type determination

Table 31. -- Components of the input form for site owner/contact.

Item	Type		Description
Individual site owner	Text	M*	Name of site owner (* = if a person)
Corporate site owner	Text	M*	Trade name of site owner (* = if not a person or Government agency; may invoke a Ref. List)
Government site owner	Ref. List	M*	Name of site owner (* = if a government agency)
Ownership date	Date		Date site owner obtained site
Owner contact	Text		Name of person to contact about the site
Contact change date	Date		Date information changed about contact
Contact phone number	Text		Phone number of owner or contact
Contact address	Text		Street or road address for mailing
Contact city	Text		City of owner's/contact's address
Contact state	Text		State of owner's/contact's address
Contact zip code	Text		Postal zip code of owner's/contact's address
Remarks	Text		Remarks about owner or contact

Table 32. -- Components of the input form for site remarks.

Item	Type		Description
Site remark date	Date	M	Date of remark entry
Site remark observer	Ref. List	M	Person making site remark
Site remark	Text	M	Remarks about the site

Table 33. -- Components of the input form for miscellaneous site information.

Item	Type		Description
Miscellaneous site info. date	Date	M	Date miscellaneous data were entered
Miscellaneous site info. type	Ref. List	M	Type of miscellaneous data
Miscellaneous site info. format	Ref. List	M	Format of miscellaneous data
Miscellaneous site info. location type	Ref. List		Type of location of miscellaneous data
Miscellaneous site info. observer	Ref. List	M	Person entering miscellaneous data
Miscellaneous site info. data link	Link		Link to computer location of miscellaneous data

Table 34. -- Components of the input form for site water-use category.

Item	Type		Description
Agency determining category	Ref. List		Name of agency making water-use category determination
Water use determination date and time	Text	M	Date and time water use was determined
SIC code	Ref. List		Standard Industrial Classification (SIC) code (multiple entries allowed)
Water use type	Ref. List	M	Code for water-use category (automatically entered when SIC Code known)

Table 35. -- Components of the input form for site water-use subcategory

Item	Type		Description
Water-use USGS type	Ref. List	M	USGS general water use type
Water use local subcategory	Text	M	Local subcategory of water use types
SIC code	Ref. List		SIC codes included in local subcategory
Begin date of use	Date		Date use of local definition started
End date of use	Date		Date use ended (if null, then to present day)
State or district of application			

EARTH/ATMOSPHERE INTERFACE (MARSH, SWAMP, ATMOSPHERIC, TERRESTRIAL, AND POND) TYPE SITE INFORMATION INPUT FORMS

Table 36. --Components of the input form for general climatic-site information

Item	Type	Description
Data reliability	Ref. List	Keyword describing the reliability of the site data
Agency use of site	Ref. List	Keyword describing agency's use of the site
Primary use of site	Ref. List	Keyword describing primary use by site owner
Secondary use of site	Ref. List	Keyword describing secondary use by site owner
Date started	Date	Date site became active
Location	Text	Description of location
Description	Text	Site description

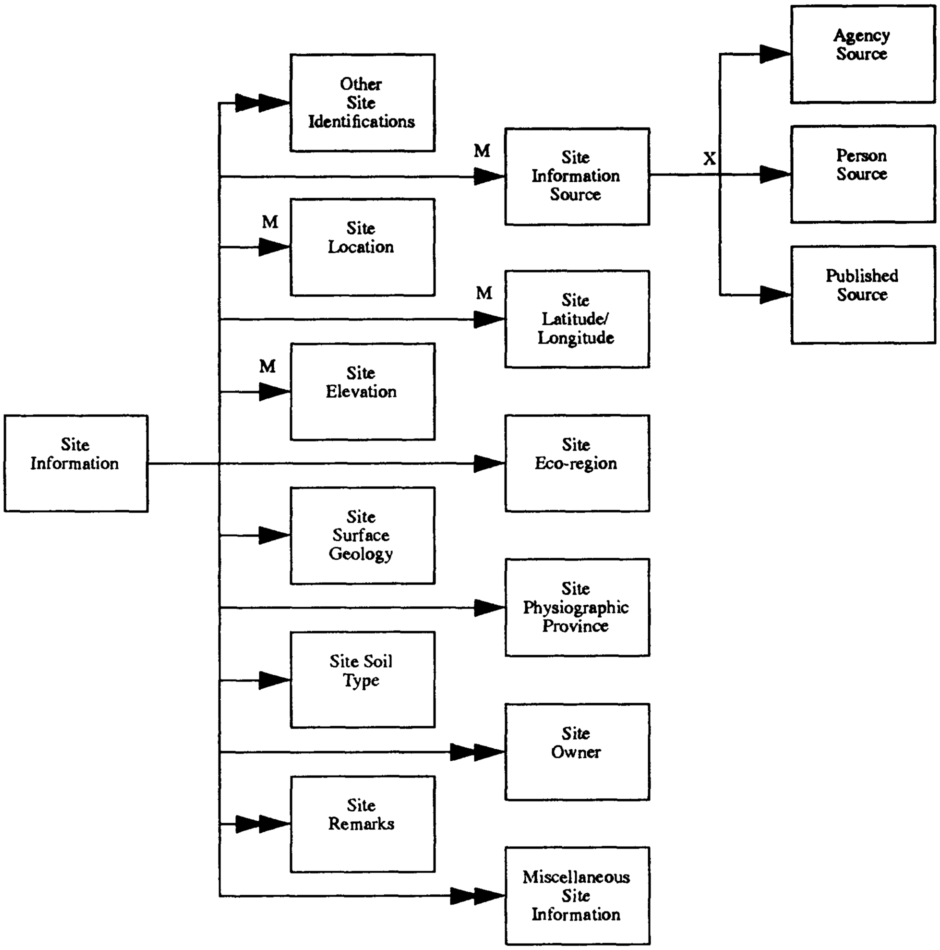


Figure 33. -- Input form flow for earth/atmosphere interface type sites.

B. WELL SITE-TYPE INFORMATION INPUT FORMS

Table 37. -- Components of the input form for general well site-type information.

Item	Type		Description
Data reliability	Ref. List	M	Keyword describing the reliability of the site data
Well site type	Ref. List	M	Keyword describing the type of site
Agency use of site	Ref. List		Keyword describing the agency's use of the site
Primary use of site	Ref. List		Keyword describing the primary use by the site owner
Secondary use of site	Ref. List		Keyword describing the secondary use by the site owner
Tertiary use of site	Ref. List		Keyword describing the tertiary use by the site owner
Primary use of water	Ref. List		Keyword describing the primary use of the water by the site owner
Secondary use of water	Ref. List		Keyword describing the secondary use of the water by the site owner
Tertiary use of water	Ref. List		Keyword describing the tertiary use of the water by the site owner
Primary aquifer	Ref. List		Name of the primary aquifer contributing to the well
Aquifer type	Ref. List		Keyword describing the type of aquifer contributing to the well
Hole depth	Number		Depth in feet of the hole
Well depth	Number		Depth in feet of the well
Depth to bedrock	Number		Depth in feet to uppermost bedrock surface
Source of depth data	Ref. List		Keyword describing source of depth data

Table 38. -- Components of the input form for well construction.

Item	Type		Description
Well construction, date started	Date	M	Date that the well was constructed
Well construction, date completed	Date		Date that the well was completed
Well construction data source	Ref. List	M	Source of well construction data
Well contractor name	Text		Name of contractor that constructed well
Well construction method	Ref. List		Keyword identifying the construction method
Well type of finish	Ref. List		Keyword identifying the type of well finish
Well development method	Ref. List		The method of well development
Well hours of development	Number		The number of hours the well was developed
Well special treatment	Ref. List		Keyword identifying any special treatment the well received

Table 39. -- Components of the input form for well hole.

Item	Type		Description
Well hole depth to top of interval	Number	M	Depth to top of defined hole interval, in feet
Well hole depth to bottom of interval	Number		Depth to bottom of defined hole interval, in feet
Well hole diameter of interval	Number		Diameter of defined hole interval, in inches

Table 40. -- Components of the input form for well casings.

Item	Type		Description
Well casing depth to top of casing	Number	M	Depth to top of defined casing interval, in feet
Well casing depth to bottom of casing	Number		Depth to bottom of defined casing interval, in feet
Well casing diameter of casing	Number		Diameter of defined casing interval, in inches
Well casing material	Ref. List		Material of defined casing interval
Well casing thickness	Number		Thickness of defined casing interval, in inches

Table 41. -- Components of the input form for well openings.

Item	Type		Description
Well opening depth to top of interval	Number	M	Depth to top of defined well opening, in feet
Well opening depth to bottom of interval	Number		Depth to bottom of defined well opening, in feet
Well opening diameter of interval	Number		Diameter of defined well opening, in inches
Well opening material type	Ref. List		Material type of defined well opening
Well opening type of opening	Ref. List	M	Type of opening of defined well opening
Well opening length of opening	Number		Length of defined well opening, in inches
Well opening width of opening	Number		Width of defined well opening, in inches

Table 42. -- Components of the input form for well fill intervals.

Item	Type		Description
Well fill depth to bottom	Number		Depth to bottom of well fill from site reference point, in feet
Well fill depth to top	Number	M	Depth to top of well fill from site reference point, in feet
Well fill diameter inside	Number		Diameter of well fill on outside, in inches
Well fill diameter outside	Number		Diameter of well fill on the inside, in inches
Well fill material type	Ref. List		Type of well fill material
Well fill volume	Number		Volume of well fill, in cubic feet

Table 43. -- Components of the input form for pits, ponds, quarries, and tunnels.

Item	Type		Description
Pit/pond/quarry/tunnel name	Text		Name of pit, pond, quarry or tunnel
Type	Text		Is this a pit, pond, quarry or tunnel
Pit/pond bearing	Number		Orientation of the long dimension of a noncircular pit, pond, quarry or tunnel, in degrees from due north, read clockwise
Pit/pond depth	Number		Average depth of the pit, pond, quarry or tunnel, in feet
Pit/pond length	Number		The longest length of the pit, pond, quarry or tunnel, or its diameter if it is circular (in feet)
Pit/pond width	Number		The shorter dimension in feet of the noncircular pit, pond, quarry or tunnel
Quarry area	Number		The area of a quarry in acres
Tunnel dip	Number		The dip of the tunnel, in degrees above or below (-) horizontal

Table 44. -- Components of the input form for well measurement points (MP).

Item	Type		Description
Well MP begin date	Date	M	Begin date that MP is to be used
Well MP end date	Date		End date that MP is to be used
Well MP altitude	Number	M*	Altitude of MP in feet (* = when height above LSD unknown)
Well MP height to LSD	Number	M*	Height of MP in feet above (+) or below (-) land surface datum (* = when altitude of MP unknown)
Well MP. accuracy	Number	M*	Accuracy of altitude of MP in feet (* = only when altitude of MP necessary)
Well MP determination method	Ref. List	M*	Method of determination of altitude of MP (* = only when altitude of MP necessary)
Well MP. description	Text	M	Description of MP

Table 45. -- Components of the input form for well lifts.

Item	Type		Description
Well lift type	Ref. List	M	Type of well lift
Well lift date recorded	Date		Date information was collected and entered
Well lift date installed	Date		Date that the well lift was installed
Well lift date removed	Date		Date that the well lift was removed
Well lift pump intake depth	Number		Depth of pump intake in feet
Well lift horse-power rating	Number		Power rating of the well lift in horse-power
Well lift manufacturer	Text		Company manufacturing well lift
Well lift serial number	Text		Serial number of well lift
Well lift pump rating	Number		Rating of pump lift in gallons per minute
Well lift maintainer	Text		Person or company maintaining well lift
Well lift rated pump capacity	Text		Pumping capacity of well lift
Well lift additional head	Number		The additional head above land surface against which a pump works, in feet of water
Well lift total head	Number		Total head pressure of well lift in feet
Well lift standby horsepower	Number		Power of standby well lift in horse power

Table 46. -- Components of the input form for well lift power.

Item	Type		Description
Well lift type of power	Ref. List	M	Type of power driving well lift
Well lift standby type of power	Ref. List		Type of power driving standby well lift
Well lift power co. account number	Text		If power from utility, account number of utility
Well lift power company name	Text		Utility company name
Well lift power meter Kh factor	Number		Kh factor number shown on the electric meter, in watt-hours per revolution of the meter disc
Well lift power meter multiplier	Number		Multiplier number shown on the electric meter (where the multiplier number is not shown on the meter and the meter is not directly wired into the power line, this number is obtained by multiplying together the current and voltage transformer ratios)
Well lift power meter number	Text		Power supply meter number

Table 47. -- Components of the input form for well collectors.

Item	Type		Description
Well collector lateral depth	Number	M	Depth that well collector lateral starts, in feet below LSD
Well collector lateral length	Number		Length of well collector lateral, in feet
Well collector lateral diameter	Number		Diameter of well collector lateral, in inches
Collector lateral screen mesh/slot size	Number		Screen mesh or slot size of well collector lateral, in inches

Table 48. -- Components of the input form for well repairs.

Item	Type		Description
Well repair contractor	Text		Name of contractor doing repair
Well repair date	Date	M	Date of well repair
Well repair nature	Ref. List	M	Type of well repair being done
Well repair performance change	Number		Change in well performance after well repair, in gpm

Table 49. -- Components of the input form for local well registration and inspection.

Item	Type		Description
Well contractor's registration number	Text		Registration number assigned to well
Well registration agency	Ref. List		Agency responsible for well registration or inspection
Permit number	Text	M*	Water appropriation permit number (* = if permit assigned)
Well inspection date	Date		Date of well inspection
Well inspection status	Text		Status of well inspection
Well disapproval reason	Text		If not approved, reason for nonapproval

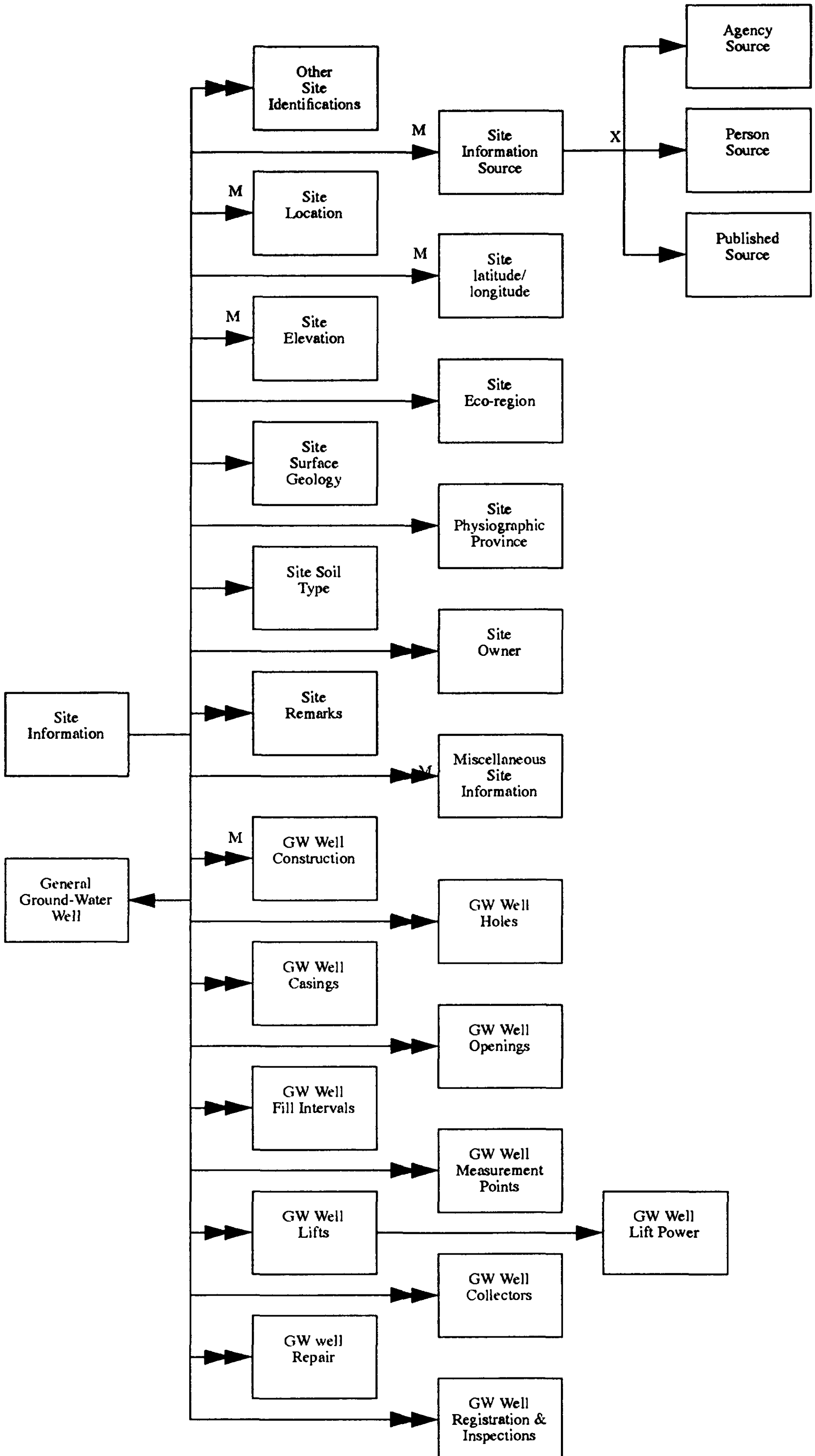


Figure 34. -- Input form flow for ground water well type site information.

C. GROUND-WATER SPRING TYPE SITE INFORMATION INPUT FORMS

Table 50. -- Components of the input form for ground-water spring sites.

Item	Type	Description
Spring type	Ref. List	Type of spring
Spring basis for variability	Ref. List	Basis for determining variability of spring flow
Spring contributing hydrogeologic unit	Text	Hydrogeologic aquifer unit contributing to spring
Spring flow variability	Number	Computed variability of spring, in percent
Spring improvements	Ref. List	Keyword describing Improvements to spring
Spring number of openings	Integer	Number of spring openings
Spring permanence	Ref. List	Keyword describing permanence of spring
Spring receptor name	Text	Name assigned to spring receptor
Spring receptor type	Ref. List	Type of spring receptor
Sphere of discharge	Text	Subaerial or subaqueous
Regulatory classification	Ref. List	If spring bubbles above ground on its own = surface water, if it requires a pipe driven into ground = ground water

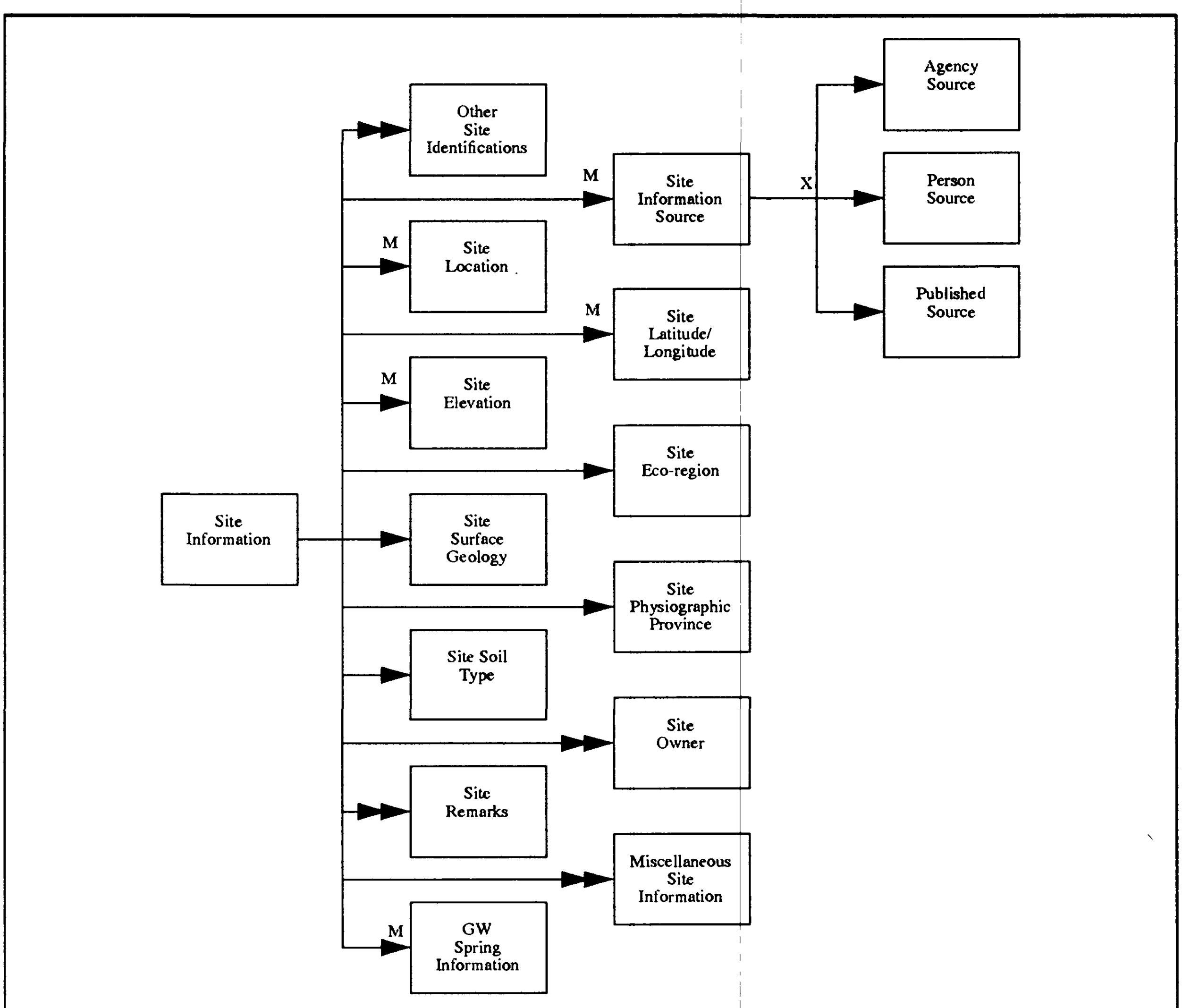


Figure 35. -- Input form flow for spring type site information

D. WATER-USE FACILITY TYPE SITE INFORMATION INPUT FORMS

Table 51. -- Components of the input form for water-use (WU) facility.

Item	Type		Description
Facility number	Number	M	Site number assigned to facility, lat/long location to represent center of water use between points of inflow and outflow (either of which may be used by default) at plant or business
Water-use facility name	Text	M	Facility name, trade name
Sites or site group ID's owned	Number/Spatial		ID of site or site group owned by facility (multiple entries allowed)
Facility type	Ref. List		Major type of water use at facility
Water-use facility start date	Date		Date facility went online
Water-use facility end date	Date		Date facility went offline
Water-use facility permit existence	Y/N		Does a water-use permit exist for this facility?
Water-use facility water right file no.	Text		Applies to western States with water rights doctrine
Water-use facility remarks	Text		Remarks about the water-use facility

Table 52. -- Components of the input form for water-use-facility physical location or tenant at site.

Item	Type		Description
Name of facility or tenant	Text	M	Facility name or name of tenant at a site
Change date	Date		Date information on tenant or physical location of facility changed
Phone	Text		Phone number at facility or tenant's home
Address	Text		Street or road address of facility/tenant
City	Text		City of facility's/tenant's address
State	Text		State of facility's/tenant's address
Zip code	Text		Postal zip code of facility's/tenant's address
Remarks	Text		Remarks about facility's/tenant's physical location

Table 53. -- Components of the input form for water-use facility capacity change.

Item	Type		Description
Water-use facility date of change	Date	M*	Date of expected change in capacity at water-use facility (* = if type is expansion or reduction)
Water-use facility type of change	Ref. List	M	Type of change in facility (expansion, reduction, or breakdown)
Water-use facility change description	Text		Description of change in water-use facility
Water-use facility change	Number		Change in water-use facility capacity, in MGD, with positive or negative
Water-use facility breakdown date	Date	M*	Date that water-use facility broke down (* = if type is breakdown)
Water-use facility return to service date	Date	M*	Date that water-use facility returned to service (* = if type is return to service)

Table 54. -- Components of the input form for water-use (WU) facility size.

Item	Type		Description
WU facility size determination date	Date	M	Date that the WU facility size was determined
WU facility size units	Ref. List		Units in which facility size assessed
WU facility size	Number		Facility size in units specified above
WU facility fixture/amenity type	Ref. List		Type of fixture or amenity counted at facility
WU facility fixture/amenity count	Number		Number of fixtures or amenity, as defined above
WU facility institutional category	Ref. List		Categories for institutional or commercial facilities

Table 55. -- Components of the input form for water-use and other permits.

Item	Type		Description
Permit number	Text		Permit number (multiple entries allowed)
Permit type	Ref. List		Withdrawal, return, transfer, civil, unknown
Water permit allowed rate	Number		Pumpage rate allowed, In legal units
Legal units	Ref. List		Usually gpd or million gal/year
Permit status	Ref. List		Is permit active or in good standing?
Water permit restrictions	Text		Pumping restrictions (Y/N) and basis
Permit agency	Ref. List	M*	Agency issuing the permit (* = when issued by a listed agency)
Other permit grantor	Text		Name of permit grantor when not a listed agency
Permit start date	Date	M*	Date permit was issued (* = for water withdrawals)
Permit end date	Date		Date permit was withdrawn

Table 56. -- Components of the input form for water rights information.

Item	Type		Description
Water-use facility water right file no.	Text	M*	File number currently used to access the water rights information for a particular user or facility (* = Applies to Western States with water-rights doctrine)
Application number	Text		The sequential number assigned by the State Water Resources Agency (SWRA) to each application for water right
Certification number	Text		The sequential number assigned by the SWRA to each water right upon completion of a survey of field acreage
Permit number	Text		Permit number (multiple entries allowed)
Priority date	Date		Date of receipt of application for the water right by the SWRA
Rights status	Ref. List		Are water rights active or not?
Acreage affected	Text		If irrigation, enter two 7-digit numbers (with decimal fractions if necessary), separated by a slash, for primary and supplemental irrigated acreage
Legal diversion	Number		Maximum rate at which water is allowed to be pumped, in legal flow units
Legal flow units	Ref. List		Unit of flow legally prescribed for diversion (e.g., cfs)
Legal allowance	Number		Maximum amount of water legally allowed per year for a water right, in legal units
Legal volume units	Number		Unit of volume for legal allowance (e.g., acre-feet)
Date legal irrigation begins	Date		Date irrigation can legally begin in the spring
Date legal irrigation ends	Date		Date irrigation should legally end in the fall

Table 57. -- Components of the input form for water-supply facility trends.

Item	Type		Description
Water-supply date of determination	Date	M	Date to which this information applies
Water-supply population served	Number	M	Population served by facility, In thousands
Water-supply water present	Number		Amount of water present in the supply system at any given time, in gallons X 1000

Table 58. -- Components of the input form for water-supply sources.

Item	Type		Description
Water supply date of determination	Date	M	Date this information was determined
Source of site information	Ref. List	M	Source of data on water-supply sources
Water-supply ground-water sources	Integer		Water supply from ground-water sources in percent
Water-supply surface-water sources	Integer		Water supply from surface-water sources in percent
Water-supply transfer-water sources	Integer		Water supply transferred from other water-supply company in percent (entry > 0 invokes purchases form)
Water-supply number of reservoirs	Integer		Number of active reservoirs used by water-supply facility
Water-supply number ofSW intakes	Integer		Number of active surface-water intakes used by water-supply facility
Water-supply number of wells	Integer		Number of active supply wells used by water-supply facility

Table 59. -- Components of the input form for water-supply delivery destination.

Item	Type		Description
Site group ID	No./Spatial	M	A representative site number., lat/long or GIS areal outline of entire group of associated sites or destinations
Water delivery date of determination	Date	M	Date the delivery service area was determined
Water delivery rate structure	Text or graphic		Billing rate structure
Water delivery service area	Spatial		Outline size and location of service area

Table 60. -- Components of the input form for sewage-treatment facility treatment types.

Item	Type		Description
Level of treatment	Ref. List	M	Keywords describing the level of treatment applied to water prior to its return in order to improve the quality of the water
Sewage treatment type	Ref. List		Keywords describing type of sewage treatments used
NPDES permit	Text	M	National Pollution Discharge Elimination System permit number
Sewage plant capacity	Number		Plant flow capacity in gpd x 1,000
Discharge waterbody	Text		Name of waterbody to which effluent discharged

Table 61. -- Components of the input form for reuse by a commercial/industrial/mining/ aquaculture/recreational facility.

Item	Type	Description
Start	Date	Earliest date reuse (wastewater reclamation, not recirculation) known at site, ignoring seasonal variance
End	Date	Date reuse ended at site, ignoring seasonal variance
Facility number.	Number	Site number of facility
Reuse purpose	Ref. List	Purpose for which water reused
Product	Text	Product produced, sold, or distributed as result of reuse

Table 62. -- Components of the input form for power generation facility.

Item	Type		Description
Power generation date of determination	Date	M	Date this information was determined
Power generation capacity	Number		Capacity for power generation of facility, in gigawatts
Power generation head	Number		If hydro power type, pressure head of facility In feet
Power generation plant efficiency	Integer		Efficiency of power production in percent
Power gen. hydro/thermo category	Ref. List		Type of power generation nuclear, geothermal, fossil, hydro
Power gen. fossil-fuel subcategory	Ref. List		Type of fossil fuel used

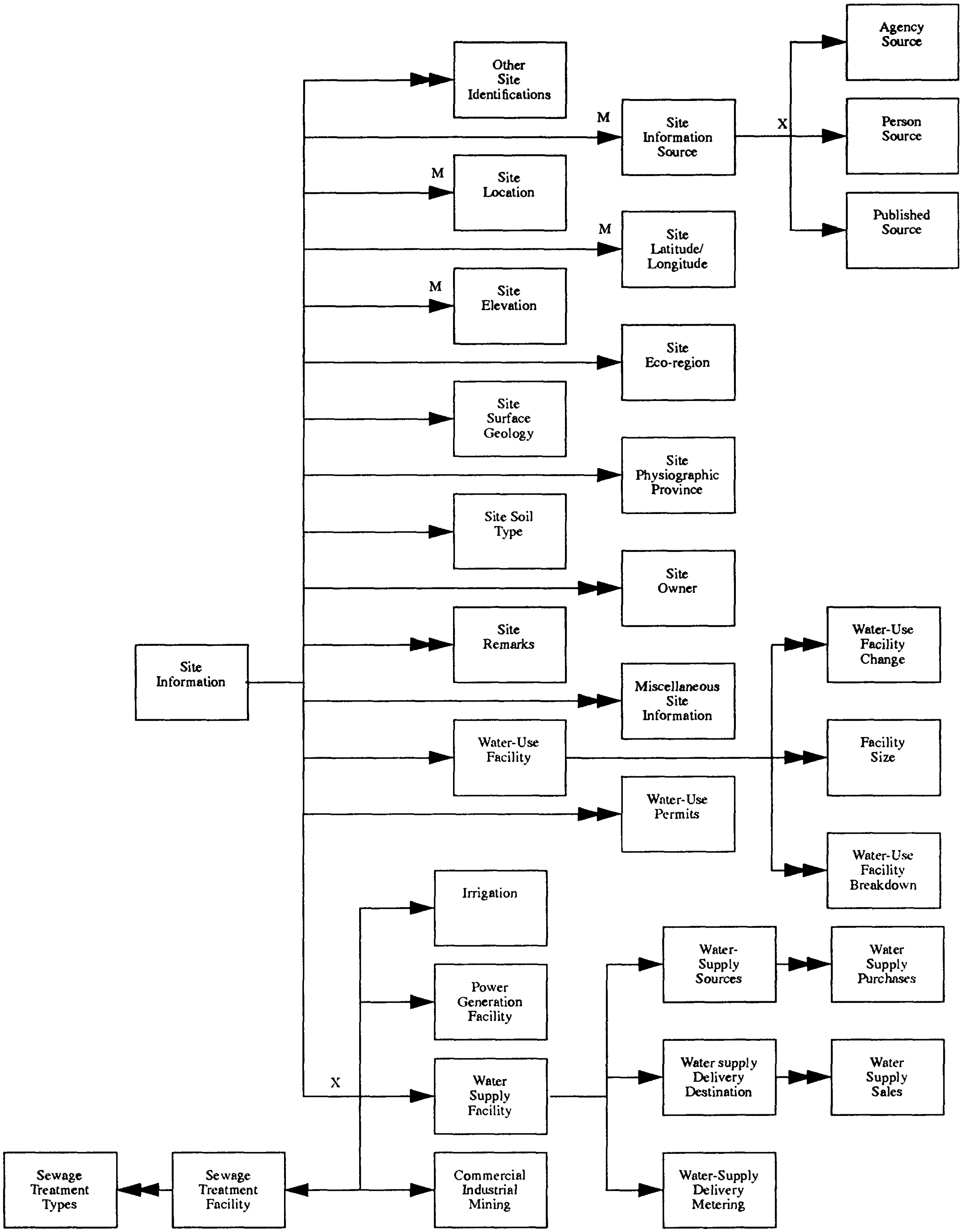


Figure 36 -- Input form flow for water-use facility type site.

E. CONVEYANCE TYPE SITE INFORMATION INPUT FORMS

Table 63. -- Components of the input form for water conveyance.

Item	Type		Description
Water conveyance type	Ref. List	M	Keyword describing the type of water conveyance
Water conveyance water type	Ref. List	M	Keyword describing the type of water moved through the conveyance
Water conveyance "from" site ID	Number	M*	The site number of endpoint where the water flow starts (* = unless plotted with GIS topology)
Water conveyance "to" site ID	Number	M*	The site number of endpoint where the water flow is moving to (* = unless plotted with GIS topology)
Water conveyance owner	Text		Name of owner of conveyance (default to owner of "from" site ID)
Water conveyance in-service date	Date		Date that this conveyance went into service
Water conveyance out-of-service	Date		Date that this conveyance went out of service
Water conveyance remarks	Text		Remarks about the status of conveyance, etc.
Source quality	Text		Fresh, saline, reclaimed sewage

Table 64. -- Components of the input form for pipe conveyance.

Item	Type	Description
Water conveyance pipe diameter	Integer	Diameter of pipe conveyance, In inches
Water conveyance pipe material	Ref. List	Material of pipe conveyance

Table 65. -- Components of the input form for water channel conveyance.

Item	Type	Description
Channel conveyance width	Integer	Width of channel conveyance, In feet
Channel conveyance bottom material	Ref. List	Material of conveyance channel bottom

Table 66. -- Components of the input form for interbasin transfer[1,2]

Item	Type		Description
Conveyance name	Text		Official name for channel, canal, pipeline, or reservoir system
Export deliveries	Number	M	Percent of pumpage delivered to users in importing basin (i.e., percent exported)
Home deliveries	Number		Percent of pumpage delivered to users within exporting basin (i.e., percent not exported)
Date determined	Date	M	Date to which delivery percentages apply
Purchase/transfer	Y/N		"Y" = water was purchased or sold to initiate flow, "N" = water was transferred with no money exchange (default)
Connection totaling method	Text		Owner, reported, GIS, or estimation
Import connections	Number		Percent of connections or irrigated fields in importing basin
Export connections	Number		Percent of connections or irrigated fields in exporting basin
Importing basin	Ref. List		Drainage basin no. as defined by USGS receiving water
Exporting basin	Ref. List		Drainage basin no. as defined by USGS exporting water
Interbasin reference number	Number		ID number consecutively assigned to each interbasin conveyance described

1 [The connection totaling method should be able to invoke a GIS computation if desired. This computation compares the areas on either side of the basin boundary lying within the political boundaries of the municipality, and applies these percentages to the total number of connections to estimate import and export connections]

2 [This form should be automatically invoked whenever both of two conditions exist: 1) the site location is within 12 miles of a subregional watershed boundary, and 2) the water-use category is Public Supply, Sewage Treatment, Irrigation, or Mining]

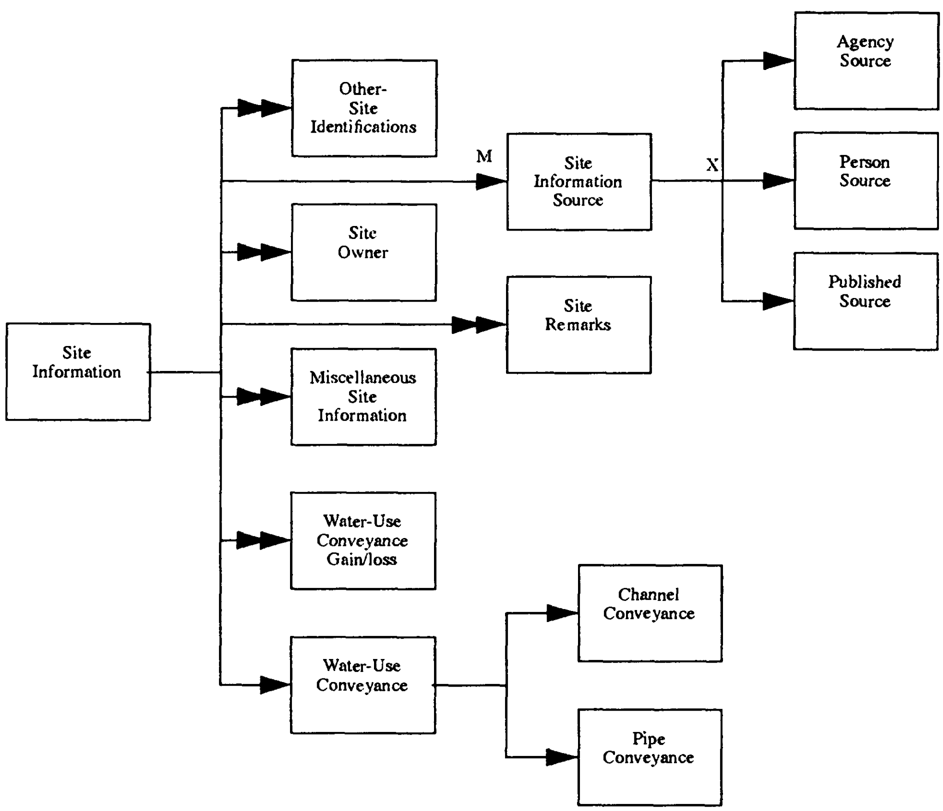


Figure 37. -- Input form flow for water-use conveyance type site.

F. STREAM, RIVER, LAKE, RESERVOIR TYPE SITE INFORMATION INPUT FORMS

Table 67. -- Components of the input form for site river mile.

Item	Type		Description
Site river mile number	Number	M	River mile number, in miles, for site
Site river mile datum	Text	M	Description of point where river mile was measured from
Site river mile determination method	Ref. List	M	Method of determining site's river mile
Site river mile determination date	Date	M	Date of river mile determination
Site river mile determination person	Ref. List	M*	Person determining the site river mile (* = if WRD employee)
Site river mile agency	Ref. List		Information on agency determining the site river mile alternate number
Alternate river mile number	Number		Alternate number to identify river mile, in units dependent on determining agency
Site river mile determination instrument	Ref. List		Instrument used to determine the site river mile

Table 68. -- Components of the input form for site river reach.

Item	Type		Description
Site river reach identification	Ref. List	M	Identification of site's river reach segment as defined by EPA
Site river reach determination date	Date	M	Date of determination for river reach identification
Site river reach determiner	Ref. List	M	Person determining the site's river reach identification
Site river reach reference	Text		Reference used to determine the site's river reach identification

Table 69. -- Components of the input form for reservoir or lake information.

Item	Type		Description
Man-made	Y/N		Y = man-made, N = natural
Reservoir start date	Date	M*	Date the reservoir or lake storage began (* = if man-made)
Elev. of spillway	Number		Elevation of spillway or lake outlet, In feet above MSL
Management agency	Text		Agency responsible for management of lake or reservoir
Reservoir design use	Ref. List		Uses for which reservoir or lake was designed (multiple entries allowed)

Table 70. -- Components of the input form for surface-water intake.

Item	Type		Description
Water intake construction date	Date		Date intake was constructed
Permit number	Text	M	Water appropriation permit number
Water intake construction description	Text		Description of the intake
Water intake pump capacity	Number		Maximum pumping capacity of the intake, in gpd X 1000

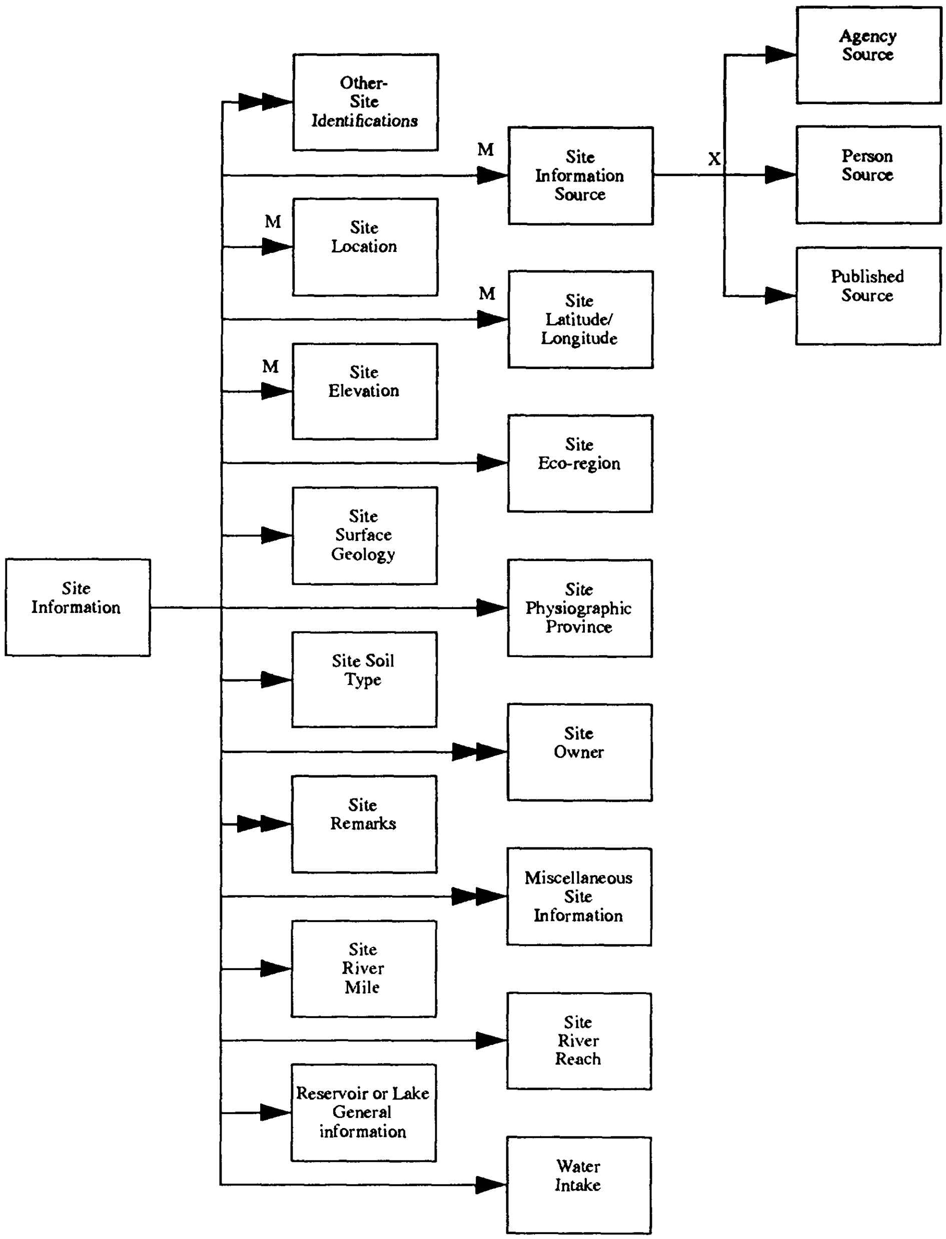


Figure 38. -- Input form flow for stream, estuary, lake, and reservoir type sites.

II. SITE-EVENT INPUT AND EDIT FORMS AND FORMS FLOW

The site-event input and edit forms are the forms used to enter and edit events taking place at a site. These events may include facility maintenance events, measurement events, sampling events, etc. this section is divided into the following subsections; general site events, ground-water site events, spring type site events, surface-water site events, marsh or swamp site events, water-use facility site events, atmospheric type site events.

A. GENERAL SITE-EVENT INPUT FORMS

Table 71. -- Components of the input form for site visit.

Item	Type		Description
Site Visit site identification	Number	M	Site number of site where event taking place
Site Visit start date and time	Date	M	Date and time that site event starts
Site Visit end date and time	Date	M	Date and time that site event ends
Site Visit purpose	Ref. List	M	Purpose of event
Site Visit agency	Ref. List	M	Agency of personnel doing visit
Site Visit personnel	Ref. List	M	Person(s) doing event

Table 72. -- Components of the input form for miscellaneous site comments.

Item	Type		Description
Miscellaneous comments date & time	Date	M	Date and time comments taken
Miscellaneous comments observer	Ref. List	M	Person making miscellaneous comments
Miscellaneous site comments	Text	M	Miscellaneous comments

Table 73. -- Components of the input form for site event.

Item	Type		Description
Site event date & time	Date	M*	Date & time at which site event was made (* = when no begin/end interval given)
Site event begin	Date		Date & time at which site event began
Site event end	Date		Date & time at which site event ended
Site event person	Ref. List	M	Name of person doing site event
Event type	Ref. List	M	Type of site events

Table 74. -- Components of the input form for site-event point.

Item	Type		Description
Site-event point description	Text	M	Short description of site-event point for identification purposes
Site-event point establishment date	Date	M	Date event point was first used or established
Site-event point accuracy	Number		Accuracy of event-point location, in feet
Site-event point altitude	Number		Altitude of site-event point, in feet NGVD
Site reference point used	Number		Identification of the site reference point (survey marker, etc.) used to locate event point
Site-event point location type	Ref. List		Type of event point location (3D, Angle, text description)

Table 75. -- Components of the input form for site-event point third location.

Item	Type	Description
Elevation change from ref. point	Number	Change in elevation from site reference point to event point, in feet
North-south distance from ref. point	Number	Distance from site reference point to event point in north -south direction, in feet
East west distance from ref. point	Number	Distance from site reference point to event point in east-west direction, in feet

Table 76. -- Components of the input form for site-event point angle and distance location.

Item	Type	Description
Elevation change from reference point	Number	Change in elevation from site reference point to event point, in feet
Azimuth from reference point	Number	Azimuth angle from site reference point to event point, in degrees

Table 77. -- Components of the input form for site-event point description location.

Item	Type	Description
Description of event point	Text	Description of location of event point with respect to site reference point

Table 78. -- Components of the input form for miscellaneous site events comments.

Item	Type		Description
Miscellaneous comments date & time	Date	M	Date and time comments taken
Miscellaneous comments observer	Ref. List	M	Person making miscellaneous comments
Miscellaneous site event comments	Text	M	Miscellaneous comments

Table 79. -- Components of the input form for site-event environmental observations.

Item	Type	Description
Hydrologic conditions	Ref. List	Hydrologic conditions observed
Meteorologic conditions	Ref. List	Meteorologic conditions observed
Air temperature	Number	Air temperature measurement, in degrees Fahrenheit
Stream or lake bed type	Ref. List	Description of stream or lake bed composition
Streambed conditions	Text	Description of streambed conditions.
Environmental conditions comments	Text	Additional information about the environment conditions

Table 80. -- **Components of the input form for site land-use observations.**

Item	Type		Description
Land-use observation range	Number	M	Range in specified units of land-use observation
Land-use observation range units	Ref. List	M	Unit of land-use observation range
Land-use remarks	Text		Additional comments on land-use observations

Table 81. -- Components of the input form for site land use.

Item	Type		Description
Land-use identifier	Ref. List	M	Keyword identifying category of land use
Land-use percentage	Number	M	Percentage of land in specified land use category
Land-use changes period	Number		Period of time used in description of land use changes, in years
Land-use changes descriptions	Text		Description of land use changes since above time
Land-use comments	Text		Addition comments on land use

Table 82. -- Components of the input form for site land-use local features.

Item	Type		Description
Feature	Ref. List	M	Land-use feature observed with land-use observation range
Comments	Text		Additional comments on land-use feature observed

Table 83. -- Components of the input form for site land-use irrigation practices.

Item	Type		Description
Extent of irrigation	Ref. List	M	Acres irrigated
acres of irrigation	Number	M	Acres irrigated
Irrigation method	Ref. List	M	Keyword describing method of irrigation
Source of irrigation	Ref. List		Keyword describing source of irrigation
Application rate - water	Number		Rate of irrigation application in Inches per acre irrigated
Pesticide and fertilizer use	Text		Description of pesticide and fertilizer used
Application rate - chemicals	Number		Application rate of chemicals in pounds per acre
Crop types	Text		Description of crop types, multiple entries allowed
Field rotation practices	Text		Description of field rotation practices

Table 84. -- Components of the input form for site land-use animal husbandry

Item	Type		Description
Animal type	Text	M	Description of animal or insect type, multiple entries allowed
Rate of use	Number	M	Rate of water use in gpd for one individual of type
Source of rate	Ref. List		Reference for publication documenting rate of use
State	Ref. List		State in which rate of use is applicable

Table 85. -- Components of the input form for site habitat.

Item	Type		Description
Habitat	Ref. List	M	Habitat of site
Person determining habitat	Ref. List		Person making habitat determination
Date and time of determination	Date	M	Date and time habitat was determined
Habitat comments	Text		Additional information about the habitat

Table 86. -- Components of the input form for site level notes.

Item	Type	Description
Equipment used to measure	Ref. List	Equipment used to make site-level measurements
BM number	Number	Benchmark identification number
BM elevation as found by levels	Number	Elevation of benchmark, in feet NGVD
RM number	Number	Reference mark identification number
RM elevation as found by levels	Number	Elevation of reference mark, in feet NGVD
RP number	Number	Reference point identification number
RP elevation as found by levels	Number	Elevation of reference point, in feet NGVD
ET indicator	Number	Elevation of electric tape, in feet NGVD
Tape reading at ET weight	Number	Tape reading where electric tape enters attached weight, in feet
Length of ET weight	Number	Length of weight attached to electric tape, in inches
IG elevation	Number	Elevation of the inside gage, in feet NGVD
IG reference point reading	Number	Inside gage reference point elevation as read from gage, in feet NGVD
OG elevation	Number	Elevation of the outside gage, in feet NGVD
OG reference point reading	Number	Outside gage reference point elevation as read from gage, in feet NGVD
WW elevation (by levels)	Number	Elevation of the wire weight gage as found by levels (bottom of weight), in feet NGVD
WW reading	Number	Wire weight gage as read at point of levels, in feet
WW check bar elevation (by levels)	Number	Elevation of wire weight check bar as found by levels, in feet NGVD
WW check bar elevation (as read)	Number	Elevation of wire weight check bar as read from dial, in feet NGVD
Outside water stage	Number	Elevation of outside water stage as read from outside reference gage, in feet NGVD
Outside water stage time	Date	Time of outside gage reading
Outside water surface	Number	Elevation of outside water surface as found by levels, in feet NGVD
Outside water surface time	Date	Time of water-surface reading
Inside water stage	Number	Elevation of inside water stage as read from inside reference gage, in feet NGVD
Inside water stage time	Date	Time of inside gage reading
Base (primary gage) correction	Number	Base gage correction as found by levels, in inches
HWM elevation	Number	Elevation of high-water mark, in feet NGVD
CSG elevation	Number	Elevation of crest stage gage as found by levels, in feet NGVD
Orifice elevation	Number	Elevation of orifice found by levels, in feet NGVD
Point of zero flow	Number	Elevation of point-of-zero-flow as found by levels, in feet NGVD
Site level notes remarks	Text	Remarks about the survey

Table 87. -- Components of the input form for facility maintenance.

Item	Type		Description
Facility maintenance date and time	Date	M	Date of time of facility maintenance
Facility maintenance person	Ref. List	.M	Person doing facility maintenance
Facility maintenance type	Ref. List	M	Keyword describing type of facility maintenance
Facility maintenance comments	Text		Comments on facility maintenance

Table 88. -- Components of the input form for monthly water-flow data

Item	Type		Description
Data year	Date	M	Year of data
Data accuracy	Text		Calculated, estimated, or metered (null = metered)
Jan	Number		Monthly average in gpd X 1000 for January
Feb	Number		Monthly average in gpd X 1000 for February
Mar	Number		Monthly average in gpd X 1000 for March
Apr	Number		Monthly average in gpd X 1000 for April
May	Number		Monthly average in gpd X 1000 for May
Jun	Number		Monthly average in gpd X 1000 for June
Jul	Number		Monthly average in gpd X 1000 for July
Aug	Number		Monthly average in gpd X 1000 for August
Sep	Number		Monthly average in gpd X 1000 for September
Oct	Number		Monthly average in gpd X 1000 for October
Nov	Number		Monthly average in gpd X 1000 for November
Dec	Number		Monthly average in gpd X 1000 for December

Table 89. -- Components of the input form for generic monthly data

Item	Type		Description
Data year	Date	M	Year of data
Data accuracy	Text		Calculated, estimated, or metered (null = metered)
Data units	Text		User-specified units (e.g., gigawatts, manufactured products) with input-screen defaults
Jan	Number		Monthly average for January
Feb	Number		Monthly average for February
Mar	Number		Monthly average for March
Apr	Number		Monthly average for April
May	Number		Monthly average for May
Jun	Number		Monthly average for June
Jul	Number		Monthly average for July
Aug	Number		Monthly average for August
Sep	Number		Monthly average for September
Oct	Number		Monthly average for October
Nov	Number		Monthly average for November
Dec	Number		Monthly average for December

B. GROUND-WATER WELL TYPE SITE-EVENT INPUT FORMS

Table 90. -- Components of the input form for ground-water level measurements.

Item	Type		Description
GW level measurement accuracy code	Number		Accuracy of measurement in feet
Ground-water level altitude	Number		Altitude of the water surface in a well or piezometer, in feet above NGVD
Method	Ref. List	M	Keyword describing method of water level measurement
Water level status	Ref. List		Status of the site at the time the water level was measured
Well Status	Ref. List		Status of the well affecting ability to measure

Table 91. -- Components of the input form for ground-water-level tape measurements.

Item	Type		Description
Hold MP	Number		Measuring point on tape at site measurement point, in feet
Cut MP	Number		Point on tape where water level reached, in feet
GW water level depth to water MP	Number	M*	Ground-water well depth to water from measurement point, in feet (* = when depth from LSD unavailable)
GW water level depth to water LSD	Number	M*	Ground-water well depth to water from land surface datum, in feet (* = when depth from MP unavailable)

Table 92. -- Components of the input form for ground-water pressure measurements.

Item	Type		Description
Depth to transducer	Number	M	Depth to pressure transducer, in feet
Pressure	Number	M	Pressure measured by transducer in psi
Pressure head	Number	M	Head of pressure in feet
Pressure measurement type	Ref. List	M	Type of pressure measurement
Specific Weight	Number		Density of the ground water at 0^{o} C and 1 atm pressure, in kg/meter (null = 1.00 by default)

Table 93. -- Components of the input form for ground-water discharge or recharge measurements.

Item	Type		Description
Discharge/recharge indicator	Ref. List	M	Indicates whether flow is discharging or recharging an aquifer.
Flow rate	Number	M	Measured well discharge or recharge in gpm
Flow rate qualifier	Ref. List		Statistical qualifier for flow rate
Date and time of flow measurement	Date	M	Date and time of flow measurement
Measurement method	Ref. List	M	Keyword describing method used to determine discharge or recharge
Discharge data source	Ref. List		Keyword describing source of discharge or recharge data
Activity period	Number		Length of time between first and last measurements for the pump or recovery test, in hours
Flow type	Ref. List	M*	Is discharge pumped or flowing (* = for a discharge measurement)
Depth to bottom of source/destination	Number		Depth to the bottom of the screened interval of discharge, in feet
Depth to top of source/destination	Number		Depth to the top of the screened interval of discharge, in feet
Drawdown	Number		Change in water level due to pumping, in feet
Specific capacity	Number		Discharge in gpm per unit drawdown in feet
Volume	Number		The volume of water discharged or recharged during the activity period, in gallons
Equipment, instruments	Ref. List		Equipment or instrument used to make measurement

Table 94. -- Components of the input form for ground-water well logs.

Item	Type		Description
Well log measurement date	Date	M	Date of well measurement
Well log type	Ref. List	M	Type of well log
Equipment operator	Text		Person who operates well logging equipment
Probe identification	Text		Identification of logging probe
Depth to bottom	Number		Depth to bottom of logged interval, in feet
Depth to top	Number		Depth to top of logged interval, in feet
Format of log	Ref. List	M	Format log is entered into data base
Log key	File	M	Link to well log file, if on-line
Input-form header	Text		Header information of geophysical logs
Well temperature hole bottom	Number		Water temperature at bottom of well during construction, in degrees Fahrenheit
Remarks	Text		Remarks about the log or process
Log source agency	Ref. List		Agency providing log

Table 95. -- Components of the input form for drill stem tests.

Item	Type	Description
Water-level recovery fraction	Number	Length of flow into tubing, in feet
Time open -- Initial	Number	Time allowed for the initial flow of fluid into the tube, in minutes
Time open -- final	Number	Time allowed for the flow of fluid into the tube, in minutes
Pressure head	Number	Pressure expressed as a height of a water column, in feet
Equivalent fresh-water head (C)	Number	Head expressed as the depth of fresh water above the measuring point, in feet
Specific Weight	Number	Density of the ground water at 0^{o} C and 1 atm pressure, in kg/meter (null = 1.00 by default)

Table 96. -- Components of the input form for hydraulic property input form.

Item	Type		Description
Barometric efficiency	Number		Atmospheric pressure change / water level change
Date of measurement	Date	M	Date record was entered or modified
Depth to bottom of source/destination	Number		Depth to the bottom of the screened interval being tested, in feet
Depth to top of source/destination	Number		Depth to the top of the screened interval being tested, in feet
Diffusivity	Number		Transmissivity / Storage Coefficient, in ft^2/day
Horizontal Hydraulic Conductivity	Number		A measurement aquifer's capacity to transmit a fluid in a horizontal direction, in feet/day
Hydraulic Unit	Ref. List		Hydrogeologic units to which formation hydraulics apply
Hydraulic unit type	Link		Type of unit (aquifer or confining)
Leakance	Number		Vertical hydraulic conductivity / thickness of the confining unit, in liters/day
Method of computation	Text		Description of the methods (aquifer test) used
Specific Storage	Number		The volume of water released from or taken into the storage by a unit volume of aquifer per unit change in head, in units of length (1/L)
Specific Yield	Number		The ratio of the volume of water which a saturated rock will yield by gravity to the volume of the rock
Storage Coefficient	Number		The volume of water an aquifer releases from or takes into storage per unit area per unit head, dimensionless
Transmissivity	Number		A measurement of an aquifer's capacity to transmit a fluid through a unit of its width, in ft^2/day
Vertical Conductivity	Number		A measurement of an aquifer's capacity to transmit a fluid in a vertical direction, in feet/day

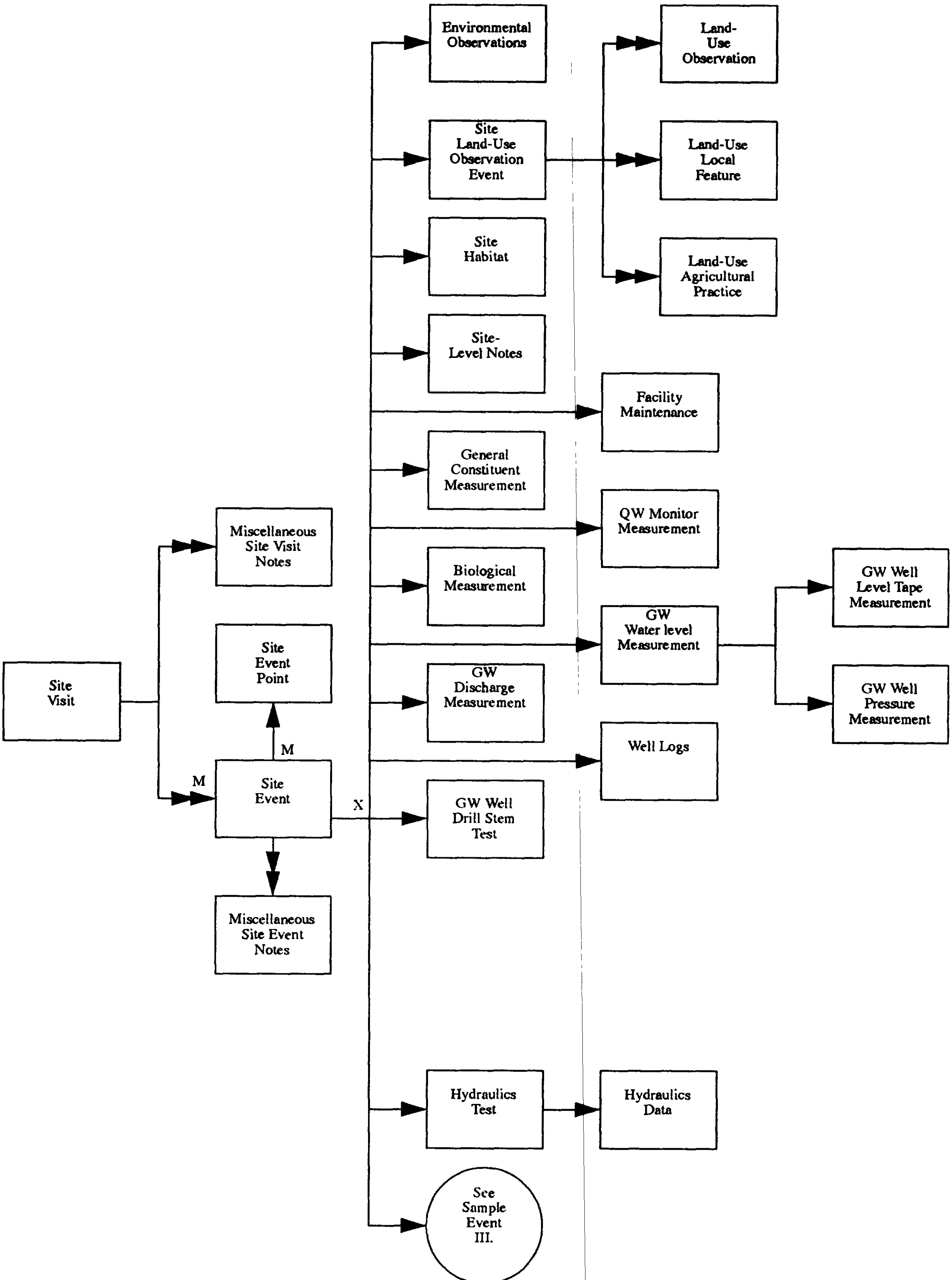


Figure 39. -- Forms flow for ground-water well type site events.

C. SURFACE-WATER TYPE SITE-EVENT INPUT FORMS

Table 97. -- Components of the input form for discharge-measurement notes.

Item	Type		Description
Measurement number	Number	M	Assigned discharge measurement number
Measurement type	Ref. List	M	Method of discharge measurement
Method	Ref. List	M*	Method of measurement (* = if measurement type is by current meter)
Current meter type	Ref. List	M*	Type of current meter used (* = if measurement type is by current meter)
Meter number	Ref. List	M*	Discharge measurement meter identification (* = if measurement type is by current meter)
Starting time	Time	M	Starting time of the discharge measurement
Ending time	Time	M	Ending time of the discharge measurement
Mean gage height	Number	M	Mean gage height during the measurement, in feet
Width	Number	M*	Width of stream at discharge measurement point (* = if measurement type is by current meter), in feet
X-area	Number	M*	Cross-section area of stream at measurement point (* = if measurement type is by current meter), in ft^2
Mean velocity	Number	M*	Mean velocity of stream at measurement point (* = if measurement type is by current meter), in feet/second
Time taken for velocity observations	Number		Average time in seconds for point velocity observations
Q measured	Number	M	Discharge measured, in ft^3/second
Q corrected	Number		Corrected discharge, in ft^3/second
Number of sections	Number		Number of sections measured in discharge measurement
Measurement rated	Ref. List	M	Quality rating of measurement
Control conditions	Ref. List		Condition of stream control section
Control remarks	Text		Remarks about the stream control section
Remarks	Text		Remarks about the measurement
QW field measurements	Ref. List		Water-quality measurements made in the field
Maximum stage indicator	Number		Computed maximum stage using indicator reading, in feet NGVD
Minimum stage indicator	Number		Computed minimum stage using indicator reading, in feet NGVD
HWM (other observed max stage)	Number		High water mark of stream from other than max indicator, in feet NGVD
Point of zero flow, PZF	Number		Gage height of zero flow, in feet NGVD
Auxiliary. gage height	Number		Gage height as determined on the auxiliary device, in feet NGVD
Adjusted discharge type	Ref. List		Type of adjusted discharge
Measured discharge type	Ref. List		Type of measured discharge
Coefficient used	Ref. List		Type of discharge measurement coefficient used

Table 98. -- Components of the input form for discharge meter spin test.

Item	Type		Description
Current meter type	Ref. List	M	Type of current meter used
Meter number	Ref. List	M	Discharge measurement meter identification.
Date and time of spin test	Date	M	Date and time of the spin test
Spin test results	Number		Minutes of spin test

Table 99. -- Components of the input form for discharge-measurement gage heights.

Item	Type		Description
Inside starting gage height	Number	M	Gage height at the starting time of the measurement, in feet
Inside ending gage height	Number	M	Gage height at the ending time of the measurement, in feet
Outside starting gage height	Number	M	Gage height at the starting time of the measurement, in feet
Outside ending gage height	Number	M	Gage height at the ending time of the measurement, in feet
Gage height change	Number		Change in gage height during measurement, in feet
Starting time of measurement	Date		Date and starting time of the measurement
Ending time of measurement	Date		Date and ending time of the measurement
Inside intermediate gage height	Number		Gage height at intermediate observation of gage height during discharge measurement, in feet
Outside intermediate gage height	Number		Gage height at intermediate observation of gage height during discharge measurement, in feet
Time of intermediate observation	Date		Date and time of intermediate observation of gage height

Table 100. -- Components of the input form for crest-stage inspection notes.

Item	Type		Description
Crest-stage reference point	Ref. List	M	Reference point of the crest stage gage for this site
Elevation of crest stage reference point	Number	M	Elevation of crest stage gage reference point for this site, in feet NGVD (default entry from a Ref. List)
Distance to high water mark	Number	M	Distance from the reference point to the high-water mark, in feet
High water mark elevation	Number		Computed high water mark (crest stage gage height), in feet NGVD
High water mark elevation, other	Number		High water mark as determined from marks outside gage, in feet NGVD
Remarks	Text		Remarks about the inspection

Table 101. -- Components of the input form for stream cross-section control.

Item	Type		Description
Elevation of water surface	Number		Average elevation of water surface at control, in feet above gage datum
Type of control	Text		Ledge of rock, fallen log, boulder-covered riffle, overflow dam, etc.
Energy head (H)	Number	M	Total energy head in feet near upstream side of control
Control variable (C)	Number	M	A function of gage height computed using the section control cross section and input of one or more points on the rating
Width of control (L)	Number	M	Width of cross-section control normal to the flow, in feet (a function of gage height)
Gage height difference(h)	Number	M	Gage height minus gage height at zero flow, in feet

Table 102. -- Components of the input form for computing a theoretical rating curve.

Item	Type		Description
Hydraulic radius (R)	Number	M	Ratio of cross-sectional area to wetted perimeter
Wetted perimeter	Number	M	Wetted perimeter of the cross section, in feet
Channel slope (S)	Number	M	Slope of river at cross section, in feet per foot
Roughness (n)	Number	M	Manning's roughness coefficient for stream at cross section

Table 103. -- Components of the input form for stream form observations at a cross section

Item	Type	Description
Bed forms	Ref. List	Ripples, dunes, etc.
Alinement	Text	Straight or meandering (to station description)
Channel shape	Graphic	Shape of channel in cross section
Remarks	Text	Remarks about the stream cross section and bed forms

Table 104. -- Components of the input form for surface-water miscellaneous field notes.

Item	Type	Description
Gage height reading of water surface	Number	Water surface reading at site, in feet NGVD
Gage read (type)	Ref. List	Type of gage at which reading was taken
Time of reading	Date	Date and time at which reading was taken
HWM elevation	Number	Elevation of high-water mark, in feet NGVD
Remarks	Text	Remarks about the miscellaneous notes

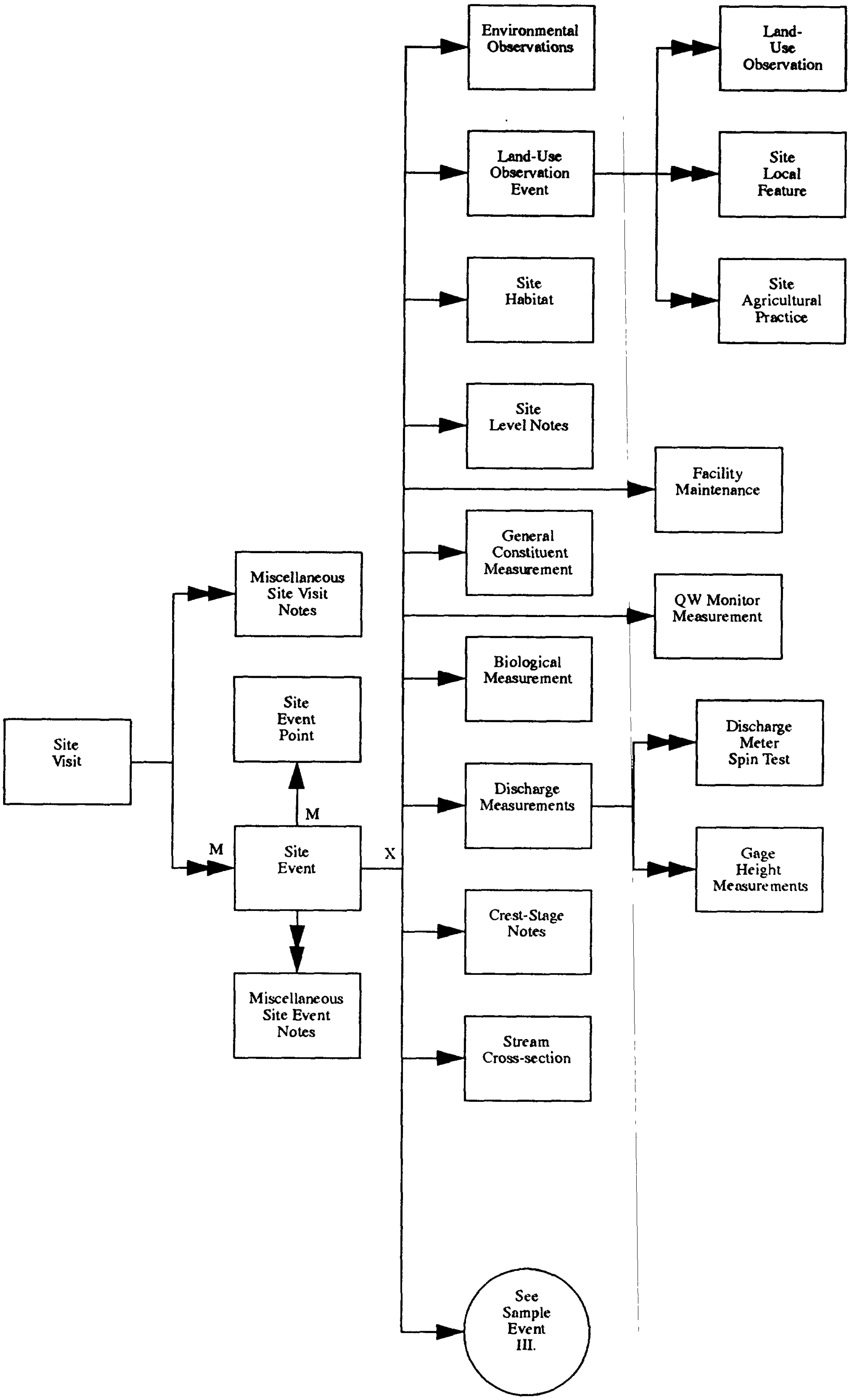


Figure 40. -- Forms flow for a site event at a stream, lake, reservoir, pond, or estuary type site.

D. ATMOSPHERIC TYPE SITE-EVENT INPUT FORMS

Table 105. -- Components of the input form for climatology analysis of temperature and pressure.

Item	Type		Description
Date and time	Time	M	Date and time of the analysis
Data entry code	Text		Manual or automatic entry of values
Observation interval	Ref. List		Time interval that data are recorded
Miscellaneous data	Ref. List		Observer and notes
Units code	Ref. List		System of measurements used upon entry
Vapor pressure - eo	Number		Computed partial pressure exerted by water vapor, in millibars
Saturation vapor pressure - es	Number		Computed pressure when water vapor equals capacity of air at the ambient air temperature, in millibars
Maximum air temperature	Number		Maximum ambient air temperature over observation interval, in °Celsius
Minimum air temperature	Number		Minimum ambient air temperature over observation interval, in °Celsius
Dry bulb temperature	Number		Ambient temperature of the air, in °Celsius
Wet bulb temperature	Number		Temp. if cooled to saturation, in °Celsius
Wet bulb depression	Number		Difference between wet & dry bulb temps., in °Celsius
Relative humidity	No. or Ref. List		The ratio of the water vapor content of the air to the water vapor content the air would have if it were saturated at the same pressure and temperature (eo/es X 100 or from a lookup table.
Degree days	Number		Number of degree days above or below stated reference
Barometric pressure	Number		Pressure exerted by atmosphere at a given elevation, in millibars
Dewpoint temperature	Ref. List		Temperature in °Celsius to which air must be cooled at constant pressure and water vapor content to reach saturation with respect to water (from lookup table).
Frost-point temperature	Ref. List		Temperature in °Celsius to which air must be cooled at constant pressure and water vapor content to reach saturation with respect to ice (from lookup table).

Table 106. -- Components of the input form for wind events.

Item	Type		Description
Date and time	Time	M	Date and time of the analysis
Data entry code	Text		Manual or automatic entry of values
Observation interval	Ref. List		Time interval that data are recorded
Units code	Ref. List		System of measurements used upon entry
Miscellaneous data	Ref. List		Observer and notes
Wind direction	Number		Instantaneous value, in degrees from true north
Wind speed	Number		Instantaneous speed of the wind, in miles per hour
Wind run	Number		Total distance the wind travels over the observation interval, usually a day, in miles per day
Resultant wind	Number		The computed vector sum of wind velocity vectors over the observation period, in miles per hour and degrees from true north

Table 107. -- Components of the input form for solar radiation events.

Item	Type		Description
Date and time	Time	M	Date and time of the analysis
Data entry code	Text		Manual or automatic entry of values
Observation interval	Ref. List		Time interval that data are recorded
Miscellaneous data	Ref. List		Observer and notes
Units code	Ref. List		System of measurements used upon entry
Direct solar radiation	Number		Instantaneous solar radiation coming from the solid angle of the sun's disk on a surface perpendicular to the axis of the solid angle, in calories/cm^2
Sky radiation	Number		Downward diffuse solar radiation as received on a horizontal surface from a solid angle of 2 pi, with the exception of the solid angle subtended by the sun's disk, in calories/cm^2
Global solar radiation	Number		Incoming direct and sky solar radiation, in calories/cm^2
Reflected solar radiation	Number		Instantaneous solar radiation reflected from the earth's surface, in calories/cm^2
Net solar radiation	Number		The computed difference between global and reflected solar radiation, in calories/cm^2
Atmospheric radiation	Number		Longwave radiation emitted by the atmosphere and received at the earth's surface, in calories/cm
Terrestrial radiation	Number		Longwave radiation emitted by the earth's surface, in calories/cm^2
Net longwave radiation	Number		The computed difference between atmospheric and terrestrial radiation, in calories/cm^2
Net radiation	Number		Computed algebraic sum of net solar and net longwave radiation, in calories/cm^2

Table 108. -- Components of the input form for precipitation-related events.

Item	Type		Description
Date and time	Time	M	Date and time of the analysis
Data entry code	Text		Manual or automatic entry of values
Observation interval	Ref. List		Time interval that data are recorded
Units code	Ref. List		System of measurements used upon entry
Precipitation	Number		Solid and liquid precipitation that has accumulated over the observation interval, in inches
Miscellaneous data	Ref. List		Observer and notes
Depth of water added	Number		Verification data, in inches
Volume of water added	Number		Verification data, in inches
Sunshine duration	Number		The duration of direct sunshine over the observation interval, usually a day, in minutes
Sunshine percentage	Number		The computed amount of direct sunshine as a percentage of that possible over the observation interval, usually a day
Tree ring growth rate	Number		Inches per year

E. ATMOSPHERIC TYPE SITE-EVENT INPUT FORMS

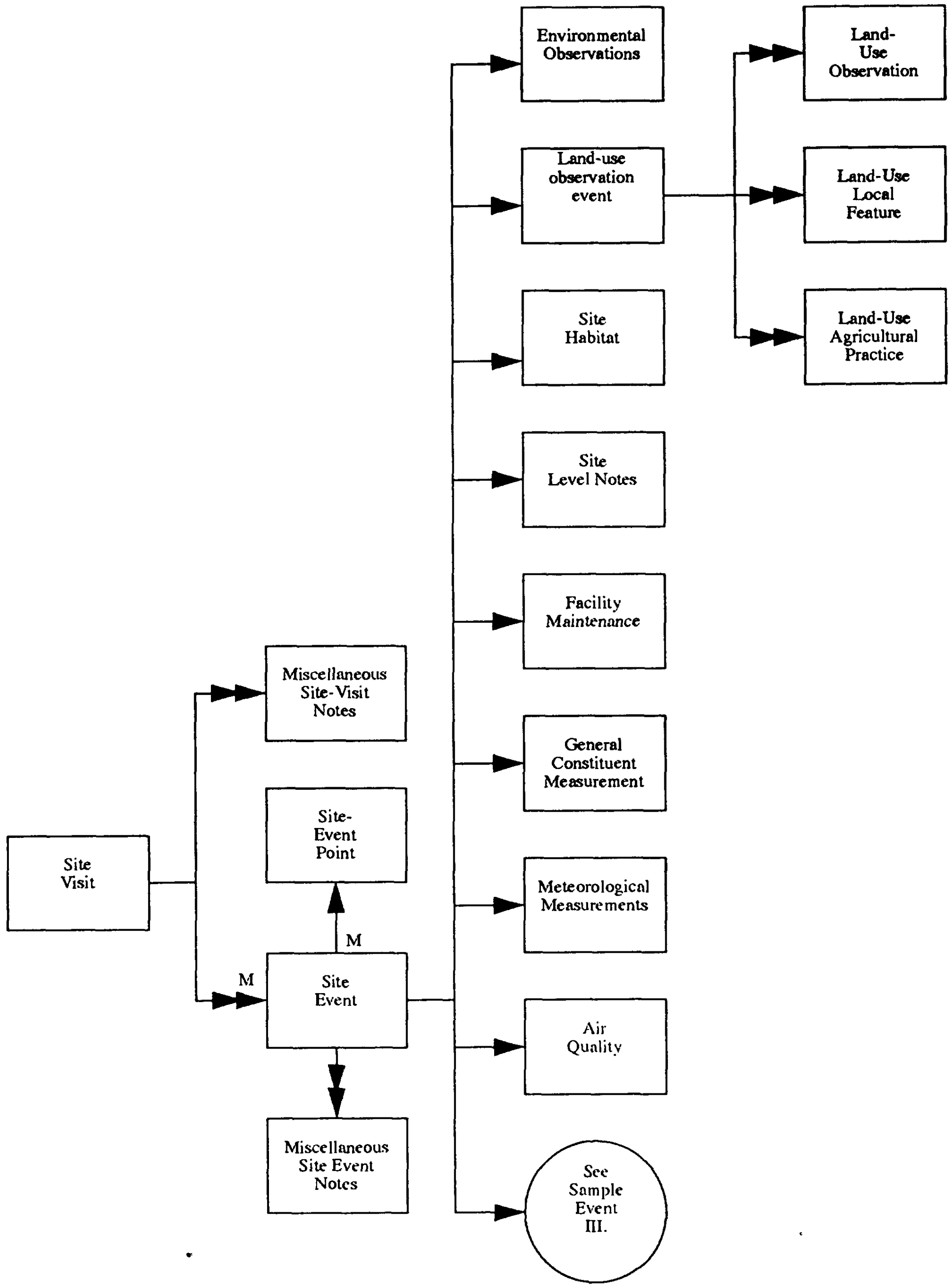


Figure 41. -- Forms flow for a site event at an atmospheric type site.

F. WATER-USE TYPE SITE-EVENT INPUT FORMS

Table 109. -- Components of the input form for water-use flow measurement.

Item	Type		Description
Permit number	Text	M	Number of permit authorizing flow
Measurement method	Ref. List		Measurement method for flow
Water conveyance point elevation	Number		Conveyance elevation at measuring point, in feet above mean sea level
Flow rate	Number		Gallons per minute

Table 110. -- Components of the input form for method of flow measurement.

Item	Type	Description
Meter	Ref. List	Methods related to conveyance flowmeters
Time	Ref. List	Methods related to time pumped
Yield	Ref. List	Methods related to well discharge
Estimated	Ref. List	Methods estimating from related data
Reported	Ref. List	Source information for reported data

Table 111. -- Components of the input form for flow-meter (pipe flow) input form.

Item	Type	Description
Meter ID number	Text	Serial number
Flow-meter value	Number	Value of flow readout in meter units
Reliability	Number	Percent error based on meter technology or age

Table 112. -- Components of the input form for pump-time totalizer.

Item	Type		Description
Totalizer type	Text		Ditt or Dvtt, etc.
Date and time of installation	Date		Installation of totalizer
Date and time of removal	Date		Removal of totalizer
Totalizer meter number	Number		Serial number or other ID number of totalizer
Rest speed	Number		Clicks per month before installation
Totalizer multiplier	Number		Totalizer readout unit adjustment (multiply for conversion to hours)
Begin reading	Number		Reading at installation, in totalizer units
End reading	Number		Reading at removal, in totalizer units
Date and time of reading	Date	M	Date and time of reading of totalizer (initial or final)
Totalizer value	Number	M	Totalizer meter readout, in totalizer units
Pump time	Number		Adjusted totalizer indication of time pumped, in hours (automatically calculated for each final reading)
Totalizer reading status	Ref. List	M	ID of reading as initial, final, or both (leave blank if totalizer values are not to be used for computation of pump time)
Elapsed time	Number		Time elapsed between initial and final reading, in days
Reported pumping schedule	Text		Hours on/off per week

Table 113.-- Components of the input form for reported monthly and annual average flow.

Item	Type		Description
Site number	Number	M	USGS identifier number for site
Facility number	Number		USGS identifier number for facility owning site
Reported flow data source	Ref. List	M	Keyword indicating type of data source
Reported flow agency	Ref. List		Keyword identifying agency providing data
Reported flow reporter	Ref. List		Person who reported flow
Reported flow method of determination	Ref. List		Method flow was determined, if known
Water source	Ref. List		Ground, surface, mixed
Salinity	Text		Fresh, saline, or unknown
Flow activity type	Text	M	Withdrawal, delivery point from withdrawal, return, release point to return, transfer, or reuse (each may invoke associated forms)
Annual flow value	Number		Value reported for annual flow in gpd x 1000
Annual flow date	Date		Year of reported annual flow
Monthly average flow	Ref. List		Average flow for individual months, in gpd x 1000
Accuracy	Ref. List	M	Excellent, good, fair, poor
Preference flag	Text		"Secondary" means this is secondary data and should not be included in calculations upon retrieval, when "null" the data will be retrieved by applications
Calculate flag	Text		"Calculate" means calculate annual data from monthly data, when "null" do not calculate annual data from monthly data
Water quality organization	Ref. List		Organization that will make available water data at or near this site (GIS proximity test by default)
Extended data	Ref. List		Other aggregate information being stored about this site
Remarks	Text		Other data concerning monthly or annual flow reported

Table 114. -- Components of the input form for number of service connections

Item	Type		Description
Service connections date	Date	M	Year to which these values apply or were determined
Water delivery service connections	Integer		Total connections
Water delivery connections by type	Ref. List		Number of service connections by type of customer

Table 115. -- Components of the input form for water conveyance gain or loss.

Item	Type		Description
Conveyance "from" site number	Number	M	Site number of conveyance endpoint where the water flow starts
Gain or loss effective date	Date	M	Date that water conveyance gain or loss first recorded
Conveyance gain/loss period	Number		Days per year of gain/loss conditions (annual average)
Gain/loss coefficient	Number		Number by which flow at "from" endpoint may be multiplied in order to compute flow at "to" endpoint (positive = gain, negative = loss, null = no gain or loss)
Coefficient begin date	Date		Date after which values are calculated using this coefficient
Coefficient end date	Date		Date coefficient no longer valid (if null then valid to current date)
Water conveyance gain or loss	Ref. List	M	Average monthly water conveyance gain or loss, In gpd x 1000 (positive = gain, negative= loss)
Method of gain/loss measurement	Ref. List	M	The system should use actual metered data rather than coefficient estimated data when available.

Table 116. -- Components of the input form for percent distributions released from a water-supply facility.

Item	Type		Description
Site number	Number	M	USGS identifier number of water-use facility from which water is being released
Percentage date	Date	M	Year to which these values apply
Water delivery residential connections	Number		Percent to residential customers
Water delivery industrial connections	Number		Percent to industrial customers
Water delivery commercial connections	Number		Percent to commercial customers
Water delivery mining connections	Number		Percent to mining customers
Water delivery irrigation connections	Number		Percent to irrigation customers
Water delivery thermoelectric con.	Number		Percent to thermoelectric customers
Water delivery other connections	Number		Percent to other customers or destinations
Water delivery public utility use	Number		Percent used by utility for back-flushing, etc.
Water delivery lost	Number		Percent lost or unaccounted for
Water delivery to purveyors	Number		Percent sold to purveyors, entry > 0 invokes sales form

Table 117. -- Components of the input form for water-supply metered deliveries.

Item	Type		Description
Water metering annual total date	Date	M	Year to which these values apply
Water metering reading frequency	Number		Readings per year
Water metering year	Number		Year to which above data applies or was last updated
Water delivery to residential meters	Number		To residential customers, in gal X 1000
Water delivery to industrial meters	Number		To industrial customers, in gal X 1000
Water delivery to commercial meters	Number		To commercial customers, in gal X 1000
Water delivery to mining meters	Number		To mining customers, in gal X 1000
Water delivery to irrigation meters	Number		To irrigation customers, in gal X 1000
Water delivery to thermoelectric meters	Number		To thermoelectric customers, in gal X 1000
Water delivery to other meters	Number		To other customers or destinations, in gal X 1000
Water delivery to public meters	Number		Used by utility for back-flushing, etc., in gal X 1000
Water withdrawn but not delivered	Number		Lost or unaccounted for, in gal X 1000
Water delivery to purveyors	Number		In gal X 1000, entry > 0 invokes sales form unless completed

Table 118. -- Components of the input form for water-supply purchases.

Item	Type		Description
Purchasing facility site number	Number	M	Site number of facility making purchase
Water purchases, annual total date	Date	M	Year to which these values apply
Water purchases, supplier ID	Text		Identification number of water company supplying water
Water purchases, supplier group ID	Ref. List		USGS group ID of location of supplier's water source
Water purchases, amount purchased	Number		In gallons x 1000, by month, from this supplier
Sale/transfer code	Text		S = water was sold, or null (default) = water was transferred with no money exchanged

Table 119. -- Components of the input form for water sales.

Item	Type		Description
Purveyor facility site number	Number	M	Site number of facility making sale
Water sales, annual total date	Date	M	Year to which these values apply
Water sales, customer ID	Text		Identification of customer, if another public supply
Water sales, customer site ID	Number		USGS site ID of location of entry point to customer's system, in latitude and longitude
Water sales, popula. served by cust.	Number		Population served by this customer, in thousands
Water sales, amount sold	Ref. List		In gallons x 1000, by month, to this customer
Purchase/transfer code	Text		P = water was purchased, or null (default) = water was transferred with no money exchanged

Table 120. -- Components of the input form for withdrawals at an irrigation site or facility.

Item	Type		Description
Irrigation data year	Date	M	Calendar year to which these values apply
Crop type	Integer		Standard industrial classification of the land use type reported by the irrigator, multiple entries allowed
Annual production	Number		Amount of the crop (identified by the element CROP TYPE) that was produced during the indicated year, in tons
Crop acres	Number		Number of acres dedicated to indicated crop
Withdrawals applied, monthly	Ref. List		Average monthly rate of water applied to the crop identified in the CROP TYPE item
Withdrawals applied, annual total	Number		Average rate of water applied to the crop identified in the CROP TYPE item during the calendar year, in inches/acre
Application efficiency	Number		Production per acre (from Ref. List) per annual amount applied
Irrigation remarks	Text		Comments on multiple crops per year, alternation of crops, irrigation seasons, etc.

Table 121. -- Components of the input form for sewage treatment facility.

Item	Type		Description
Sewage treatment year of data	Date	M	Year to which this data applies
Sewage treatment rate structure	Text/Graphic		Basis for sewer rates charged
Sewage treatment service area	Spatial		Outline size and location of service area
Salinity	Text		Fresh, saline, unknown

Table 122. -- Components of the input form for reservoir evaporation.

Item	Type		Description
Reservoir evaporation year of data	Date	M	Year to which this data applies
Reservoir name	Text		Name of reservoir, a man-made impoundment with a normal capacity equal to or greater than 5,000 acre-feet
Average surface area	Number		Average surface area of reservoir, in acres
Reservoir evaporation	Number	M	Evaporation from reservoir, in acre-feet
Salinity	Text		Fresh, saline, unknown
Max. water depth	Number		Maximum depth of reservoir or lake, In feet
Spillway release	Number		Spill way release volume, in mgd
Storage type	Ref. List		Type of open water storage
Storage content	Number		Amount of water stored in reservoir, in acre-feet
Reference for surface area	Ref. List		Publication or map from which area was determined
Reference for depth	Ref. List		Publication or map from which depth was determined

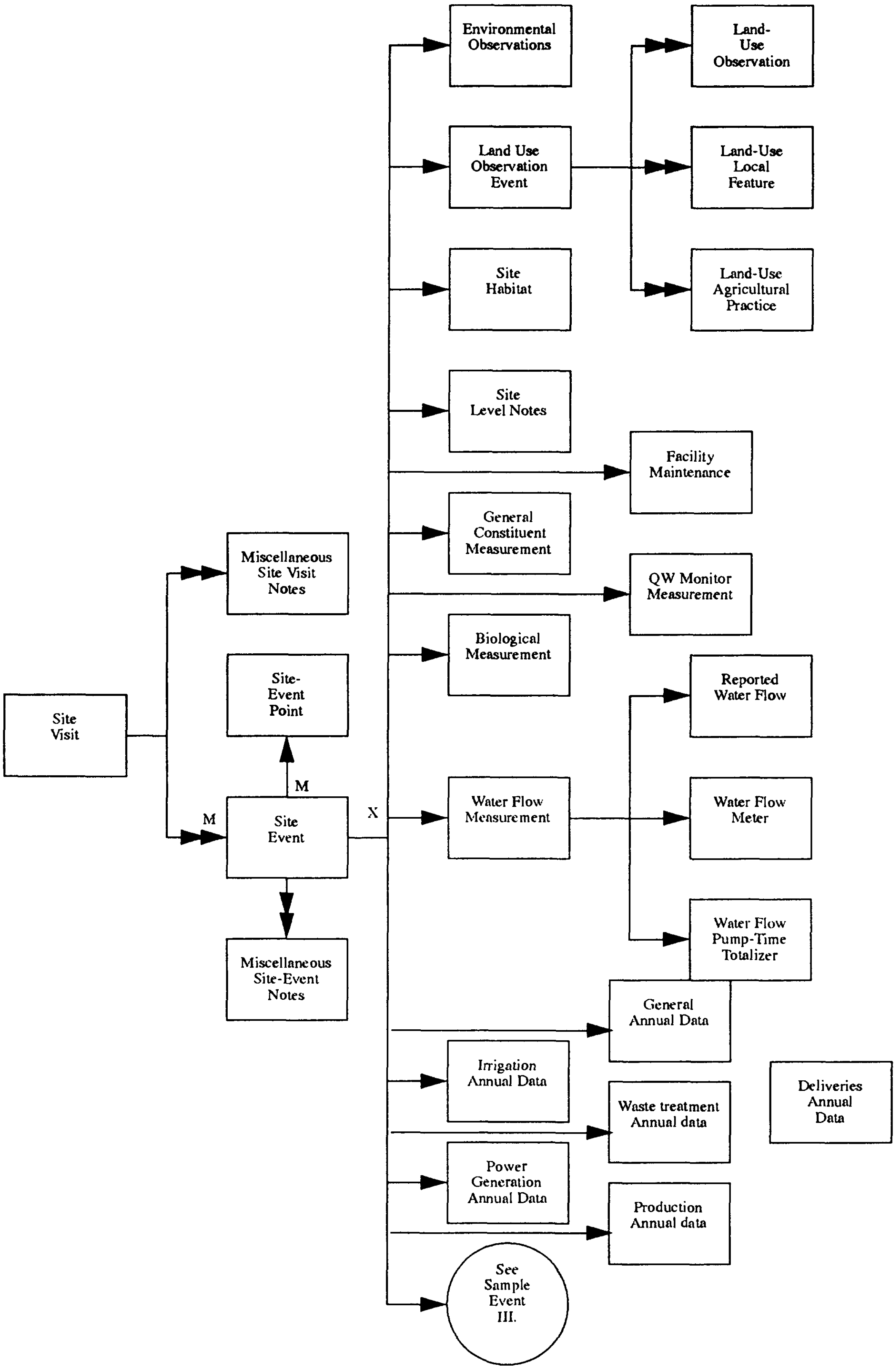


Figure 42. -- Forms flow for a site event at a water use facility type site.

III. SAMPLE EVENT INPUT AND EDIT FORMS AND FORMS FLOW

The event forms in this section describe the input and editing of information related to the taking of samples, including water, sediment, and biological samples. This input process, in general, means entering general information about the sampling event, specifying the sampling event point within the site, specifying the type of sample, filling out forms for certain special sampling events, and then filling out forms related to the sample itself, the containers holding the sample, and any preparation and preservation done to the sample. Forms used for special sampling events are 1) EDI sample, 2) Automatic sampler, 3) Bedload sample, and 4) Bed material sample (see Figure 43).

A. GENERAL SAMPLE-EVENT INPUT FORMS

Table 123. -- Components of the input form for sample events.

Item	Type		Description
Sample collection method	Ref. List	M	Sampling collection method
Sample collection equipment	Ref. List	M	Equipment used to collect samples
Sample collection comments	Text		Comments on the collection of the sample
Sample purpose	Ref. List		Keywords that describe the sample purpose
Sample purpose narrative	Text		Comments on the sample purpose
Sample medium/matrix	Ref. List		Keywords that describe the sample medium, table dependent on sample collection method (multiple entries allowed)
Sample medium narrative	Text		Comments on the sample medium
Sample type	Ref. List		Keywords that describe the sample type
Sample type narrative	Text		Comments on the sample type
Ambient conditions	Y/N		Was sample collected during "normal" conditions (or during flood, etc.), default = Y and N invokes a Ref. List for hydrologic event

Table 124. -- Components of the input form for sample.

Item	Type		Description
Sample begin date and time	Date	M	Date and time sample was begun
Sample end date and time	Date		Date and time sample was ended
Sample ID	Number	M	Sample ID automatically assigned by system

Table 125. -- Components of the input form for subsample.

Item	Type		Description
Subsample date and time	Date	M	Date and time subsample was taken
Sample ID	Number	M	Sample ID of sample where subsample was taken
Subsample ID	Number	M	Subsample ID automatically assigned by system

Table 126. -- Components of the input form for general constituent measurement.

Item	Type		Description
Measurement constituent	Ref. List	M	Constituent being measured
Measurement method	Ref. List	M	Keywords that describe the measuring methods
Measurement equipment	Ref. List	M	Keywords for equipment used to make measurements
Measurement value	Number	M	Numeric quantitative data value, in units dependent on constituent
QA evaluation	Ref. List		Keyword to describe the quality of the measurement
QA comments	Text		Comments on the quality of the quantitative values

Table 127. -- Components of the input form for constituent qualitative measurements

Item	Type		Description
Measurement constituent	Ref. List	M	Constituent being measured
Measurement method	Ref. List	M	Keywords that describe the measuring methods
Measurement equipment	Ref. List	M	Keywords for equipment used to make measurements (table dependent on method)
Measurement value	Ref. List	M	Keyword for qualitative data value, e.g. present, absent, galeforce, green (table dependent on measuring equipment)
QA evaluation	Ref. List		Keyword to describe the quality of the measurement
QA comments	Text		Comments on the quality of the qualitative values

Table 128. -- Components of the input form for filtering

Item	Type	.Description
Filter composition	Text	Composition as described on manufacturer's label
Filter size	Number	Diameter of filter, in millimeters
Pore size	Number	Filter pore size, in millimeters

Table 129. -- Components of the input form for water-quality monitor or field measurements.

Item	Type	Description
pH	Ref. List	Calls general constituent input form for pH parameter
Dissolved oxygen	Ref. List	Calls general constituent input form for DO parameter
Temperature	Ref. List	Calls general constituent input form for temperature parameter
Conductance	Ref. List	Calls general constituent input form for conductance parameter

Table 130. -- Components of the input form for biological measurements.

Item	Type		Description
Measurement Constituent	Ref. List	M	Identifier describing constituent being measured
Measurement method	Ref. List	M	Keywords that describe the measuring methods
Measurement equipment	Ref. List	M	Keywords for equipment used to make measurements
Measurement value	Number	M	Numeric quantitative data value measured, in units dependent on measurement equipment
Biological level identifier	Ref. List	M	Identifier describing the biological level at which the measurement was made
Narrative for biological identifier	Text		Comments on the biological level identification
Comments on measurement	Text		Comments on what is being measured
QA/QC on measurement value	Text		Comments on the quality of the quantitative values

Table 131. -- Components of the input form for taxonomic ID methods used to identify the organism.
The information for the following three tables was scanned from a late submission by the Biology User Group:

Keyword Description of identification methods.
Narrative description of taxonomic ID methods.
Date and time -When identification was done.
Reference -Reference used for taxonomic identification; the key used for identification may provide information about possible errors in the identification.
Modifications -Modifications to identification procedure.
Narrative description of modifications to the taxonomic methods.
Reference -reference for modifications to methods.
OA/OC Information -information about the quality of the identification.
Personnel -information about personnel making the identification.
Name and Location of Identification Site - Name and address of the place at which identification of organism took place.
Environmental Conditions -comments on environmental conditions at the place of identification which might affect the process of identifying organisms, e.g., rolling ship.
Equipment -Information about equipment used in identification.
Preparation Methods-information about the methods and equipment used to prepare the organism/sample for identification.
Preservation Methods-information about the methods and equipment used to preserve the sample/organism for identification.
Type - type of identification, e g., this may be a repeated identification of an organism which has been sent to several labs for quality control or re-identification.
Comments-comments about the identification not addressed by the other components in the identification section.

Table 132. -- Components of the input form for nontaxonomic ID methods used to identify the organism.

Keyword Description of identification methods.
Narrative description of nontaxonomic ID methods.
Date and time -When identification was done.
Reference -Reference used for nontaxonomic identification; the key used for identification may provide information about possible errors in the identification.
Modifications -Modifications to identification procedure.
Narrative description of modifications to the nontaxonomic methods.
Reference -Reference for modifications to methods.
OA/OC Information -information about the quality of the identification.
Personnel -information about personnel making the identification.
Name and Location of Identification Site. Name and address of the place at which identification of organism took place
Environmental Conditions -comments on environmental conditions at the place of identification which might affect the process of identifying organisms, e.g., rolling ship.
Equipment -Information about equipment used in identification.
Preparation Methods-information about the methods and equipment used to prepare the organism/sample for identification.
Preservation Methods-information about the methods and equipment used to preserve the sample/organism for identification.
Type-type of identification, e.g., this may be a repeated identification of an organism which has been sent to several labs for quality control or re-identification.
Comments-comments about the identification not addressed by the other components in the identification section.

Table 133. -- Components of the input form for biological sample tracking information.

This information describes the locations and times at which the sample is at whatever place it goes to get analyzed. This will include such items as date sample mailed.

Table 134. -- Components of the input form for sample container.

Item	Type		Description
Sample container type	Ref. List	M	The type of container (i.e., box, bottle, bag)
Sample container size	Number	M	The size of the sample container, in milliliters
Sample container identification	Number	M	Identification of the container

Table 135. -- Components of the input form for sample preparation.

Item	Type		Description
Sample preparation date & time	Date	M	Date & time at which sample was prepared
Sample preparation person	Ref. List	M	Names of person preparing samples
Sample preparation method	Ref. List	M	Sample preparation method
Sample preparation modifications	Text		Description of the modifications to the preparation method
Sample preparation equipment	Ref. List		Equipment used to prepare samples
Sample preparation comments	Text		Comments on the preparation of the sample
Preparation location	Spatial		Location at which sample was prepared

Table 136. -- Components of the input form for sample preservation.

Item	Type		Description
Sample preservation date & time	Date	M	Date & time at which sample was preserved
Sample preservation person	Ref. List	M	Names of person(s) preserving sample
Sample preservation method	Ref. List	M	Keywords that describe the preservation method
Sample preservation modifications	Text		Description of the modifications to the preservation method
Sample preservation references	Text		References of the modifications to the preservation method
Sample preservation equipment	Ref. List		Equipment used to preserve sample

Table 137. -- Components of the input form for electronic analytical service request (EASR).

Item	Type		Description
EASR ID	Text	M	Six-digit alphanumeric from SMS
Data base ID	Ref. List	M	Control number for each NWIS node of origin
Return data base ID	Ref. List	M	Control number for NWIS node to which data are to be returned
Destination laboratory	Ref. List	M	Keyword identification of laboratory conducting analysis
Project identifiers	Ref. List		Projects responsible for sample, from admin support file
Phone number	Ref. List		Work phone number of contact
Request type	Ref. List		Type of request (default = normal schedule)
District analytical group	Ref. List	M	Keyword(s) describing Type(s) of analysis requested
Sample handling comment	Text		District comments about the shipment to analyst
Sample containers shipped	Ref. List	M	Identification of sample containers shipped to lab, selected from sample containers
Sample shipping Date & time	Date	M	Date & time at which sample was delivered to shipping agent
Shipping agent	Text		Identifier of carrier (default = US Postal Service)
Hazardous sample type	Ref. List		Explosive, flammable, etc.
Hazardous sample comment	Text		Special comments due to hazardous nature of shipment, from field to lab
Sample preservative	Ref. List		For example, 1 ml ampoule of mercuric chloride
Security code	Ref. List		Proprietary limits on rights to see analytical data

Table 138. -- Components of the input form for electronic analytical service request water-quality priority[1]

Item	Type	Description
Sample priority	Text	Priority assigned by requesting person
Special requests	Ref. List	Requests not covered in normal District analytical group
Priority handling code	Ref. List	Priority in running analyses given by lab personnel
Priority authorization person	Text	Identifies lab person who gave approval for priority

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[1][This table was designed before responsibility for NWQL tables was shifted away from NWIS-II. It contains elements only codable by lab personnel and these are retained at this time for NWQL reference only, as they design their own system]

Table 139. -- Components of the input form for district rerun request

Item	Type		Description
Constituent ID	Ref. List	M	Identifies analyte to be rerun, multiple entries allowed
Method	Ref. List	M	Method of analytical determination
Original value	Text		Original value for constituent
Reason	Text		Reason for rerun request

Table 140.--Components of the input form for precipitation data-collection

Item	Type	Description
Date started	Date	Date precipitation data-collection began
Number of gages	Integer	Number of gages installed at site
Gage(n)	Ref. List	Keyword describing type of gage (n)
Location (n)	Ref. List	Location of gage(n) relative to station location reference point
Shield (n)	Ref. List	Keyword describing type of precipitation gage shield installed
Equipment(n)	Ref. List	Keyword identifying make, model, and WRD ID number

Table 141.--Components of the input form for temperature data-collection

Item	Type	Description
Date started	Date	Date temperature data-collection began
Number of instruments	Integer	Number of instruments installed at site instruments
Instrument (n)	Ref. List	Keyword describing type of instrument (n)
Location (n)	Ref. List	Location of instrument(n) relative to station location reference point
Height (n)	Number	Instrument height above land surface, in feet
Shelter or shield (n)	Ref. List	Keyword describing type of radiation shield or shelter used
Equipment(n)	Ref. List	Keyword identifying make, model, and WRD ID number

Table 142.--Components of the input form for atmospheric pressure data-collection

Item	Type	Description
Date started	Date	Date atmospheric pressure data-collection began
Number of instruments	Integer	Number of instruments installed at site
Instrument (n)	Ref. List	Keyword describing type of instrument (n)
Location (n)	Ref. List	Location of instrument(n) relative to station location reference point
Height (n)	Number	Instrument height above land surface, in feet
Shelter or shield (n)	Ref. List	Keyword describing type of radiation shield or shelter used
Equipment(n)	Ref. List	Keyword identifying make, model, and WRD **ID number**

Table 143.--Components of the input form for atmospheric humidity data-collection

Item	Type	Description
Date started	Date	Date atmospheric humidity data-collection began
Number of instruments	Integer	Number of instruments installed at site
Instrument (n)	Ref. List	Keyword describing type of instrument (n)
Location (n)	Ref. List	Location of instrument(n) relative to station location reference point
Height (n)	Number	Instrument height above land surface, in feet
Shelter or shield (n)	Ref. List	Keyword describing type of radiation shield or shelter used
Equipment(n)	Ref. List	Keyword identifying make, model, and WRD **ID number**

Table 144.--Components of the input form for solar and longwave radiation data-collection

Item	Type	Description
Date started	Date	Date radiation data-collection began
Number of instruments	Integer	Number of instruments installed at site
Instrument (n)	Ref. List	Keyword describing type of instrument (n)
Location (n)	Ref. List	Location of instrument(n) relative to station location reference point
Height (n)	Number	Instrument height above land surface, in feet
Equipment(n)	Ref. List	Keyword identifying make, model, and WRD **ID number**

Table 145.--Components of the input form for evaporation data-collection

Item	Type	Description
Date started	Date	Date evaporation data-collection began
Number of instruments	Integer	Number of instruments installed at site
Instrument (n)	Ref. List	Keyword describing type of instrument (n)
Location (n)	Ref. List	Location of instrument(n) relative to station location reference point
Height (n)	Number	Instrument height above land surface, in feet
Equipment(n)	Ref. List	Keyword identifying make, model, and WRD **ID number**

Table 146.--Components of the input form for soil-moisture data-collection

Item	Type		Description
Date started	Date		Date soil-moisture data-collection began
Number of sites	Integer		Number of sample sites at which soil moisture is measured
Location (n)	Ref. List		Location of instrument(n) relative to station location reference point
Method (n)	Ref. List	M	Keyword describing type of method used at site n
Instrument (n)	Ref. List		Keyword describing type of instrument (n)
Number of depths (m)	Integer		Number of sampling depths or depth intervals at site n
Depth (m)	Number		Sampling depth or depth interval below land surface at site n, in feet
Comments	Text		Comments regarding soil-moisture sampling at site n
Equipment(n)	Ref. List		Keyword identifying make, model, and WRD **ID number**

Table 147.--Components of the input form for soil-temperature data-collection

Item	Type	Description
Date started	Date	Date soil-temperature data-collection began
Number of sites	Integer	Number of measurement sites at which soil temperature is measured
Location (n)	Ref. List	Location of instrument(n) relative to station location reference point
Instrument (n)	Ref. List	Keyword describing type of instrument (n)
Number of depths (m)	Integer	Number of sampling depths or depth intervals at site n
Depth (m)	Number	Sampling depth or depth interval below land surface at site n, in feet
Comments	Text	Comments regarding soil-temperature measurement at site n
Equipment(n)	Ref. List	Keyword identifying make, model, and WRD **ID number**

B. SAMPLE-EVENT FORMS FOR WATER SAMPLES

Table 148. -- Components of the input form for manual point samples.

Item	Type		Description
Time valve open (seconds.)	Number	M	Time suspended sediment sampler intake valve was open, in seconds

Table 149. -- Components of the input form for automatic point samples.

Item	Type		Description
Automatic sampler bottles installed	Date		Date and time sample bottles installed in automatic sampler
Automatic sampler date of removal	Date	M	Date and time samples were removed from automatic sampler
Automatic sampler bottles removed	Number	M	Number of sample bottles removed from automatic sampler

Table 150. -- Components of the input form for bedload sample.

Item	Type		Description
Bedload start date and time	Date	M	Time first sample was collected
Bedload end date and time	Date	M	Time last sample was collected
Active width of transport zone	Number		Cross-sectional width of active bed-load transport zone, in feet
Sampler bag mesh size	Number	M	Mesh size of bed-load sampler bag, in millimeters
Stayline used	Y/N		Stayline used (yes or no)

C. SAMPLE-EVENT FORMS FOR SOLID MATERIAL SAMPLES

Table 151. -- Components of the input form for bed material sample.

Item	Type		Description
Bed material sample interval start	Number	M	Starting depth below stream-bed surface that sample was collected, in inches
Bed material sample interval end	Number	M	Ending depth below stream-bed surface that sample was collected, in inches
Bed material sampling remarks	Text		Remarks about the bed material sampling

Table 152. --**Components of the input form for snow data-collection at a snow course.**

Item	Type	Description
Date started	Date	Date snow course was activated
Description	Text	Description of snow course layout
Frequency	Ref. List	Keyword describing sampling frequency
Location (n)	Ref. List	Location of sampling sites(n) relative to station location reference point
Instrument	Ref. List	Keyword describing snow or ice sampler used
Comments	Text	Comments regarding snow sampling at snow course
Equipment(n)	Ref. List	Keyword identifying make, model, and WRD ID number

Table 153. -- Components of the input form for a snow survey.

Item	Type		Description
Site information	Ref. List	M	Snow course ID, name, etc.
Site location	Ref. List	M	Drainage basin
Personnel	Ref. List		Full name of each person involved in survey
Sample ID and time	Ref. List	M	Automatically assigned ID and date
Beginning time	Date	M	Beginning time of survey
Ending time	Date	M	Ending time of survey
Sampler	Ref. List		Type of snow sampler used
Number of samples	Integer		Number of snow samples taken at this course
Sample number n	Integer		Nth snow sample taken
Depth of snow	Number		Depth of snow at nth sample point, inches
Length of core	Number		Length of snow core at nth sample point, inches
Weight of empty tube	Number		Weight of empty tube at nth sample point, inches
Weight of tube and core	Number		Combined weight at nth sample point, inches
Snow water equivalent	Number		Water equivalent of sample at nth sample point, inches
Density	Number		Snow density at nth sample point, percent
Remarks	Text		Remarks pertaining to nth sample point
Total depth	Number		Total of snow depths from n samples, inches
Mean depth	Number		Total depth/n, inches
Total weight of empty tube	Number		Total of empty weights from n samples, inches
Total weight of tube and core	Number		Total of tube and core weights from n samples, inches
Total water equivalent	Number		Total tube and core - total empty, inches
Mean water equivalent	Number		Total water equivalent/n, inches
Weather	Text or Ref. List		Weather at time of sampling
Snow conditions at course	Text		Ease of obtaining cores, condition of soil surface, etc.
General snow conditions	Text		Condition of snowpack in vicinity of snow course
General streamflow conditions	Text		Ice conditions, flows noted, turbidity, etc.
General remarks	Text		General remarks about snow survey, additional samples taken, etc.

Table 154. -- Components of the input form for miscellaneous snow survey data

Item	Type	Description
Quality of snow	Integer	Amount of ice in a snow sample, percent of the weight
Ramssonde hardness	Number	Ram number resistance to penetration
Extent of cover	Integer	Areal extent of snow or ice expressed as a percent of a related spatial unit
Spatial unit for extent	Text	Basin, county, state, etc.

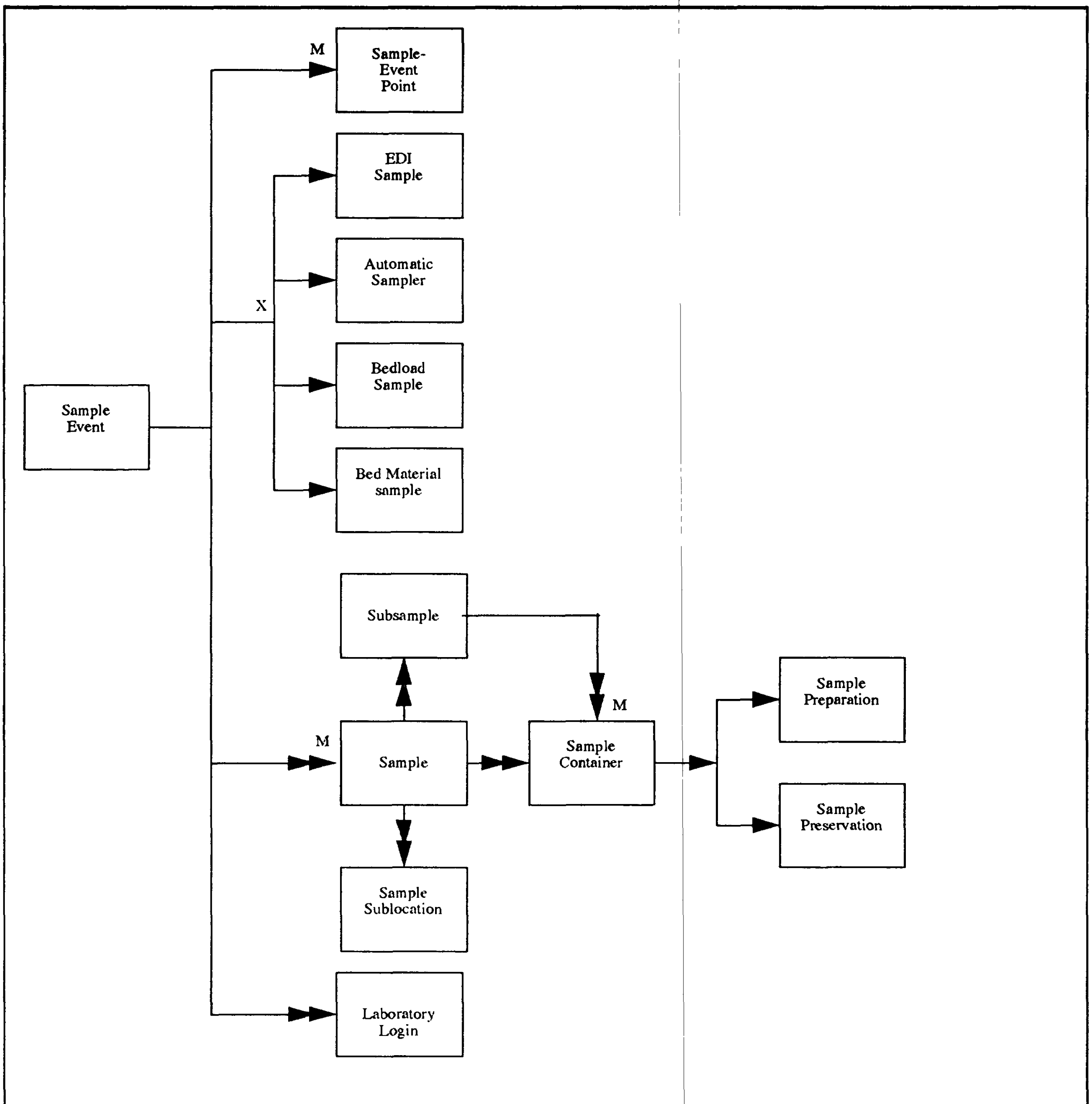

Figure 43. -- Forms flow for a site sampling event.

IV. SAMPLE ANALYSIS INPUT AND EDIT FORMS AND FORMS FLOW

The forms described in this section are the entry and edit forms used in entering data from the analysis of water, soil, biological, or other types of samples.L

A. GENERAL ANALYSIS-EVENT INPUT FORMS

Table 155. -- Components of the input form for analysis event.

Item	Type		Description
Sample ID	Number	M	Identification of sample to be analyzed
Date of analysis	Date	M	Date analysis was conducted.
Analysis person	Ref. List	M	Name of person determining preforming the analysis
Date of verification	Date		Date of verification for the analysis
Location of analysis	Ref. List		Location where analysis was conducted (e.g., field, sediment laboratory, water-quality laboratory)
Location narrative	Text		Narrative description, possibly including address of a lab
Environmental conditions	Ref. List		Environmental conditions at the laboratory or place where the analysis occurred that might affect the result (default = no observed problem)
Narrative on conditions	Text	M*	Narrative description of any potential or observed problems at the site of the analysis that might affect the results (* = only when environmental condition are other than default)

Table 156. -- Components of the input form for sample-source information for biology.

Item	Type		Description
Name of location	Text	M	Name of place at which the sample was prepared/ derived
Keywords for sample source	Ref. List	M	Keywords that describe the sample source
Sample source description	Text		Description of sample source (e.g., biological supply house)
Number of location	Number		Designation of specific location by station or site number
Narrative on location	Text		Comments about location, address, or home range
Person making the determination	Ref. List		Name of person(s) making location determination
Narrative on site source	Text		Comments on location
Narrative on conditions	Text		Comments on conditions at the location at which the sample was obtained
Personnel for conditions	Ref. List		Name of person(s) making conditions determinations
Experience classification	Ref. List		Years experience in a particular discipline, multiple entries allowed for multiple disciplines

For Input forms defined previously see: Environmental observations .... Table 71
Sample Preservation .... Table 123
Sample Preparation .... Table 123
General Constituent measurement................ Table 126

B. BIOLOGICAL SAMPLE-ANALYSIS EVENT INPUT FORMS

Table 157. -- Components of the input form for biological identification.

Item	Type		Description
Identification Method	Ref. List	M	Method used in the identification process
Identification Equipment	Ref. List	M	Equipment used to identify organisms
Identification Type	Ref. List	M	Type of identification
Identification References	Text		References used for identification
Identification Method modification	Text		Comments that describe modifications to method
Identification QA/QC	Text		Information about the quality of the identification
Identification Comments	Text		Comments about the identification not addressed

Table 158. -- Components of the input form for biological taxonomic identification.

Item	Type		Description
Taxonomic name	Text	M	Taxonomic name assigned, based on a system of hierarchical phylogenetic classification of organisms
Taxonomic Authority (NODC)	Ref. List	M*	The NODC-approved taxonomic author and the official publication date of the article used in selection of name (* = required for genus and species level identifications)
Taxonomic authority other	Ref. List		Non-NODC approved taxonomic authority
NODC code	Ref. List	M	Unique taxonomic code
Narrative taxonomic identification	Text		Narrative description of taxonomic identity.
Taxonomic identity associations	Ref. List		Optional user-defined group of taxonomic identities

Table 159. -- Components of the input form for biological nontaxonomic Identification.

Item	Type		Description
Nontaxonomic identity	Text	M	Name based on nontaxonomic classification
Nontaxonomic ID associations	Ref. List		A user-defined group of nontaxonomic identifiers
Classification scheme name	Ref. List	M	Classification scheme upon which the non-taxonomic identity is based (invokes one of the following)
Morphological classification	Ref. List		Organisms size, shape or structure
Physiologic classification	Ref. List		Organisms classified by the chemical processes by which energy is derived and material is assimilated, e.g. denitrifying, anaerobic
Respiratory classification	Ref. List		Organisms classified by their respiration type
Trophic classification	Ref. List		Organisms classified by their position in the food chain
Assemblage classification	Ref. List		Organisms classified by their assemblage type (environment and/or behavior)
Ecologic classification			Organisms classified by their interaction with the environment
Genetic classification	Ref. List		Organisms classified by their chromosome number or DNA sequences
Biochemical classification	Ref. List		Organisms classified by their biochemical characteristics
Classification Scheme Reference	Ref. List	M	The reference(s) for the classification scheme used

Table 160. -- Components of the input form for biological analysis.

Item	Type		Description
Measurement description	Ref. List	M	What the measurement is, e.g. counts, dimension, gender, biomass, concentration
Measurement description narrative	Text		Narrative description of the measurement/analysis for more definition than allowed by keyword(s) alone
Constituent description	Ref. List	M	The constituent/substance being measured, e.g., iron, lipids, chlorophyll A.
Constituent narrative	Text		Narrative description of the constituent, for more definition
Phase	Ref. List	M	Phase of the constituent/substance being measured ("not applicable" will be a permitted keyword), e.g., total, dissolved, suspended.
Phase narrative	Text		Narrative description of the phase, for more definition
Size restriction	Text		Description of size restrictions, such as concentration of suspended sediment "<.062 mm", or count of number of individuals of species xy that are "less than 4 inches in length"
Size-restriction method	Ref. List		Descriptor for size-restriction process, e.g., sieve, micrometer.
Size-restriction narrative	Text		Narrative description for method of size restriction
Life stage	Ref. List		Life-stage restrictions for biological samples, e.g., adult, larval.
Life-stage narrative	Text		Narrative description of the life stage for biological samples, for greater definition
Measurement/analysis date and time	Date	M	When measurement or analysis was done, should permit begin-end times also

For Input forms defined previously see: Biological measurement .... Table 130

C. SEDIMENT SAMPLE-ANALYSIS EVENT INPUT FORMS

Table 161. -- Components of the input form for sediment concentration measurement.

Item	Type		Description
Measurement method	Ref. List	M	Method used in the measurement process
Weighing method	Text	M	Method used to determine sample weight (e.g., sample submerged, sample dried)
Measurement equipment	Ref. List		Equipment used to determine the concentration
Sediment concentration	Number	M	Sediment concentration, in milligrams per liter
Weight of sample	Number		Total weight of sediment sample with water, milligrams
Weight of sediment	Number		Total weight of sediment sample dried, milligrams

Table 162. -- Components of the input form for sediment particle-size measurement.

Item	Type		Description
Measurement method	Ref. List	M	Method used in the measurement process
Measurement equipment	Ref. List	M	Equipment used to determine the particle size
Particle-size class	Ref. List	M	Particle size class selected from 15 particle-size classes
Weight of material in class	Number	M	Weight of suspended-sediment, bed-material, or bedload sample in a size class specified above, in milligrams

Table 163. -- Components of the input form for sediment petrology measurement.

Item	Type		Description
Sedimentary petrology description	Text	M	Description of the specimen rock type(s)
Sedimentary petrology specific weight	Number		Specific weight of specimen, in lb/ft^3
Sedimentary petrology shape	Text		Roundness of particles in specimen
Sedimentary petrology color	Text		Description of specimen color

Table 164. -- Components of the input form for sediment particle-count measurement.

Item	Type		Description
Measurement method	Ref. List	M	Method used in the measurement process
Measurement equipment	Ref. List	M	Equipment used to determine the count
Particle-size class	Ref. List	M	Particle size class selected from 15 particle-size classes
Number of particles in size class	Number	M	Number of sediment particles in the specified size class

Table 165. -- Components of the input form for sediment/particle description.

Item	Type		Description
Particle-count grid reference info.	Text		Description of particle-count grid location.
Location of node	Text		Location of node from grid reference point.
Length of specimen A-axis	Number		Length of specimen in A-axis, in millimeters
Length of specimen B-axis	Number		Length of specimen in B-axis, in millimeters
Length of specimen C-axis	Number		Length of specimen in C-axis, in millimeters

D. WATER-QUALITY ANALYSIS EVENT INPUT FORMS

NOTE: These tables were designed before responsibility for NWQL tables was shifted away from NWIS-II. They are retained at this time for NWQL reference only, as they design their own system.

Table B. -- Components of the input form for lab reply to EASR

Item	Type	Description
Bottle types	Ref. List	List for each schedule (from Lab)
Bottle labels	Ref. List	List for each schedule
Lab codes	Ref. List	List for each schedule

Table C. -- Components of the input form for laboratory arrival login

Item	Type	Description
Lab ID	Text	ID assigned to the sample by the lab, 9 characters (as many as 3 lab ID's per individual sample)
Bottle check	Text	OK or incomplete
Improper sample notes	Text	Remarks describing potential impropriety
Special comments	Text	Observations on samples logged in
Date received	Date	Date the sample was received
Max. holding time	Ref. List	Standard allowable holding times for sample type
Due date	Date	Estimated completion of analysis
Request status	Ref. List	Completion status of the request for analysis
Date status invoked	Date	Date status invoked for tracking

Table E. -- Components of the input form for QW analysis results

Item	Type	Description
Request number	Number	Initial or rerun sequence number
Create date	Date	Date record of results created by district SMS program
Last update	Date	Date record last updated by districtSMS program
Schedule type	Ref. List	Type of analysis requested
Method code	Ref. List	Method used to perform analysis
Date test performed	Date	Date test actually run
Parameter	Ref. List	From PARMFILE described on p.637 of the 1/18/91 SRS draft
Parameter value	Number	.Multiple entries allowed
Cation total	Number	Possible automatic generation
Anion total	Number	Possible automatic generation
Precision	Text	Two-character code

Table V. -- Components of the input form for NWQL accounting

Item	Type	Description
Schedule cost	Ref. List	Cost for each included schedule (table from NWQL)
Test cost	Ref. List	Cost for each (additional?) test performed (table from NWQL)
Cost adjustment flag	Text	"+" or "-" for cost adjustments
Cost adjustment	Number	Amount of cost adjustment in dollars and cents

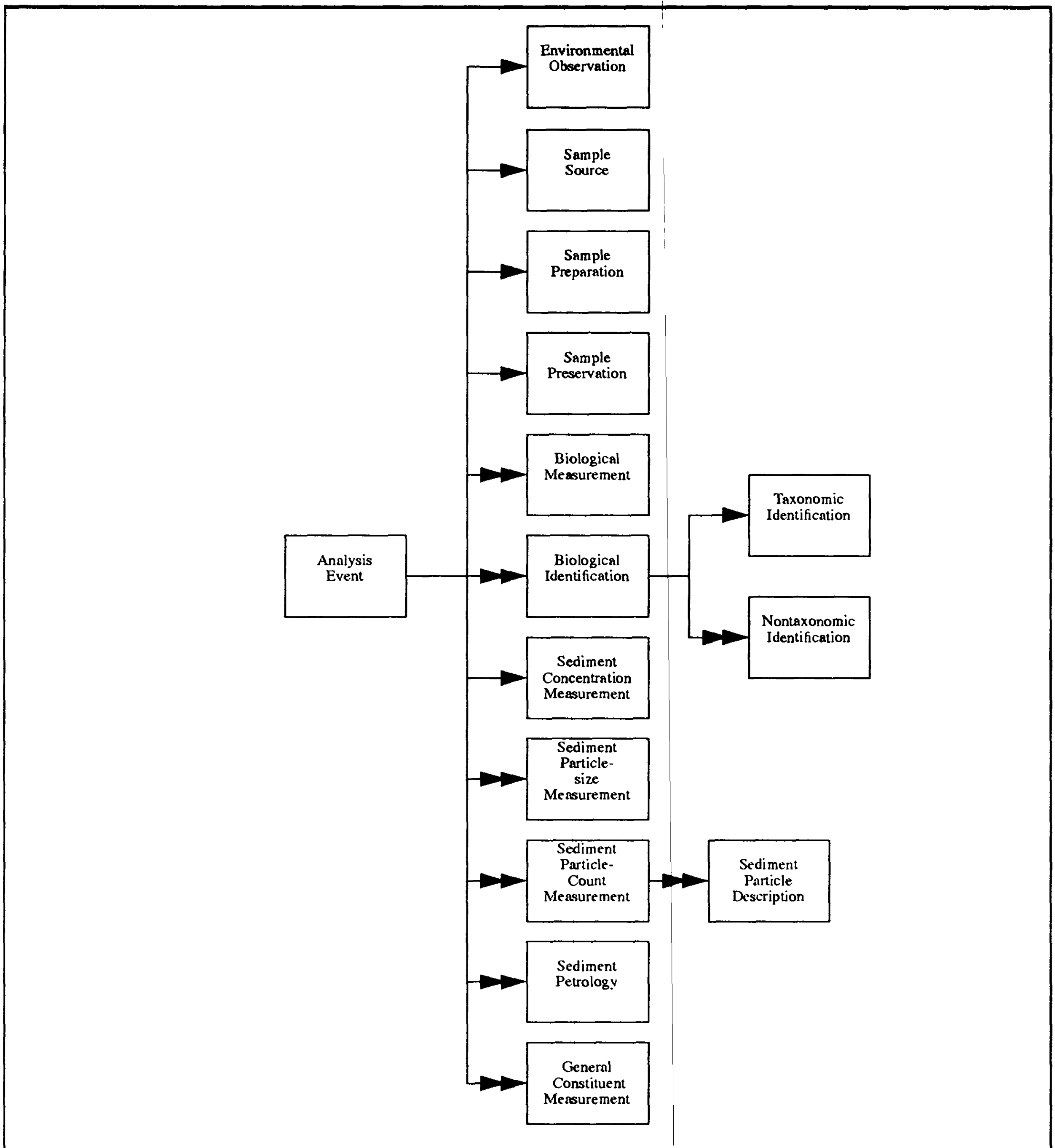

Figure 44. -- Input forms flow for sample analysis events.

V. SITE-ANALYSIS EVENT INPUT AND EDIT FORMS AND FORMS FLOW

The forms in this section describe the input and editing of analysis events for a site that are not done on samples; such as lithology, geology, and hydrogeology analysis of a ground-water well. These forms are input from the office.

Table 166. -- Components of the input form for site-analysis event.

Item	Type		Description
Site ID	Number	M	Identification of site
Date of analysis	Date	M	Date analysis was conducted.
Analysis person	Ref. List	M	Name of person determining performing the analysis
Date analysis data collected	Date	M*	Date analysis data was collected (* = unless unknown)
Analysis Data Source type	Ref. List		Keyword describing type of data source

Table 167. -- Components of the input form for lithologic units.

Item	Type		Description
Depth To Bottom	Number		Depth to bottom of lithologic unit
Depth To Top	Number	M	Depth to top of lithologic unit
Lithology	Ref. List	M	Keyword describing lithologic unit
Modifier	Text		Modifications to description of lithologic unit

Table 168. -- Components of the input form for geologic unit.

Item	Type		Description
Depth to bottom	Number		Depth to bottom of geologic unit
Depth to top	Number	M	Depth to top of geologic unit
Geologic unit Identifier	Ref. List	M	Keyword describing geologic unit

Table 169. -- Components of the input form for hydrogeologic unit.

Item	Type		Description
Depth to bottom	Number		Depth to bottom of hydrogeologic unit
Depth to top	Number	M	Depth to top of hydrogeologic unit
Contributing to well indicator	Ref. List		Indicator of aquifer contribution to well
Well contribution	Number		Percentage of water well flow contributed
Hydrogeologic unit identifier	Ref. List	M	Keyword describing the hydrogeologic unit

Table 170. -- Concentration coefficient input form.

Item	Type		Description
Date and time of sample	Date	M	Date and time of sediment sample
Concentration coefficient	Number	M	Value of instantaneous concentration coefficient corresponding to sediment sample

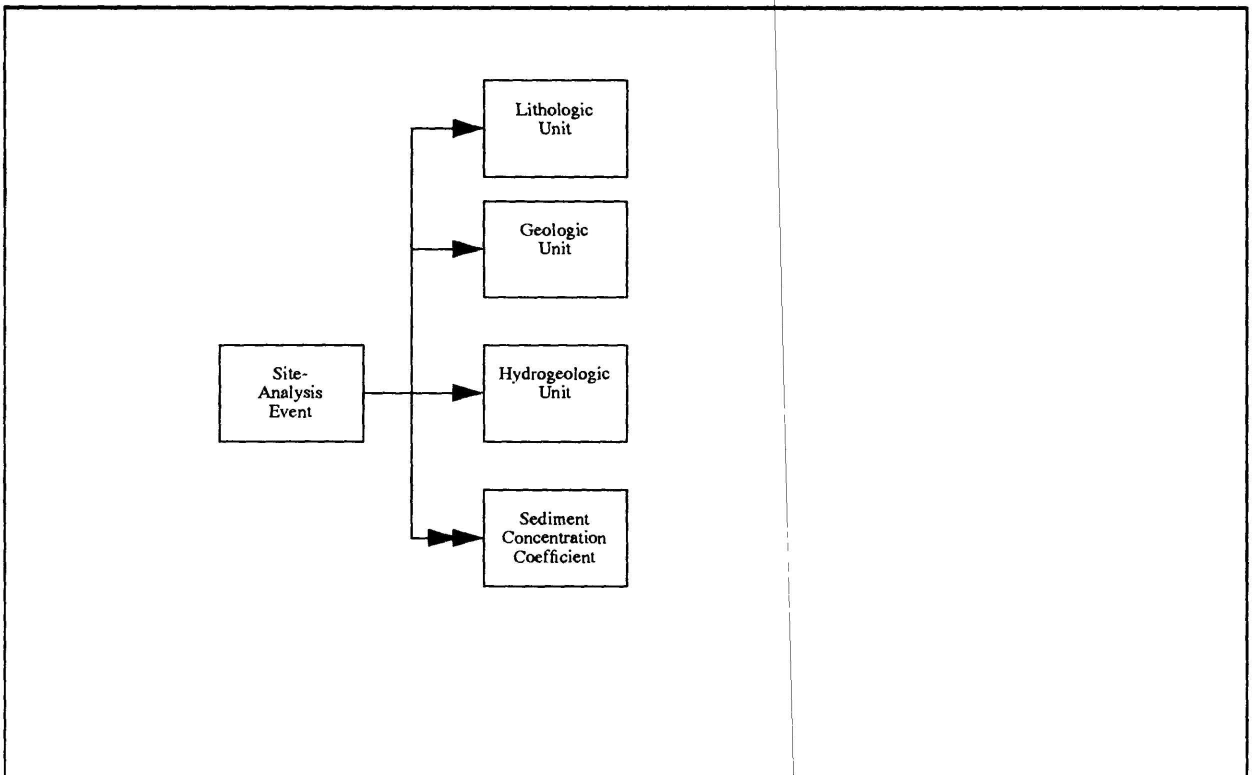

Figure 45. -- Input forms flow for site-analysis events.

VI. SITE PROCESSING INPUT AND EDIT FORMS AND FORMS FLOW

The forms in this section describe the input and editing of information that is only used to process data for the site.

Table 171. -- Components of the input form for site instrument.

Item	Type		Description
Instrument type	Text		Keyword describing type of instrument
Instrument description	Text		Description of instrument
Manufacture name	Text		Manufacture name of instrument used
Device model	Text		Manufacturer's model name.
Serial number	Text	M	Serial number of instrument used
WRD number	Text	M	W number, WRD identification number of instrument
Specifications	Text		Manufacturer's specs on the item
Reference	Ref. List		Reference for specifications
WRD field method reference	Ref. List		Reference in USGS publication (e.g., TWRI)
Size	Text		Weight, dimensions, etc.
Date of manufacture	Text		Year of manufacture, where appropriate
Purpose	Text		Explanation of use, where appropriate
Service company	Text		Name and address of service company
Catalog description	Text		Description from sales literature
Catalog code	Text		Equipment identifier and sales catalog identifier
Cost	Number		Cost of item
Cost date	Date		Date related to cost
Owner organization	Text		Responsible agency or group
Person owner	Text		Responsible individual
Installation date	Date		Date put into service
Comments	Text		Additional comments

Table 172. -- Components of the input form for portable flow meter.

Item	Type	Description
Meter ID number	Text	Serial number
Meter type	Ref. List	Code for type of flow-meter
Meter size	Number	Opening size in inches, if applicable
Meter owner	Text	USGS, cooperator, or facility
Meter units	Text	Units of meter readout (e.g., cubic feet, liters)

Table 173. -- Components of the input form for modification or repair of site instrument.

Item	Type	Description
Modifications or repair of instrument	Text	Description of modifications or repair to instrument
Modification or repair date	Date	Date that instrument was modified or repaired
Modification or repair person		Person doing modification or repair
Modification or repair QA comments	Text	Comments on any QA changes due to modification or repair

Table 174. -- Components of the input form for QA of site equipment.

Item	Type		Description
QA comments about site equipment	Text	M	Comments about the quality of function of the site equipment
QA comments date	Text	M	Date the comments were recorded
QA comments person		M	Person making comments about the QA

Table 175. -- Components of the input form for site-specific instrumentation information for decoding field-recorded data.

Item	Type	Description
Station number	Number	The official USGS site-identification number
Device number	Number	Number used to differentiate devices when more than one with the same device ID are installed at the site
Configuration ID	Text	Configuration identifier of the device configuration associated with the device at the site
Time shift	Number	Time shift used to shift the time of the recorder to the site time zone
DCP ID *	Text	Hexadecimal identification assigned by NESDIS for a DCP device
Self-timed channel number[1]	Number	GOES channel assigned for self-timed transmissions.
Assigned transmission time[1]	Number	Assigned time for synoptic transmission
Transmission interval[1]	Number	Time between transmissions
Number of values transmitted	Number	Number of sensor values transmitted in a message block
Random channel[1]	Number	GOES channel assigned for random DCP transmissions
Transfer queues[1]	Text	Queues that will determine the destination of data for this DCP
Transfer format[1]	Text	Transfer formats used to override the default transfer format

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[1][DCP type devices only]

Table 176. -- Components of the input form for site specific sensor information for decoding field recorded data.

Item	Type	Description
Sensor number	Number	Sequential sensor number identifying a unique device sensor.
Recording interval	Number	Recording interval in hours and minutes for the sensor.
Parameter identification	Text	Parameter identification that links the data from this sensor with the system data base.
Absolute minimum	Number	A minimum value used for error checking. Data values below this will be flagged as missing.
Absolute maximum	Number	A maximum value used for error checking. Data values above this will be flagged as missing.
Actual station number	Number	Official USGS site-identification number used to identify this sensor's data with another site.
Transmission time offset	Number	Time offset number used to assign times to the data for devices that do not record the time of each data value.
Alert process number[1]	Number	Identify a specific alert process to execute when this datum is processed.
Alert user number[1]	Number	Identify a specific user or group of users to be used in the alert process.

[1] [For real-time transmission devices such as DCP's only]

Table 177. -- Components of the input form for device information needed to process field-recorded data.

Item	Type	Description
Device ID	Text	Device identification information
Device type	Text	Device type identification (EDL = electronic data logger, DCP = data-collection platform, ADR = automatic data recorder, CHA = strip-chart recorder)
Device model	Text	Manufacturer's model name.
Device manufacture	Text	Name of manufacturer.
Retrieval mode	Text	Retrieval mode (DCP = satellite data relay, MAN = Manual retrieval, TEL = telephone retrieval, RAD = line-of-sight radio relay)
Time tagging mode	Text	Code to indicate the order of the data in time when uploaded from the device (a = ascending, d = descending)

Table 178. -- Components of the input form for device configuration information needed to decode field-recorded data.

Item	Type	Description
Device ID	Text	Device identification information
configuration type	Text	Type of configuration
Configuration sequence ID	Number	Sequential number for different configurations on one device.
Configuration description	Text	Description of the configuration.
Script files link	Text	Links to recording device programming scripts.
Device sensors	Text	Describe nature of multiple sensors in same device configuration
Decoding formats	Text	Fortran-like formats describing the decoding of the data.

Table 179. -- Components of the input form for device sensor configuration information needed to decode each sensor's data.

Item	Type	Description
Sensor number	Number	Sequence number used to identify different sensors.
Parameter identification	Number	
Statistic code	Number	Statistical code indicating statistical sampling of sensor.
Recording type	Text	Type of data recorded (unit or daily)?
Recording mode	Text	recording method (F = fixed interval recording, V = variable interval recording)
Field length	Number	Size of the field to be used on output.
Number of decimals	Number	Number of decimal places to use on output.
Engineering conversion method	Text	Method and variable values to use to convert the data to engineering units
Measuring height	Number	Height above LSD from which sensor measures, in feet
Measuring depth	Number	Depth below LSD from which sensor measures, in feet

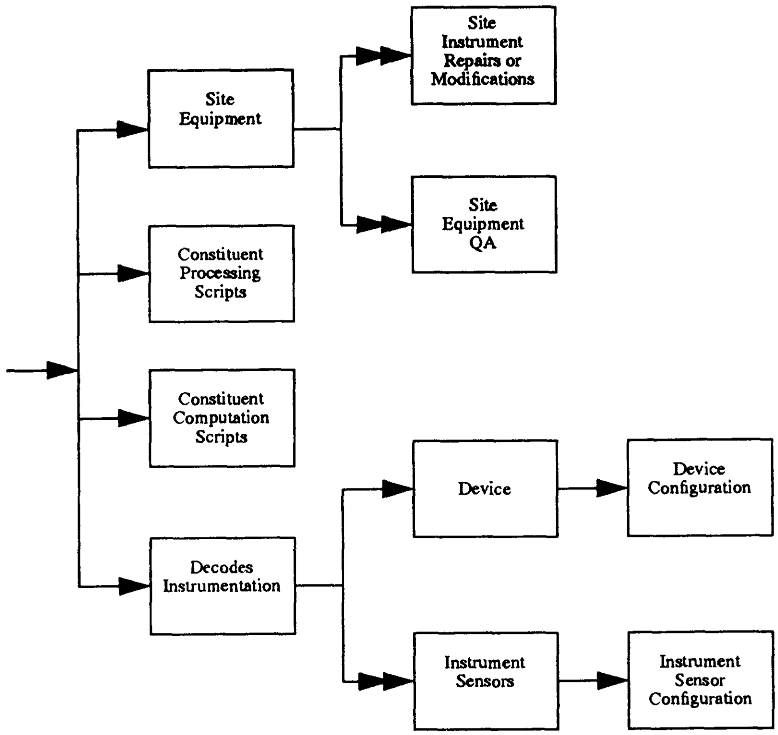

Figure 46. -- Forms flow for site processing information.

VII. NONSITE-SPECIFIC EVENT INPUT AND EDIT FORMS AND FORMS FLOW

The forms described in this section are input and edit forms used to enter data that are not site-specific, such as water-use annual areal aggregation, project information, and equipment descriptions.

Table 180. -- Components of the input form for measurement/sampling equipment

Item	Type		Description
Equipment type	Text		Keyword describing type of equipment
Equipment description	Text		Description of equipment
Manufacturer's name	Text		Manufacturer's name of equipment used
Device model	Text		Manufacturer's model name.
Serial number	Text	M	Serial number of equipment used
WRD number	Text	M	W number, WRD Identification number of equipment
Specifications	Text		Manufacturer's specs on the item
Reference	Ref. List		Reference for specifications
WRD field method reference	Ref. List		Reference in USGS publication (e.g., TWRI)
Size	Text		Weight, dimensions, etc.
Date of manufacture	Text		Year of manufacture, where appropriate
Purpose	Text		Explanation of use, where appropriate
Service company	Text		Name and address of service company
Catalog description	Text		Description from sales literature
Catalog code	Text		Equipment identifier and sales catalog identifier
Cost	Number		Cost of item
Cost date	Date		Date related to cost
Owner organization	Text		Responsible agency or group
Person owner	Text		Responsible individual
Installation date	Date		Date put into service
Comments	Text		Additional comments

Table 181. -- Components of the input form for modification, repair, or routine service of measurement/sampling equipment.

Item	Type		Description
Serial number	Text	M	Serial number of equipment used
WRD number	Text	M	W number, WRD Identification number of equipment
Equipment type	Text	M	Keyword describing type of equipment or part parent
Part identifier	Text	M*	Keyword describing part which is being repaired or replaced (* = in cases when key word identifiers not enough)
Maintenance type	Ref. List		Type of equipment maintenance
Maintenance schedule date	Date		Date item due for service
Modifications or repair of equipment	Text		Description of modifications, repair, or routine service to equipment
Modification or repair begin date	Date		Beginning date that equipment was modified, repaired, or serviced
Modification or repair end date	Date		Date that modification, repair, or servicing was completed
Installation date of modification	Date		Date that modified equipment returned to service
Modification or repair person			Person doing modification, repair, or servicing
Repair cost	Number		Cost for repair/replacement
Modification or repair QA comments	Text		Comments on any QA changes due to modification, repair, or servicing

Table 182. -- Components of the input form for quality assurance of measurement/sampling equipment.

Item	Type		Description
QA comments about equipment	Text	M	Comments about the quality of function of the equipment
QA comments date	Text	M	Date the comments were recorded
QA comments person		M	Person making comments about the QA

Table 183. -- Components of the input form for data characterization.

Item	Type		Description
Hydrologic discipline group	Ref. List		Hydrologic study area
Data characterization group	Ref. List	M	Keyword characterizing data group
Secondary data characterization	Ref. List		Keyword to further specify data type

Table 184. -- Components of the input form for basin characteristic.

Item	Type		Description
Basin characteristic identification	Ref. List	M	Keyword identifying what basin characteristic
Basin char. determination method	Ref. List	M	Method used to determine the characteristic
Basin char. determination equipment	Ref. List		Equipment used to determine the characteristic
Basin characteristic	Number	M	Basin characteristic value in applicable units

Table 185. -- Components of the input form for water use aggregation coefficient[1]

Item	Type	Description
Coefficient identification	Ref. List	Identification of specific water use coefficient used
Coefficient	Number	Coefficient used
Coefficient reference	Text	Reference describing coefficient use
Regionality of application	Ref. List	Automatic for standard list

[1][For use in documenting a particular aggregation event]

Table 186. -- Components of the input form for water-use aggregation event documentation

Item	Type		Description
State	Ref. List	M	State for which data have been aggregated
Data year	Date	M	Year to which data applies
Aggregation date	Date		Date on which data aggregated
Aggregation use category	Ref. List	M	Water-use category describing aggregation
Aggregation area	Ref. Lists	M	County, HUC, or aquifer
Source agency	Ref. List		Source agency office (multiple entries allowed)
Information description	Text		How information was derived from its printed or verbal sources (sum of site data, coefficient, etc.), using as many lines as it takes for each source

Table 187. -- Components of the input form for water-use general aggregated annual data[1]

Item	Type	Description
Water withdrawal total		
Source GW	Number	In MGD
Source SW	Number	In MGD
Source		
GW-fresh	Number	In MGD
GW-saline	Number	In MGD
SW-fresh	Number	In MGD
SW-saline	Number	In MGD
Re. sewage	Number	In MGD, reclaimed sewage
Total	Number	In MGD, conjunctive SW & GW total
Deliveries from public supply	Number	In MGD, conjunctive SW & GW total
Consumptive use		
Fresh	Number	In MGD, conjunctive SW & GW total
Saline	Number	In MGD, conjunctive SW & GW total
Total	Number	In MGD, conjunctive SW & GW total
Number of facilities	Integer	Facilities estimated in total set
No. of facilities in DB	Integer	Facilities entered in NWIS-II data base
Data year	Date	Year to which these values apply

[1][This form can be applied to any use category (e.g., public supply, commercial, domestic, thermoelectric)

Table 188. -- Components of the input form for water-use irrigation aggregated annual data.

Item	Type		Description
Data year	Date	M	Year of data
Irrigation type	Ref. List		Land use tract irrigation method
Acres irrigated	Number		Number of acres irrigated by irrigation type
Withdrawal-sewage	Number		Withdrawal from reclaimed sewage, in MGD
Conveyance losses	Number		Conveyance loss annual total, in MGD

Table 189. -- Components of the input form for water-use wastewater treatment aggregated annual data.

Item	Type		Description
Data year	Date	M	Year of data
No. of public facilities	Number		Number of public sewage treatment facilities in aggregated area
No. of other facilities	Number		Number of other sewage treatment facilities in aggregated area
Total releases	Number		Total water release in MGD
Total returns from municipal	Number		Total water returned from municipal facilities, In MGD
Salinity	Text		Fresh, saline, unknown

Table 190. -- Components of the input form for water use power generation aggregated annual data.

Item	Type		Description
Data year	Date	M	Year of data
Power generation	Number		In gigawatt-hours
Hydro use	Number		Hydroelectric use in MGD

Table 191. -- Components of the input form for reservoir evaporation aggregated annual data.

Item	Type		Description
Reservoir evaporation year of data	Date	M	Year to which these data apply
Average surface area	Number		Average surface area of reservoirs in aggregated area, in acres
Reservoir evaporation	Number		Total evaporation from all reservoirs in aggregated area, in acre-feet

Table 192. -- Components of the input form for water use deliveries aggregated annual data.

Item	Type		Description
Data year	Date	M	Year of data
Total population	Integer		Total population in the aggregated area/1000
Pop. served – GW	Integer		Residential population served ground water/1000
Pop. served – SW	Integer		Residential population served surface water/1000
Self-supplied pop.	Integer		Self-supplied population/1000
Per capita use	Integer		Per capita water use In gallons per day
Water deliveries commercial	Number		Commercial water deliveries In MGD
Water deliveries domestic	Number		Domestic water deliveries In MGD
Water deliveries industrial	Number		Industrial water deliveries In MGD
Water deliveries power	Number		Power water deliveries In MGD
Water deliveries public	Number		Public water deliveries In MGD
Water deliveries total	Number		Total water deliveries In MGD
Withdrawal + delivery	Number		Self-supplied withdrawals plus public-supplied deliveries, in MGD

Table 193. -- Components of the input form for project information[1]

Item	Type		Description
Project name	Text		Name of project
Project number	Number	M	Unique account number assigned to the project
Project keyword(s)	Text		Keywords describing the project
Project description	Text		Description of project
Project begin date	Date		Beginning date of project
Project end date	Date		Ending date of project
Project location	Text		General description of project area
Project home office	Ref. List		Home office where project is administered
Fiscal year	Date	M	FY to which this record applies
Funding	Number		Funds available at start of year
Status	Text	M	Current, suspended, completed, etc.
Project chief	Text		Person in charge of project
Project personnel	Ref. List		Names of project personnel
Project cooperator(s)	Ref. List		Cooperator(s) assisting or funding project
Project cooperator(s) contact	Ref. List		Contract person within cooperator agency
Project site	Number		Sampling and measurement sites involved in this project

[1][This table was designed before responsibility for project management tables was shifted away from NWIS-II. It is retained at this time for the Branch of Administrative Management Systems reference only as an indication of what items are desired from AIS, using "project number" as a key. The "project number" item will be permanently retained in NWIS-II]

Table 194. -- Components of the input form for the National Water Quality Assessment study unit purpose and scope.

Item	Type		Description
Unit ID number(s)	Number	M	Number assigned to NAWQA study unit by supervising office
Unit name	Text	M	Name of NAWQA study unit
Account number	Number		Number for cost accounting
Old ID number(s)	Number		Previous NAWQA study unit numbers
Local identifiers	Number		User-defined acronym, name, or number
Study unit purpose	Ref. List	M	Keywords for purpose of project unit, e.g., QW, BIO, SW, toxics, acid precipitation, landfill, surface-mine reclamation.
Narrative description	Text	M	Narrative description of NAWQA study unit purpose, goals, approach.
Begin date	Date	M	Date NAWQA study unit begins
End date	Date		Date NAWQA study unit ends

Table 195. -- Components of the input form for district workload projection.

Item	Type		Description
Projection identifier	Text	M	Fiscal year and sequence number used to identify this District Work Load projection
Project	Number	M	Project account number of project responsible for sample collection
District analysis group	Text		Identifies analyses to be performed by Central Laboratory using "district shorthand" for laboratory schedules
Lab schedule	Ref. List		Identifies analyses to be performed by Central Laboratory using laboratories own lab code ID
District contact	Ref. List		District individual responsible for this individual projection
Narrative	Text		Comments
Event point	Number		Sites and subsites at which samples are to be collected (multiple entries and input from a list allowed)
Sample type	Ref. List		Regular, spike, reference, etc.
Sampling interval/frequency	Ref. List		Monthly, storms, etc.
Cooperator	Ref. List		Cooperating agency, multiple entries allowed
Estimated start date of projection	Date		Date the sampling interval/frequency begins (not necessarily at start of year)

Table 196. -- Components of the input form for data protection initialization and update.

Item	Type	.Description
Person's computer location I.D.	Ref. List	Site codes as used in WRD Directory
Project number	Number	Unique number assigned to the project
Project chief level	Text	Names of personnel assigned these access rights
Project worker level	Text	Names of personnel assigned these access rights
Data reviewer level	Text	Names of personnel assigned these access rights
Project viewer level	Text	Names of personnel assigned these access rights
Restricted directories	Text	Directory names containing restricted data associated with the project

Table 197. -- Components of the input form for data field addition requests[1]

Item	Type	Description
Requesting user	Ref. List	User ID and phone number of requesting individual
Item number	Integer	Integer consecutively assigned to each requested item
Item name	Text	Name of item, limited to 30 characters and spaces
Item type	Ref. List	Allowable types of data items
Description	Text	Definition of item requested
References	Ref. List	Title, author, date, and pages of description source
Importance	Text	Importance of this requested addition to the project and to the rest of the USGS
Date of request	Date	Date request submitted to NWIS-II

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[1] *[User ID may require linkage to the Branch of Administrative Management System's computer system. This table is meant to cover data fields other than parameters, which are covered by NAWDEX updates]*

Table 198.-- Components of the input form for rating a data supplier.

Item	Type		Description
Agency	Ref. List	M	Agency data source
Data operation	Text	M	Keyword for type of data supplied by this operation (multiple entries tied to following repeating group allowed)
URISA Award	Y/N		Has agency competed for a URISA award, or is it meeting that criteria?
Storage Media	Ref. List		Media of data storage from MWDI listing
Meetings	Y/N		Does the agency agree to formal quarterly annual meetings with information managers of both agencies to discuss evaluations and develop long-range plans?
QA Plan	Y/N	M	Does the agency have a formal QA Plan for data supply to the USGS?
Documentation	Y/N		Is agency data-processing operation documented?
Time lag	Number		Processing time lag between input at source agency and availability to USGS, in months
Staff	Number		How many staff people are assigned to this operation?
Technology Plans	Text		What are the agency's long-range technology plans and organizational objectives for the operation supplying data to the USGS.
Rating	Number		Composite score from listed criteria (QA for selecting data partners)

Table 199. -- Components of the input form for algorithm input/edit.

Item	Type		Description
Algorithm identifier	Number	M	Unique ID for algorithm (system can be queried to create new number)
Algorithm description	Text	M	Describes purpose, function
Algorithm formula	Text	M	Mathematical statement of computation to be performed
Algorithm authority	Text	M	Documents source of algorithm
Algorithm comments	Text		Explanation of algorithm
Identifier of algorithm parent	Ref. List		(See Jim Schornick, Water Quality User Group)
Algorithm name	Text	M	Convenient name for ease of ID
Reference document	Ref. List		TWRI, other publications
Start date	Date		Algorithm not to be applied till this date
End date	Date		Discontinue use of algorithm after this date

Table 200. -- Components of the input form for data checks and thresholds.

Item	Type		Description
Data check/alert file identifier	Text	M	Reference name of a group of algorithms or alert limits to be used in verification (system generated)
District	Ref. List	M	Identifies establishing district
Data check/alert file type	Ref. List	M	Category (e.g., acceptance/review/alert) of this data check/alert file
Data check/alert file description	Text	M	Describes function of data check/alert file (e.g., Burlington County Alerts)
Data check description	Text		Brief description of an individual data check
Test identifier	Ref. List	M	Value for this test ID (combination of constituent ID fields and USGS method ID fields) will be tested by the algorithm which is identified (see Ed Pustay)
Algorithm identifier	Ref. List		Points to specific algorithm in algorithm file
Precondition	Text		An algorithm or mathematical statement which must be passed in order for this individual data check to be used (e.g., only if milliequivalent sum of ions is greater than 1)
Data check output message	Text	M	Text to be output to user if value fails the verification check
Comparison operator of data check	Text		Defines relation of data check computation to allowable limit (e.g., ion balance > maximum allowable value)
Critical minimum allowable value	Number		Value less than this fails the alert test, in units dependent on algorithm
Critical maximum allowable value	Number		Value greater than this fails the alert test, in units dependent on algorithm
Alert type identifier	Ref. List	M*	Identifies type of organization or document which established the alert limit (e.g., project, county) (* = only when "Data check/alert file type" is "alert")

VIII. NATIONAL MASTER WATER DATA INDEX INPUT FORMS

The forms in this section describe the entry and edit of site-inventory information into the national Master Water Data Index. Under the "Type" of data, "Ref. List indicates that users will be given a choice of entries from a reference list. A leading "M" under the data "Description'"indicates the field is mandatory.

Table 201. -- Components of the input form for the Master Water Data Index general-inventory data.

Item	Type		Description
Submitting person	Ref. List	M	Person who filled out the input form (paper), or if computer form is the original, the one who is filling out the entry
Submitting agency	Ref. List	M	Agency submitting entry to MWDI
Date	Date	M	Date form filled out

Table 202. -- Components of the input form for the Master Water Data Index site identifier.

Item	Type		Description
Operating organization	Ref. List	M	Agency operating site
Agency office	Ref. List		Office of agency that operates site
Site-identification number	Integer	M	Site-identification number assigned by agency

Table 203. -- Components of the input form for the Master Water Data Index site-identification information.

Item	Type		Description
Latitude	Integer	M	Latitude of site in degrees, minutes, and seconds
Longitude	Integer	M	Longitude of site in degrees, minutes, and seconds
Station Name	Text		Textual name for station
FIPS alpha country code	Ref. List		Keyword identifying Country where site is located
FIPS numeric state code	Ref. List	M	Keyword identifying State where site is located
FIPS numeric county code	Ref. List		Keyword identifying county where site is located
Hydrologic unit code	Ref. List		Keyword identifying hydro-unit where site is located
Congressional district	Ref. List		Keyword identifying congressional district where site is located
Site type	Ref. List	M	Keywords defining type of site
Other site type	Text		Description for an other-type site
Basin description	Ref. List		Up to three keywords describing basin type
Drainage area	Number		Basin drainage area of site
Noncontributing area	Y/N		Is there any noncontributing area to basin?
Primary use of water	Ref. List		Keyword describing primary use of water at site
WRD funded code	Y/N		Is this site funded by WRD?
Begin year	Date		First-year data collected by the agency
Network code	Integer		Up to four codes of four integers
Network name	Text		A name associated with each integer
Purpose of station	Ref. List		Up to four options
Aquifer name(s)	Text		Name for aquifers at a ground-water site
Type of aquifers	Text		Type of aquifer for site

Table 204. -- Components of the input form for test ID for the Master Water Data Index[1]

Item	Type		Description
Parameter name	Text	M	Name of parameter being collected
Test ID	Integer	M	This is the parameter code (USGS); if reporting source does not know, it may be entered by NAWDEX
Year	Date	M	Year data being reported was collected
Storage media	Ref. List	M	How the data are stored by owning agency
Frequency of storage	Ref. List	M	Time interval for storage of data
Frequency of collection	Ref. List	M	How often data are collected at the site
Telemetry equipment used	Ref. List	M	How data are transmitted from site
Sample daily	Y/N		If y, then no calender required, only frequency. If N, then calendar needed for dates of collection
Number of sample	Integer	M	Number of samples taken through year
Calendar	Array		12 by 31 array with days listed for dates sampled collected by organization (either calendar or water year, it is unknown at this time, probably both)
Recorder frequency	Integer		Number of collections per day, if daily collection

[1][Parameter name can include stage, Q, flood hydrograph, tides, cross-section, well construction information, transmissivity, hydraulic conductivity, water quality, and others]

Table 205. -- Components of the input form for updates.[1]

Item	Type		Description
Parameter Name	Text	M	Name of parameter being collected
Parameter ID	Integer	M	This is the parameter code (USGS), may be entered by NAWDEX if reporting source does not know it
Period of update	2 dates	M	Period for which parameter information needs correction
Erase old data	Y/N	M	If Y, then old data replaced by new data, if N, then old data supplemented by the new data
Storage media	Ref. List		How the data are stored by owning agency
Frequency of storage	Ref. List		Time interval for storage of data
Frequency of collection	Ref. List		How often data are collected at the site
telemetry equipment used	Ref. List		How data are transmitted from site
Sample daily	Y/N	M	If Y, no calender required, only frequency. If N, calendar needed for dates of collection
Number of sample	Integer	M	Number of samples taken through year
Calendar	Array		12 by 31 array with days listed for dates sampled collected by organization (either calendar or water year, it is unknown at this time, probably both)
Recorder frequency	Integer		Number of collections per day, if daily collection

[1][Parameter name can include stage, Q, flood hydrograph, tides, cross-section, well construction information, transmissivities, hydraulic conductivity, water quality, and others]

Table 206. -- Components of the input form for the Water Data Sources Directory organization description.

Item	Type		Description
NAWDEX agency	Ref. List	M	Keyword identifier of agency
Name of organization	Text	M	Official name of organization from agency file
NAWDEX membership	Y/N	M	Is organization a member of NAWDEX?
Type of organization	Ref. List	M	Code used to categorize organization
Other type of organization	Text		Entry for category not covered by previous field
Orientation 1	Ref. List	M	Primary orientation of organizational water-related activities
Orientation 2	Ref. List		Secondary orientation of organizational water-related activities
Other orientation	Text		Entry for orientation not cover by previous field
Last update	Date	M	Date of last transaction with WDSD
Directory type	Ref. List	M	Used to retrieve specific types of WDSD information

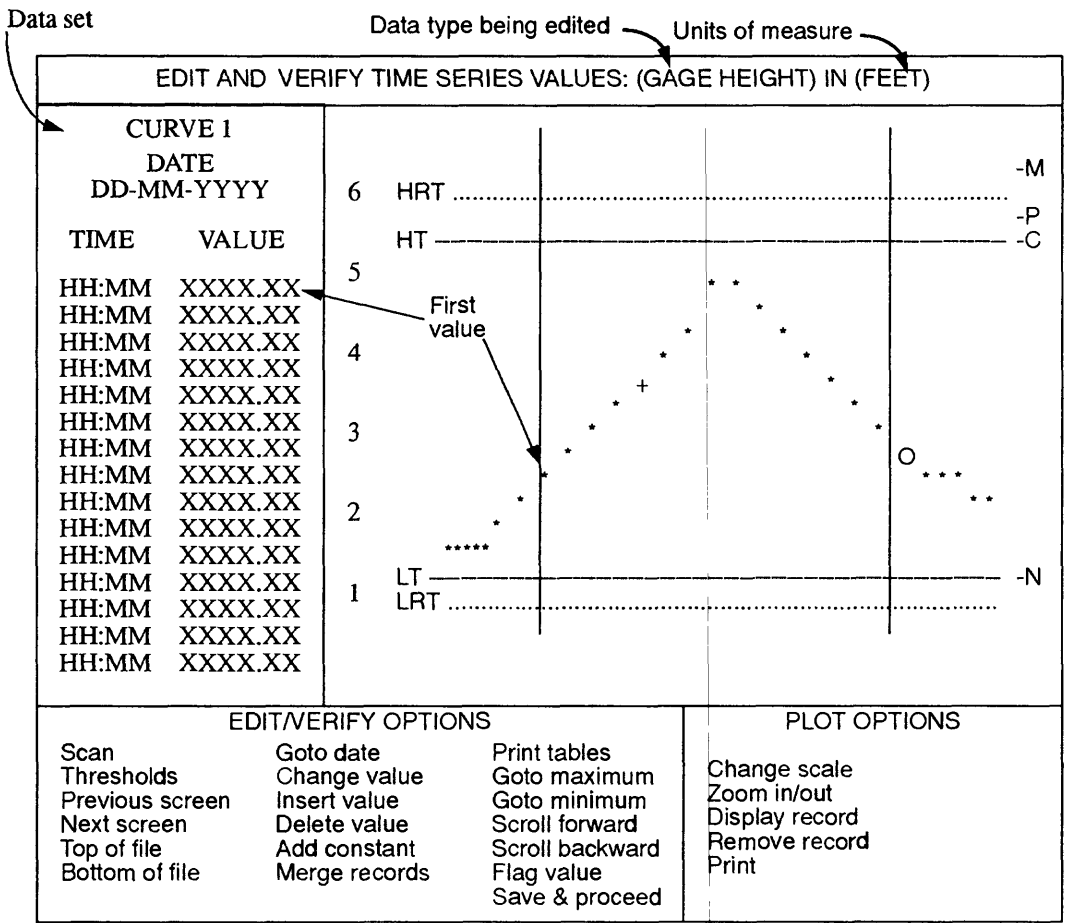
Table 207. -- Components of the input form for the Water Data Sources Directory information about office(s) of an organization.

Item	Type		Description
NAWDEX agency	Ref. List	M	Keyword identifier of agency
Name of organization	Text	M	Official name of organization from agency file
Agency office	Ref. List	M	Local office name, address, telephone
Office contact	Ref. List		Person to contact for information
Office directory type	Ref. List	M	Keyword identifier of type of directory available for retrieval
Office area	Ref. List		Keyword identifier of the geographic area encompassed by the data available from the office
Office requests	Y/N		"Y" if office responds to requests for data, and "N" if it does not
Office media	Ref. List		Keyword identifier of type(s) of media used to store the office's hydrologic data
Office liaison flag	Text		Indicates if the office is a NAWDEX Assistance Center
Office liaison hours	Text		Standardized description of hours of operation of an Assistance Center
Office comments	Text		Comments about the office and its data holdings

As part of the NWIS-II input forms design effort designated by the tables in this appendix, there are other tables being evaluated, incorporated, and prototyped into the existing forms and forms flow. These include additional forms for biology and NAWQA. Electronic versions of these forms were not available at the time of publication.

Appendix D: Input Screens

This appendix contains examples of Input screens for NWIS-II as specified or extracted from each user requirements document. These input screens are used in input of graphical data or in input of repetitive tabled data. The graphical aspect is often a means of quality assurance upon input. Although many examples are shown for stage-discharge continuous data, the examples may be applicable for other data. **The following figures are exhibits to be used by the NWIS-II software designers to develop the actual screens and are intended to be a general guide as to what will be needed on each input screen. The actual look of the input screens shall be decided during design based upon extensive prototyping with the user groups, the type of development system available, and the data base design.**



EXPLANATION:
HRT = High Rating Threshold
LRT = Low Rating Threshold
HT = High Threshold (user-supplied)
LT = Low Threshold (user-supplied)
--M = Max. Stage Indicator
--P = HWM (high-water mark)
--C = CSG (crest-stage-gage peak)
--N = Min. Stage Indicator
O = Observer's Reading
DD-MM-YYYY = day-month-year

Figure 47. -- Conceptualized layout of one parameter time-series editing and verification screen

DATA CORRECTION INPUT/EDIT

WATER YEAR 1990

STATION ID: 09185000
STATION NAME: CLEAR CREEK NR DAYTON, OH.
PARAMETER: GAGE HEIGHT IN FEET

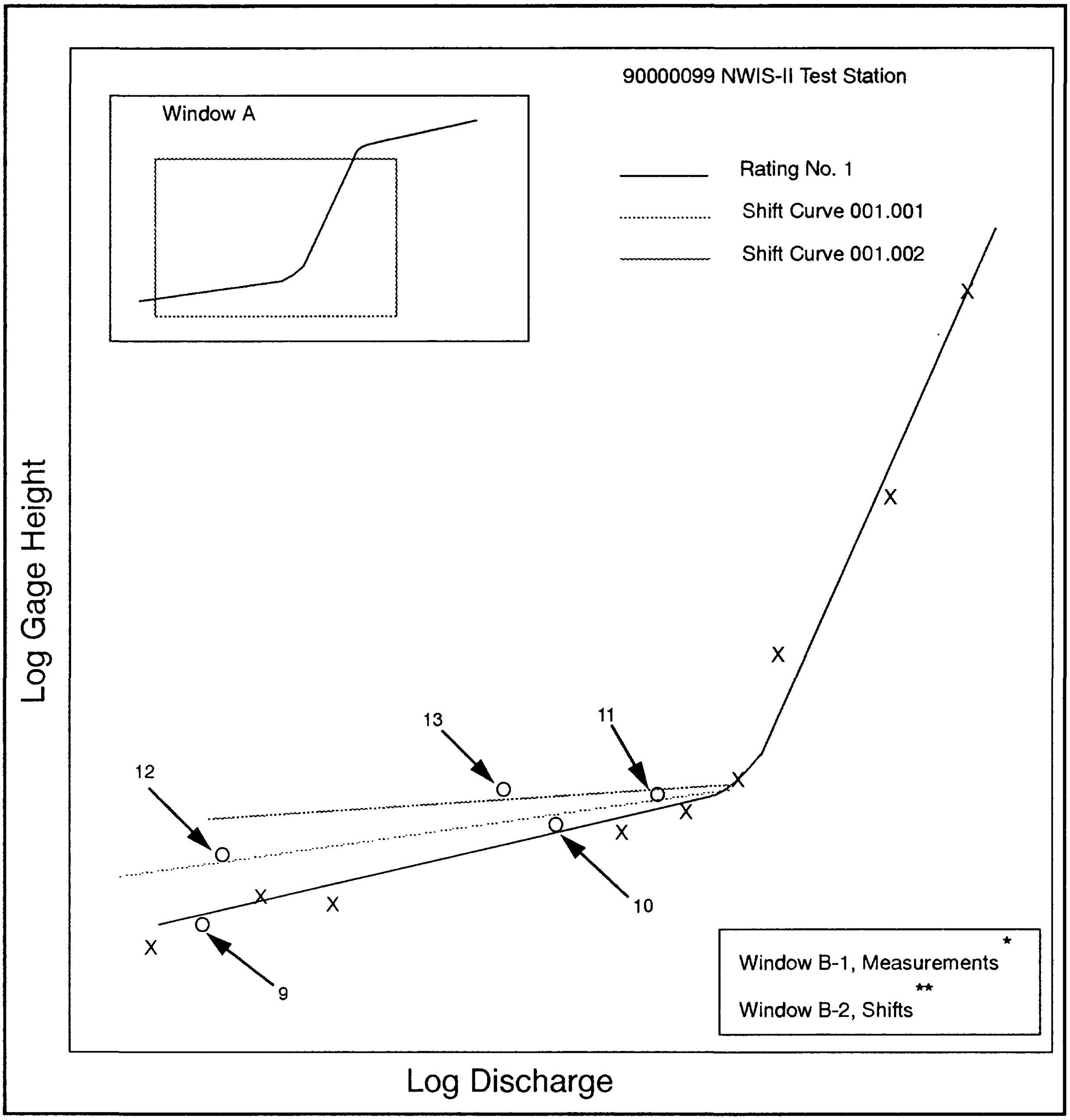
DATE/TIME MM DD HHHH	VALUE	CORR.	VALUE	CORR.	VALUE	CORR.	VALUE	CORR.	VALUE	CORR.
XX XX XXXX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX
XX XX XXXX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX
XX XX XXXX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX
XX XX XXXX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX
XX XX XXXX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX
XX XX XXXX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX
XX XX XXXX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX
XX XX XXXX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX	XXX.XX	XX.XX

Add to end of list	Page forward	Print table
Insert line	Page backward	Exit with no save
Delete line	Up one line	Save and proceed
Change line	Down one line	

Figure 48. -- Suggested data-correction values input/edit screen for gage height

Date/time	Unit value	Defined corr	IG wo/corr	IG w/corr	IG corr	OG wo/corr	OG w/corr	OG corr	Source of gage height
MMDD YR/HHHH	XX.XX	X.XX	XX.XX	XX.XX	X.XX	XX.XX	XX.XX	X.XX	Disch. Meas. (start)
MMDD YR/HHHH	XX.XX	X.XX	XX.XX	XX.XX	X.XX	XX.XX	XX.XX	X.XX	Disch. Meas. (end)
MMDD YR/HHHH	XX.XX	X.XX	XX.XX	XX.XX	X.XX	XX.XX	XX.XX	X.XX	Misc. Reading

Figure 49. -- Suggested screen display for corrections to gage heights



* A reference list will come up on the screen only when requested by the user.
** Figure 51 will come up on the screen only when requested by the user.

Figure 50. -- Suggested screen display for shift-curve analysis

Window B-2, Shifts

Summary Shift Table For Shift Curve 001.002
(Begin MM/DD/YY/TTTT)

Stage	Shift	Stage	Shift	Stage	Shift	Stage	Shift
XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX
XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX
XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX
XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX	XX.XX

A - Add
C - Change
N - Define new shift curve
R - Recall shift curve (XXX.YYY)

D - Delete
E - Exit (No save)

(Linear Interpolation of Shifts Between Table Values)

Figure 51. -- Suggested window of shift-curve descriptor points

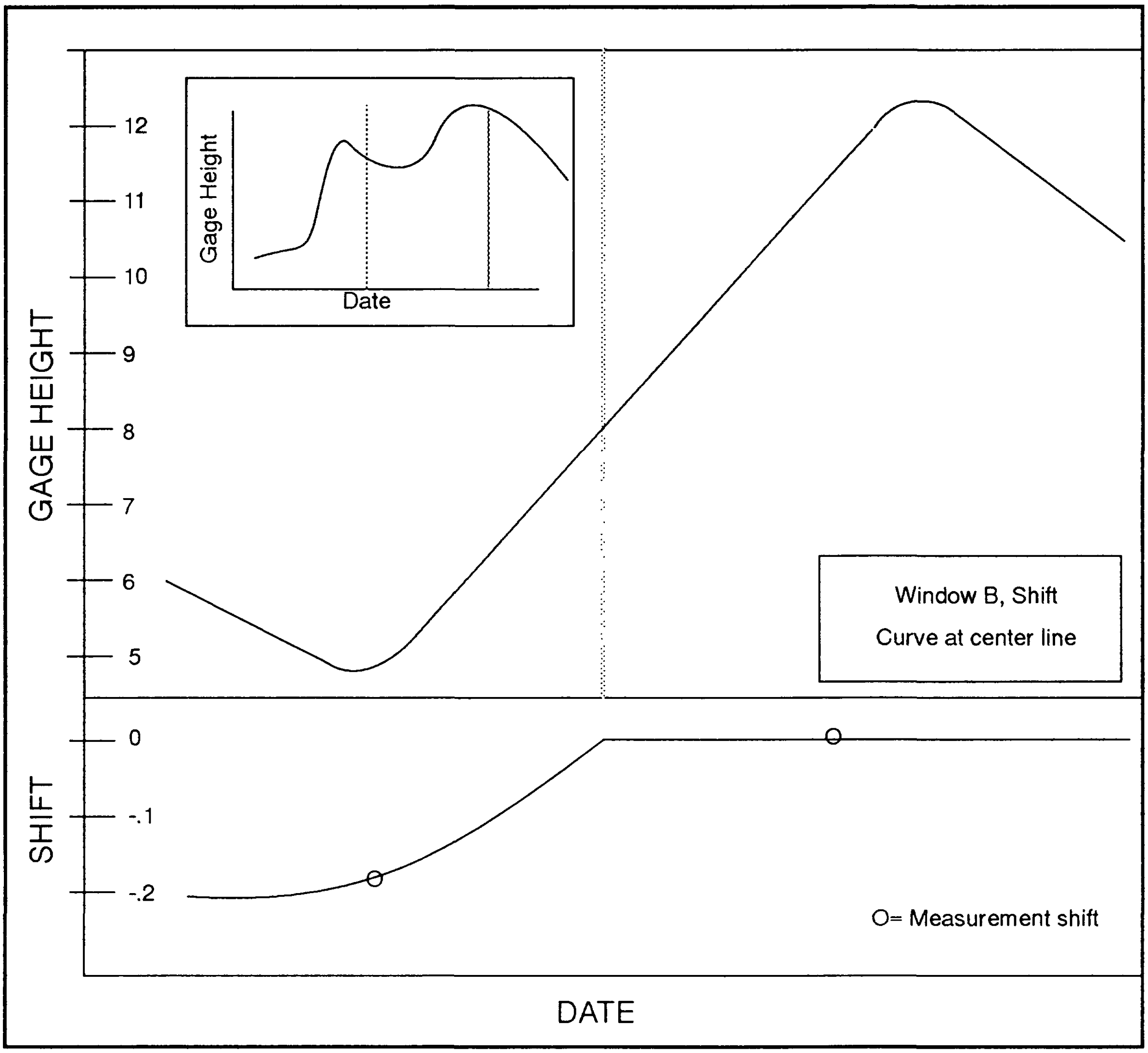


Figure 52. -- Suggested screen display of unit values and corresponding shifts

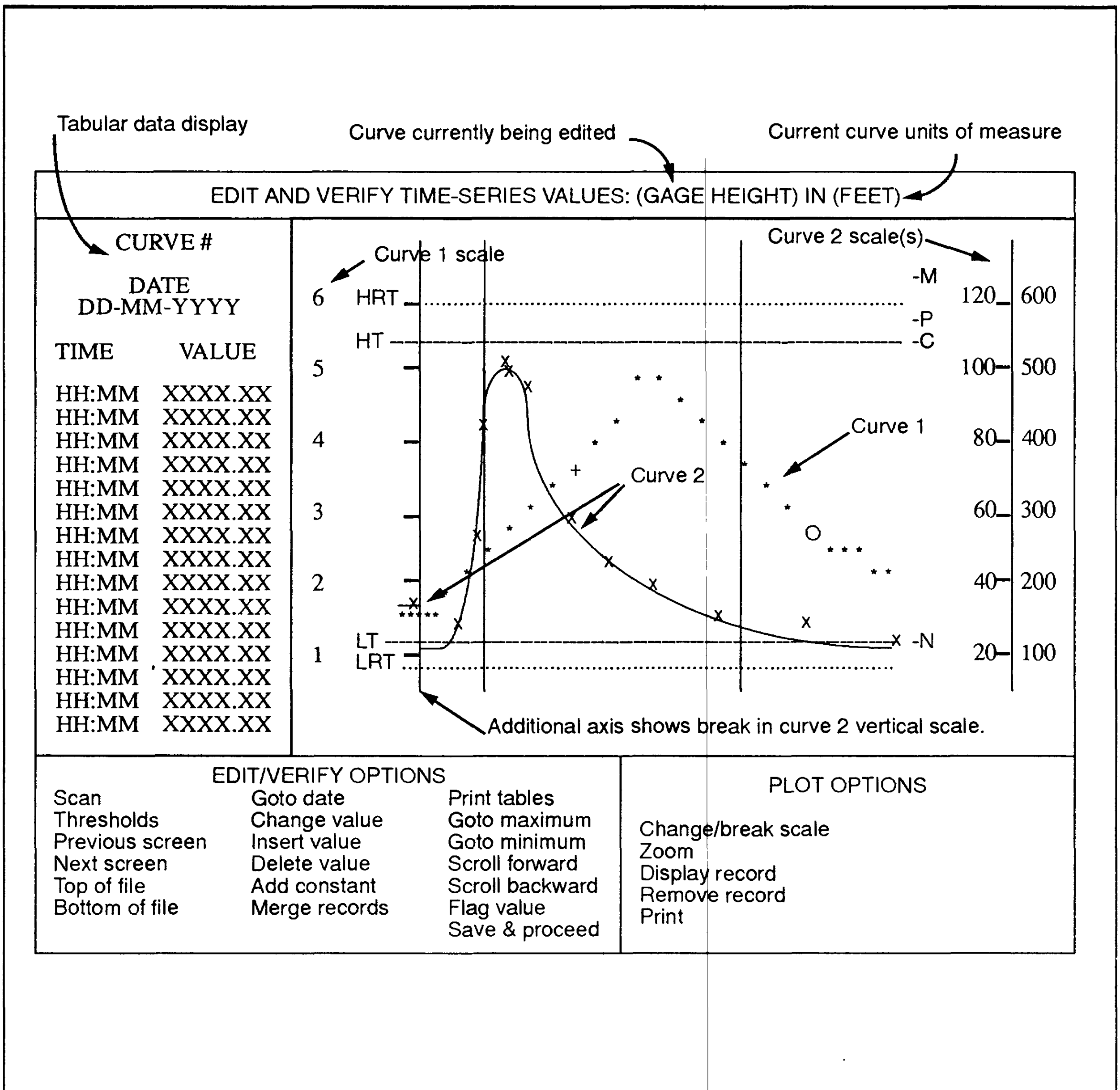
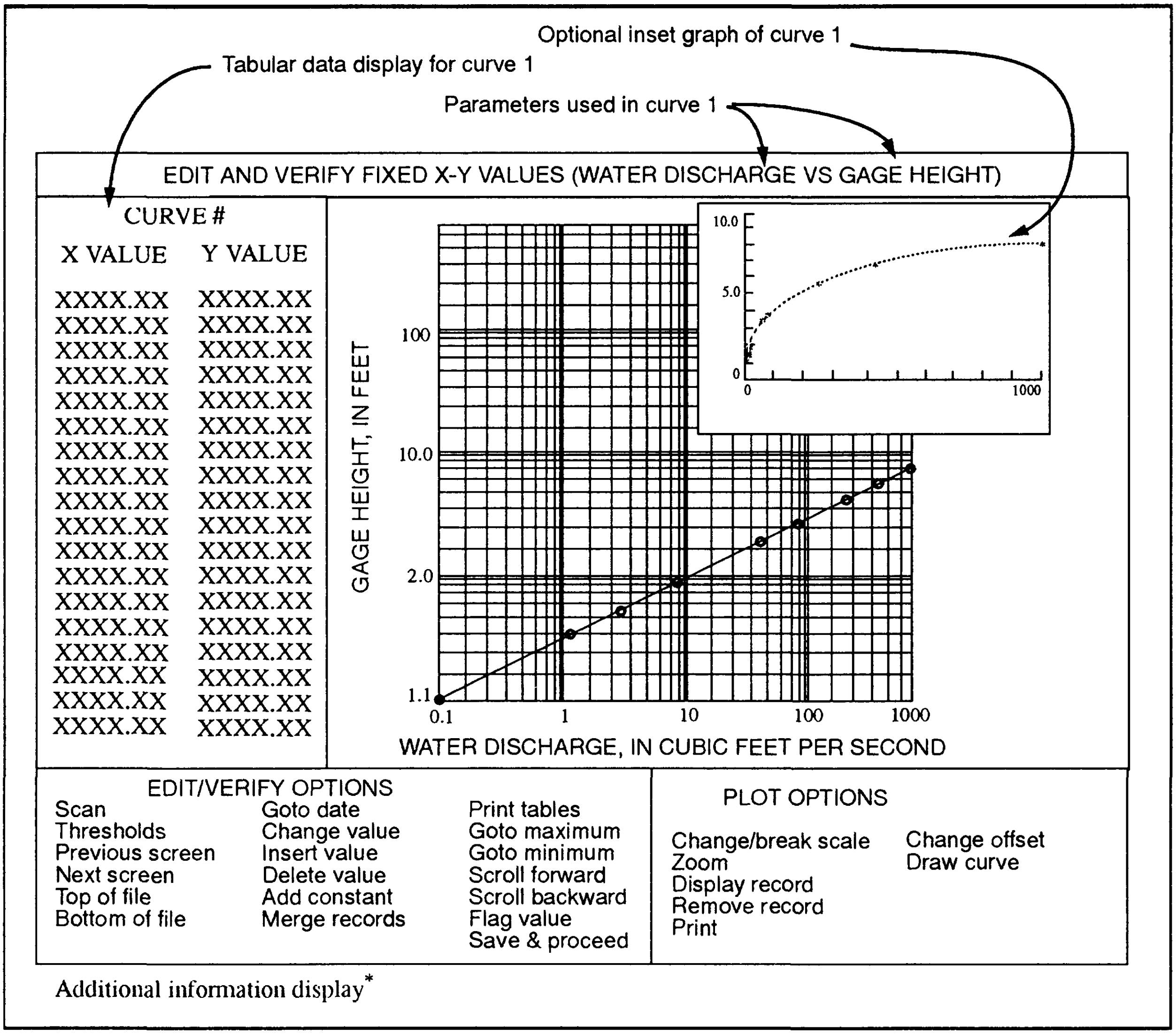


Figure 53. -- Conceptualized layout of fixed X-Y data entry, editing, and verification screenscreen (multiple curves).



*This text box will come up on the screen only when a user requests to see field notes or other information (e.g., attributes of selected X-Y pair) associated with the data.

Figure 54.-- Conceptualized layout of fixed X-Y data entry, editing, and verification screen.

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Appendix E: Unit Conversion Factors

This appendix contains the unit conversion factors to be provided by NWIS-II. These unit conversion factors will be implemented either in the direction as shown or in reverse. Also, there will be the capacity for users to define and store their own unit conversion factors to be implemented on request. The list is not complete but serves as an example of the types of conversion factors that will be added to the system.

Acres

x 43,560.	= $feet^2$
x 4,047.	= $meters^2$
x 1.562×10^{-3}	= $miles^2$
x 4,840.	= $yards^2$

Acre-feet

x 43,560.	= $feet^3$
x 3.259×10^5	= gallons
x 1,233	= $meters^3$

Atmospheres

x 76.0	= centimeters of mercury
x 29.92	= inches of mercury
x 33.9	= feet of water
x 1.033	= kilograms per square centimeter
x 14.70	= pounds per square inch
x 1.058	= ton per square foot
x 101.3	= kilopascal

Bar

x 0.9869	= atmospheres
x 1.0×10^6	= dynes per square centimeter
x 1.02×10^4	= kilograms per square meter
x 2,089.	= pound per square foot
x 14.5	= pounds per square inch
x 100	= kilopascal

Barrels, oil

x 42.	= gallons, oil
x 0.1590	= $meters^3$

British thermal units-Btu

x 0.252	= kilogram-calories
x 777.5	= foot-pounds
x 3.927×10^{-4}	= horsepower-hours
x 107.5	= kilogram-meters
x 2.928×10^{-4}	= kilowatt-hours

British thermal units per minute

x 12.96	= foot-pounds per second
x 0.02356	= horsepower
x 0.01757	= kilowatts
x 17.57	= watts

Centigrams

x 0.01	= grams

Centiliters

x 0.01	= liters

Centimeters

x 0.3937	= inches
x 0.01	= meters
x 10.	= millimeters

Centimeters of mercury

x 0.01316	= atmospheres
x 0.4461	= feet of water
x 136.	= kilograms per square meter
x 27.85	= pounds per square foot
x 0.1934	= pound per square inch

Centimeters per second

x 1.969	= feet per minute
x 0.03281	= feet per second
x 0.036	= kilometers per hour
x 0.6	= meters per minute
x 0.02237	= miles per hour
x 3.728×10^{-4}	= miles per minute

Centimeters per second per second

x 0.03281	= feet per second per second

Cubic centimeters

x 3.531×10^{-5}	= cubic feet
x 6.102×10^{-2}	= cubic inches
x 1.0×10^{-6}	= cubic meters
x 1.308×10^{-6}	= cubic yards
x 2.642×10^{-4}	= gallons
x 1.0×10^{-3}	= liters
x 2.113×10^{-3}	= pints, liquid
x 1.057×10^{-3}	= quarts, liquid

Cubic feet

x 2.832×10^{4}	= cubic centimeters
x 1,728.	= cubic inches
x 0.02832	= cubic meters
x 0.03704	= cubic yards
x 7.48052	= gallons
x 28.32	= liters
x 59.84	= pints, liquid
x 29.92	= quarts, liquid

Cubic feet of water

x 62.35	= pounds

Cubic feet per minute

x 472.	= cubic centimeters per second
x 0.1247	= gallons per second
x 0.472	= liters per second
x 62.4	= pounds of water per minute

Cubic feet per second

x 0.646317	= million gallons per day
x 448.831	= gallons per minute
x 26,928	= U.S. gallons per hour
x 60.	= cubic feet per minute
x 3,600.	= cubic feet per hour
x 86,400.	= cubic feet per day
x 0.9917	= acre-inch per hour
x 1.9835	= acre-feet per day
x 724.	= acre-feet per year
x 50.	= miners inches in Idaho, Kansas, Nebraska, New Mexico, North Dakota, and South Dakota
x 40.	= miners inches in Arizona, California, Montana, and Oregon
x 38.4	= statutory inches in Colorado

Cubic inches

x 16.39	= cubic centimeters
x 5.787×10^{-4}	= cubic feet
x 1.639×10^{-5}	= cubic meters
x 2.143×10^{-5}	= cubic yards
x 4.329×10^{-3}	= gallons
x 1.639×10^{-2}	= liters
x 0.03463	= pints, liquid
x 0.01732	= quarts, liquid

Cubic meters

x 1.0×10^{6}	= cubic centimeters
x 35.31	= cubic feet
x 61,023.	= cubic inches
x 1.308	= cubic yards
x 264.2	= gallons
x 1.0×10^{3}	= liters
x 2,115.	= pints, liquid
x 1,057.	= quarts, liquid

Cubic yards

x 7.646×10^5	= cubic centimeters
x 27.0	= cubic feet
x 46,656.	= cubic inches
x 0.7646	= cubic meters
x 202.	= gallons
x 764.6	= liters
x 1,616.	= pints, liquid
x 807.9	= quarts, liquid

Cubic yards per minute

x 0.45	= cubic feet per second
x 3.367	= gallons per second
x 12.74	= liters per second

Days

x 24.	= hours
x 1,440.	= minutes
x 86,400.	= seconds

Decigrams

x 0.1	= grams

Deciliters

x 0.1	= liters

Decimeters

x 0.1	= meters

Degrees, angular

x 60.	= minutes
x 0.01745	= radians
X 3,600.	= seconds

Degrees per second, angular

x 0.01745	= radians per second
x 0.1667	= revolutions per minute
x 0.002778	= revolutions per second

Dekagrams

x 1.0 x 10	= grams

Dekaliters

x 1.0 x 10	= liters

Dekameters

x 1.0 x 10	= meters

Drams

x 27.34375	= grains
x 0.0625	= ounces
x 1.771845	= grams

Fathoms

x 6.0	= feet

Feet

x 30.48	= centimeters
x 12.0	= inches
x 0.3048	= meters
x 0.333	= yards

Feet of water

x 0.0295	= atmospheres
x 0.8826	= inches of mercury
x 0.03048	= kilograms per square centimeter
x 62.43	= pounds per square foot
x 0.4335	= pounds per square inch

Feet per minute

x 0.5080	= centimeters per second
x 0.01667	= feet per second
x 0.01829	= kilometers per hour
x 0.3048	= meters per minute
x 0.01136	= miles per hour

Feet per second

x 30.48	= centimeters per second
x 1.097	= kilometers per hour
x 0.5921	= knots
x 18.29	= meters per minute
x 0.6818	= miles per hour
x 0.01136	= miles per minute

Feet per second per second

x 30.48	= centimeters per second per second
x 0.3048	= meters per second per second

Foot-pounds

x 1.285×10^{-3}	= British thermal unit
x 5.05×10^{-7}	= horsepower-hours
x 3.24×10^{-4}	= kilogram-calories
x 0.1383	= kilogram-meters
x 3.766×10^{-7}	= kilowatt-hours

Foot-pounds per minute

x 1.285×10^{-3}	= British thermal units per minute
x 0.01667	= foot-pounds per second
x 3.03×10^{-5}	= horsepower
x 3.24×10^{-4}	= kilogram-calories per minute
x 2.260×10^{-5}	= kilowatts

Foot-pounds per second

x 7.717×10^{-2}	= British thermal units per minute
x 1.818×10^{-3}	= horsepower
x 1.945×10^{-2}	= kilogram-calories per minute
x 1.356×10^{-3}	= kilowatts

Gallons

x 3,785.	= cubic centimeters
x 0.1337	= cubic feet
x 231.	= cubic inches
x 3.785×10^{-3}	= cubic meters
x 4.951×10^{-3}	= cubic yards
x 3.785	= liters
x 8.0	= pints, liquid
x 4.0	= quarts, liquid

Gallons, Imperial

x 1.2009	= U.S. gallons

Gallons, U.S.

x 0.83267	= Imperial gallons

Gallons, water

x 8.3453	= pounds of water

Gallons per minute

x 2.228×10^{-3}	= cubic feet per second
x 0.06308	= liters per second
x 8.0208	= cubic feet per hour

Grains, Troy

x 1.0	= grains, avoirdupois
x 0.06480	= grams
x 0.4167	= pennyweights, troy
x 2.0833×10^{-3}	= ounces, troy

Grains per U. S. gallon

x 17.118	= parts per million
x 142.86	= pounds per million gallons

Grains per Imperial gallon

x 14.286	= parts per million

Grams

x 980.7	= dynes
x 15.43	= grains
x 1.0×10^{-3}	= kilograms
x 1.0×10^{3}	= milligrams
x 0.03527	= ounces
x 0.03215	= ounces, troy
x 2.205×10^{-3}	= pounds

Grams per centimeter

x 5.6×10^{-3}	= pounds per inch

Grams per cubic centimeter

x 62. 43	= pounds per cubic foot
x 0.03613	= pounds per cubic inch

Grams per liter

x 58.417	= grains per gallon
x 8.345	= pounds per 1,000 gallons
x 0.062427	= pounds per cubic foot
x 1.0×10^{3}	= parts per million

Hectares

x 1.076×10^5	= square feet

Hectograms

x 1.0×10^2	= grams

Hectoliters

x 1.0×10^2	= liters

Hectometers

x 1.0×10^2	= meters

Hectowatts

x 1.0×10^2	= watts

Horsepower

x 42.44	= British thermal units per minute
x 33,000.	= foot-pounds per minute
x 550.	= foot-pounds per second
x 1,014.	= horsepower, metric
x 10.7	= kilogram-calories per minute
x 0.7457	= kilowatts
x 745.7	= watts

Horsepower, boiler

x 33,479.	= British thermal units per hour
x 9.803	= kilowatts

Horsepower-hours

x 2,547.	= British thermal units
x 1.98×10^6	= foot-pounds
x 641.7	= kilogram-calories
x 2.737×10^5	= kilogram-meters
x 0.7457	= kilowatt-hours

Hours

x 60.	= minutes
x 3,600.	= seconds

Inches

x 2.540	= centimeters

Inches of mercury

x 0.03342	= atmospheres
x 1.133	= feet of water
x 0.03453	= kilograms per square centimeter
x 70.73	= pounds per square foot
x 0.4912	= pounds per square inch

Inches of water

x 0.002458	= atmospheres
x 0.07355	= inches of mercury
x 0.00254	= kilograms per square centimeter
x 0.578	= ounces per square inch
x 5.202	= pounds per square foot
x 0.03613	= pounds per square inch

Kilograms

x 980,665	= dynes
x 2.205	= pounds
x 1.102×10^{-3}	= tons, short
x 1.0×10^{3}	= grams

Kilograms per meter

x 0.672	= pounds per foot

Kilograms per square centimeter

x 0.9678	= atmospheres
x 32.81	= feet of water
x 28.96	= inches of mercury
x 2,048.	= pounds per square foot
x 14.22	= pounds per square inch

Kilograms per square millimeter

x 1.0×10^{6}	= kilograms per square meter

Kiloliters

x 1.0×10^{3}	= liters

Kilometers

x 1.0×10^5	= centimeters
x 3,281.	= feet
x 1.0×10^3	= meters
x 0.6214	= miles
x 1,094.	= yards

Kilometers per hour

x 27.78	= centimeters per second
x 54.68	= feet per minute
x 0.9113	= feet per second
x 0.5396	= knots
x 16.67	= meters per minute
x 0.6214	= miles per hour

Kilometers per hour per second

x 27.78	= centimeters per second per second
x 0.9113	= feet per second per second
x 0.2778	= meter per second per second

Kilowatts

x 56.92	= British thermal units per minute
x 4.425×10^4	= foot-pounds per minute
x 737.6	= foot-pounds per second
x 1.341	= horsepower
x 14.34	= kilogram-calories per minute
x 1.0×10^3	= watts

Kilowatt-hours

x 3,413.	= British thermal units
x 3.656×10^6	= foot-pounds
x 1.341	= horsepower-hours
x 860.	= kilogram-calories
x 3.671×10^5	= kilogram-meters

Knots

x 51.479	= centimeters per second
x 6,080.	= feet per hour
x 1.689	= feet per second
x 1.8532	= kilometers per hour
x 0.515	= meters per second
x 1.0	= miles (nautical) per hour
x 1.152	= miles (statute) per hour

Leagues (U.S. nautical)

x 3,040.	= fathoms
x 18,241.	= feet

Links (engineer or Ramden's)

x 12.	= inches

Links (surveyor's or Gunter's)

x 7.92	=inches

Liters

x 1.0×10^{3}	= cubic centimeters
x 0.0353	= cubic feet
x 61.02	= cubic inches
x 1.0×10^{-3}	= cubic meters
x 1.308×10^{-3}	= cubic yards
x 0.2642	= gallons
x 2.113	= pints, liquid
x 1.057	= quarts, liquid

Liters per minute

x 5.886×10^{-4}	= cubic feet per second
x 4.403×10^{-3}	= gallons per second

Meters

x 1.0×10^{2}	= centimeters
x 3.281	= feet
x 39.37	= inches
x 1.0×10^{-3}	= kilometers
x 1.0×10^{3}	= millimeters
x 1.094	= yards

Meters per minute

x 1.667	= centimeters per second
x 3.281	= feet per minute
x 0.05468	= feet per second
x 0.06	= kilometers per hour
x 0.03728	= miles per hour

Meters per second

x 196.9	= feet per minute
x 3.281	= feet per second
x 3.6	= kilometers per hour
x 0.06	= kilometers per minute
x 2.237	= miles per hour
x 0.03728	= miles per minute

Microns

x 1.0×10^{-6}	= meters

Miles (nautical, International)

x 6,076.115	= feet
x 1,852.	= meters

Miles (statute, U.S.)

x 1.609×10^{5}	= centimeters
x 5,280.	= feet
x 1.609	= kilometers
x 1,760.	= yards

Miles per hour

x 44.7	= centimeters per second
x 88.	= feet per minute
x 1.467	= feet per second
x 1.609	= kilometers per hour
x 0.8684	= knots
x 26.82	= meters per minute

Miles per minute

x 2,682	= centimeters per second
x 88.	= feet per second
x 1.609	= kilometers per minute
x 60.	= miles per hour

Milligrams per liter

x 1.0	= parts per million

Millimeters

x 0.1	= centimeters
x 0.03937	= inches

Miner's inches

x 1.5	= cubic feet per minute (Arizona, California, Montana, and Oregon)

Minutes, angular

x 2.909×10^{-4}	= radians

Ounces

x 16.	= drams
x 437.5	= grains
x 0.0625	= pounds
x 28.349527	= grams
x 0.9115	= ounces, troy
x 2.79×10^{-5}	= tons, long
x 2.835×10^{-5}	= tons, metric

Ounces, troy

x 480.	= grains
x 20.0	= pennyweights, troy
x 0.08333	= pounds, troy
x 31.103481	= grams
x 1.09714	= ounces, avoirdupois

Ounces, fluid

x 1.805	= cubic inches
x 0.02957	= liters

Ounces per square inch

x 0.0625	= pounds per square inch

Parts per million

x 0.0584	= grains per U.S. gallon
x 0.07016	= grains per Imperial gallon
x 8.345	= pound per million gallons
x 0.00136	= tons per acre-foot
x 0.0027	= tons per day

Pounds

x 16.0	= ounces
x 256.	= drams
x 7,000.	= grains
x 0.0005	= tons, short
x 453.5924	= grams
x 1.21528	= pounds, troy
x 14.5833	= ounces, troy

Pounds, troy

x 5,760.	= grains
x 240.	= pennyweights, troy
x 12.0	= ounces, troy
x 373.24177	= grams
x 0.822857	= pounds, avoirdupois
x 13.1657	= ounces, avoirdupois
x 3.6735×10^{-4}	= tons, long
x 4.114×10^{-4}	= tons, short
x 3.7324×10^{-4}	= tons, metric

Pounds of water

x 0.01602	= cubic feet
x 27.68	= cubic inches
x 0.1198	= gallons

Pounds of water per minute

x 2.670×10^{-4}	= cubic feet per second

Pounds per cubic foot

x 0.01602	= grams per cubic centimeter
x 16.02	= kilograms per cubic meter
x 5.787×10^{-4}	= pounds per cubic inch

Pounds per cubic inch

x 27.68	= grams per cubic centimeter
x 2.768×10^{4}	= kilograms per cubic meter
x 1,728.	= pounds per cubic foot

Pounds per foot

x 1.488	= kilograms per meter

Pounds per square foot

x 0.01602	= feet of water
x 4.88×10^{-4}	= kilograms per square centimeter
x 6.94×10^{-3}	= pounds per square inch

Pounds per square inch

x 0.06804	= atmospheres
x 2.307	= feet of water
x 2.036	= inches of mercury
x 0.07031	= kilograms per square centimeter

Quarts, dry

x 67.2	= cubic inches

Quarts, liquid

x 57.75	= cubic inches

Rods

x 16.5	= feet

Square centimeters

x 1.973×10^{5}	= circular miles
x 1.076×10^{-3}	= square feet
x 0.155	= square inches
x 1.0×10^{-4}	= square meters
x 1.0×10^{2}	= square millimeters

Square feet

x 2.296×10^{-5}	= acres
x 929.	= square centimeters
x 144.	= square inches
x 0.0929	= square meters
x 3.587×10^{-8}	= square miles

Square inches

x 1.273×10^{6}	= circular miles
x 6.452	= square centimeters
x 6.94×10^{-3}	= square feet
x 1.0×10^{6}	= square miles
x 645.2	= square millimeters

Square meters

x 2.471×10^{-4}	= acres
x 10.76	= square feet
x 3.861×10^{-7}	= square miles
x 1.196	= square yards

Square miles

x 640.	= acres
x 27.88×10^{6}	= square feet
x 2.59	= square kilometers
x 3.098×10^{6}	= square yards

Square millimeters

x 1.973×10^{3}	= circular miles
x 0.01	= square centimeters
x 1.55×10^{-3}	= square inches

Temperature

Degrees Celsius

+ 273.15	= degrees Kelvin (absolute)
+ 17.78 x 1.8	= degrees Fahrenheit

Degrees Fahrenheit

+ 459.67.	= degrees Rankin (absolute)
- 32. x 0.5556	= degrees Celsius

Tons, long

x 1,016.	= kilograms
x 2,240.	= pounds
x 1.12	= tons, short

Tons, metric

x 1.0×10^{3}	= kilograms
x 2,205.	= pounds

Tons, short

x 2,000.	= pounds
x 32,000.	= ounces
x 907.18486	= kilograms
x 2,430.56	= pounds, troy
x 0.8928	= tons, long
x 29166. 66	= ounces, troy
x 0.90718	= tons, metric

Tons of water per 24 hours

x 83.333	= pounds of water per hour
x 0.16643	= gallons per minute
x 1.3349	= cubic feet per hour

Yards

x 91.44	= centimeters
x 3.0	= feet
x 36.	= inches

Watts

x 0.0569	= British thermal units per minute
x 44.26	= foot-pounds per minute
x 0.7376	= foot-pounds per second
x 1.341×10^{-3}	= horsepower
x 0.0143	= kilogram-calories per minute
x 1.0×10^{-3}	= kilowatts

Watt-hours

x 3.41	= British thermal units
x 2,656.	= foot-pounds
x 1.341×10^{-3}	= horsepower-hours
x 0.8605	= kilogram-calories
x 367.	= kilogram-meters
x 1.0×10^{-3}	= kilowatt-hours

CONVERSION FACTORS: Milligrams per liter xF_1=milliequivalents per liter; milligrams per liter xF_2=millimoles per liter (based on 1975 atomic weights, referred to carbon-12) (Hem, 1985):

Element and reported species	F1	F2
Aluminum (A^{3+})	0.11119	0.03715
Ammonium (NH_4^+)	.05544	.05544
Antimony (Sb)		.00821
Arsenic (As)		.01334
Barium (Ba^{2+})	.01456	.00728
Bicarbonate ($HC0_3^-$)	.01639	.01639
Boron (B)		.09250
Bromide (Br^-)	.01251	.01252
Cadmium (Cd^{2+}	.01779	.00890
Calcium (Ca^{2+})	.04990	.02495
Carbonate ($C0_3^{2-}$)	.03333	.01666
Cesium (Cs^+)	.00752	.00752
Chloride (Cl^-)	.02821	.02821
Chromium (Cr)		.01923
Cobalt (Co^{2+})	.03394	.01697
Copper (Cu^{2+})	.03147	.01574
Fluoride (F^-)	.05264	.05264
Hydrogen (H^+)	.99216	.99216
Hydroxide (OH^-)	.05880	.05880
Iodide (I^-)	.00788	.00788
Iron (Fe^{2+})	.03581	.01791
Iron (Fe^{3+})	.05372	.01791
Lead (Pb^{2+})	.00965	.00683
Lithium (Li^+)	.14407	.14407
Magnesium (Mg^{2+})	.08229	.04114
Manganese (Mn^{2+})	.03640	.01820
Mercury (Hg)		.00499
Molybdenum (Mo)		.01042
Nickel (Ni)		.01704
Nitrate ($N0_3^-$)	.01613	
Nitrate ($N0_2^-$	.02174	.02174
Phosphate (PO_4^{3+})	.03159	.01053
Potassium (K^+)	.02558	.02558
Rubidium (Rb^+)	.01170	.01170
Selenium (Se)		.01266
Silica ($Si0_2$)		.01664
Silver (Ag^+)	.00927	.00927
Sodium (Na^+)	.04350	.04350
Strontium (Sr^{2+})	.02283	.01141
Sulfate ($S0_4^{2-}$)	.02082	.01041
Sulfide (S^{2-})	.06238	.03119
Thorium (Th)		.00431
Titanium (Ti)		.02088
Uranium (U)		.00420
Vanadium (V)		.01963
Zinc (Zn^{2+})	.03059	

CONVERSION FACTORS FOR CHEMICAL CONSTITUENTS

To convert	To	Multiply by
Ca	$CaCO_3$	2.497
$CaCl_2$	$CaCO_3$	0.9018
HCO_3	$CaCO_3$	0.8202
HCO_3	CO_3	0.49174
Mg	$CaCO_3$	4.116
$MgCl_2$	$CaCO_3$	1.051
Na_2CO_3	$CaCO_3$	0.9442
Fe^{3+}	H_2SO_4	2.634
NO_3^-	N	0.2259
N	NO_3^-	4.4266

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Appendix F: Algorithms for Computed Parameters

This appendix contains examples of the algorithms used to calculate parameters that describe various physical and chemical characteristics of water, climatological characteristics, and aggregated water-use. Calculated parameters are parameters that need one or more other parameter values to compute. Each calculated parameter is followed by the algorithm used, usually a condition that must be satisfied, and a list of required parameters. In the algorithm description, each constant has a decimal point, and any five-digit number without a decimal point is a parameter code for a data value to be used in the computation. Standard mathematical symbols are used to denote addition (+), subtraction (-), multiplication (x), and division (/). Natural logarithms are denoted by ln. Unions are denoted by $L \cup R$ where the parameter used in the algorithm can be either *L*, the preferred operand, or *R*. an optional operand to be used if the value of *L* is not available. If there is a series of OR statements, the operand furthest to the left is the value preferred, and if not the left operand, then the first right operand, then the next right operand, and so on until a value that satisfies the algorithm is found.

NOTE: Some of the algorithms listed in this appendix are labeled with an X variable, i.e., X1, X2, X3 — X12. These are used to break up the algorithm into more manageable blocks for calculation or, if a part of an equation was repeated, to save repetition of the same part of the algorithm.

PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER

00301 - OXYGEN DISSOLVED (PERCENT OF SATURATION)

$$X1 = 10^{(8.107648849 - (\frac{1750.285888672}{235.0 - 00010}))}$$

$$X2 = \frac{00010 + 273.149902344}{100}$$

$$X3 = 143.348266602\,(ln\,(X2)) - 21.849197388\,(X2) + 173.429199219 + \frac{249.633880615}{X2}$$

$$X4 = (5.57199955 \times 0.0001 \times 00095) + (2.019999027 \times 0.000000001 \times 00095^2)$$

$$X5 = 0.014258998\,(X2) - 0.033095993 - 00017\,(X2^2)$$

$$X6 = (\frac{00025 - X1}{760 - X1}) \times 1.42759907 \times 2.718281746^{X3 + ((X4 \times X5) \cup 0.0)}$$

$$00301 = (\frac{00300}{X6}) \times 100$$

IF (00301 < 0) THEN 00301 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00300	TEMPERATURE, WATER	degrees C
00025	BAROMETRIC PRESSURE	mm of Hg
00010	SPECIFIC CONDUCTANCE	μs/cm @ 25 C
00095	OXYGEN, DISSOLVED (DO)	mg/L as O

00435 - ACIDITY, TOTAL (mg/L AS $CaCO_3$)

00435 = 71825 X 0.99216 X 50.05

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
71825	ACIDITY, TOTAL, HEATED	mg/L as H

00540 - SOLIDS, NONVOLATILE ON IGNITION, SUSPENDED (mg/L)

00540 = 00530 - 00535

IF (00540 < 0) THEN 00540 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00530	RESIDUE, TOTAL NONFILTERABLE	mg/L
00535	RESIDUE, VOLATILE NONFILTERABLE	mg/L

00600 - NITROGEN, TOTAL (mg/L AS N)

00600 = 00625 + 00630

IF (00600 < 0) THEN 00600 - 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00625	NITROGEN, AMMONIA PLUS ORGANIC, TOTAL	mg/L as N
00630	NITROGEN, NITRITE PLUS NITRATE, TOTAL	mg/L as N

00602 - NITROGEN, DISSOLVED (mg/L AS N)

00602 = 00623 + 00631

IF (00602 < 0) THEN 00602 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00623	NITROGEN, AMMONIA PLUS ORGANIC, DISSOLVED	mg/L as N
00631	NITROGEN, NITRITE PLUS NITRATE, DISSOLVED	mg/L as N

00605 - NITROGEN, ORGANIC, TOTAL (mg/L AS N)

00605 = 00625 - 00610

IF (00605 < 0) THEN 00605 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00625	NITROGEN, AMMONIA PLUS ORGANIC, TOTAL	mg/L as N
00610	NITROGEN, NITRITE PLUS NITRATE, TOTAL	mg/L as N

00607 - NITROGEN, ORGANIC, DISSOLVED (mg/L AS N)

00607 = 00623 - 00608

IF (00607 < 0) THEN 00607 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00623	NITROGEN, AMMONIA PLUS ORGANIC, DISSOLVED	mg/L as N
00608	NITROGEN, AMMONIA, DISSLOVED	mg/L as N

00618 - NITROGEN, NITRATE, DISSOLVED (mg/L AS N)

00618 = 00631 - 00613

IF (00618 < 0) THEN 00618 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00631	NITROGEN, NITRITE PLUS NITRATE, DISSOLVED	mg/L as N
00613	NITROGEN, NITRITE, DISSOLVED	mg/L as N

00620 - NITROGEN, NITRATE, TOTAL (mg/L AS N)

00620 = 00630 - 00615

IF (00620 < 0) THEN 00620 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00630	NITROGEN, NITRITE PLUS NITRATE, TOTAL	mg/L as N
00615	NITROGEN, NITRATE, TOTAL	mg/L as N

00621 - NITROGEN, NITRATE, TOTAL IN BOTTOM MATERIAL (mg/kg AS N)

00621 = 00633 - 00616

IF (00621 < 0) THEN 00621 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00633	NITROGEN, NITRITE PLUS NITRATE, TOTAL IN BM, DRY WT	mg/kg as N
00616	NITROGEN, NITRITE, TOTAL IN BM, DRY WT	mg/kg as N

00650 - PHOSPHATE, TOTAL (mg/L AS PO_4)

00650 = 70507 x 3.06618

IF (00650 < 0) THEN 00650 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
70507	PHOSPHOROUS, ORTHOPHOSPHATE, TOTAL	mg/L as P

00660 - PHOSPHATE, ORTHO, DISSOLVED (mg/L AS PO_4)

00660 = 00671 x 3.06618

IF (00660 < 0) THEN 00660 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00671	PHOSPHOROUS, ORTHOPHOSPHATE, DISSOLVED	mg/L as P

00669 - PHOSPHORUS, HYDROLYZABLE, TOTAL (mg/L AS P)

00669 = 00678 - 70507

IF (00669 < 0) THEN 00669 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00678	PHOSPHOROUS, HYDROLYZABLE + ORTHOPHOSPHATE, TOTAL	mg/L as P
70507	PHOSPHOROUS, ORTHOPHOSPHATE, TOTAL	mg/L as P

00670 - PHOSPHORUS, ORGANIC, TOTAL (mg/L AS P)

00670 = 00665 - $(06678 \cup (70507 + 00669))$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00665	PHOSPHOROUS, TOTAL	mg/L as P
00669	PHOSPHOROUS, HYDROLYZABLE, TOTAL	mg/L as P
00678	PHOSPHOROUS, HYDROLYZABLE + ORTHOPHOSPHATE, TOTAL	mg/L as P
70507	PHOSPHOROUS, ORTHOPHOSPHATE, TOTAL	mg/L as P

00672 - PHOSPHORUS, HYDROLYZABLE, DISSOLVED (mg/L AS P)

00672 = 00677 - 00671

IF (00672 < 0) THEN 00672 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00671	PHOSPHOROUS, ORTHOPHOSPHATE, DISSOLVED	mg/L as P
00677	PHOSPHOROUS, HYDROLYZABLE + ORTHOPHOSPHATE, DISSOLVED	mg/L as P

00673 - PHOSPHORUS, ORGANIC, DISSOLVED (mg/L AS P)

$00673 = 00666 - (00677 \cup (00672 + 00671))$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00666	PHOSPHOROUS, DISSOLVED	mg/L as P
00671	PHOSPHOROUS, ORTHOPHOSPHATE, DISSOLVED	mg/L as P
00677	PHOSPHOROUS, HYDROLYZABLE + ORTHOPHOSPHATE, DISSOLVED	mg/L as P
00672	PHOSPHOROUS, HYDROLYZABLE, DISSOLVED	mg/L as P

00687 - CARBON, ORGANIC, TOTAL IN BOTTOM MATERIAL, DRY WEIGHT (gm/kg)

00687 = 00693 - 00686

IF (00687 < 0) THEN 00687 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00686	CARBON, INORGANIC, BOTTOM MATERIAL	gm/kg as C
00693	CARBON, INORGANIC + ORGANIC, TOTAL IN BM, DRY WEIGHT	gm/kg as C

00690 - CARBON, TOTAL (mg/L AS C)

00690 = 00685 + 00680

IF (00690 < 0) THEN 00690 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00680	CARBON, ORGANIC, TOTAL	mg/L as C
00685	CARBON, INORGANIC, TOTAL	mg/L as C

00900 - HARDNESS, TOTAL (Mmg/L AS $CaCO_3$)

$X1 = ((01005 \times 0.00001456) \cup 0.0) + ((01080 \times 0.00002283) \cup 0.0)$

00900 = ((00915 x 0.0499) + (00925 x 0.08229) + X1) x 50.05

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00915	CALCIUM, DISSOLVED	mg/L as Ca
00925	MAGNESIUM, DISSOLVED	mg/Las Mg
01005	BARIUM, DISSOLVED	μg/L as Ba
01080	STRONTIUM, DISSOLVED	μg/L as Sr

00902 - NONCARBONATE HARDNESS, WATER, WHOLE, TOTAL, FIELD (mg/L AS $CaCO_3$)

$$X1 = 0.0499\,(00916 \cup 00918) + 0.08229\ldots(00927 \cup 00921) + (0.00002283\,(01082 \cup 01084))$$

$$X2 = ((01007 \cup 01009) \times 0.00001456) \cup 0.0$$

$$X3 = (00450 \cup 00440 \cup 99440) + (((00447 \cup 00445 \cup 99445) \times 0.03333) \cup 0.0002)$$

$$X4 = \frac{00419 \cup 00410 \cup 29813 \cup 99430 \cup 00431}{50.05}$$

$$00902 = (X1 + X2 - (X3 \cup X4)) \times 50.05$$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00916	CALCUIM, TOTAL, RECOVERABLE	mg/L as Ca
00918	CALCUIM, TOTAL, RECOVERABLE	mg/L
00927	MAGNESIUM, TOTAL	mg/L as Mg
00921	MAGNESIUM, TOTAL, RECOVERABLE	mg/L as Mg
00450	BICARBONATE, WATER, WHOLE, INCREMENTAL TITRATION, FIELD	mg/L as HCO_3
00440	BICARBONATE, WATER, WHOLE, FIXED ENDPOINT TITRATION, FIELD	mg/L as HCO_3
99440	BICARBONATE, INCREMENTAL TITRATION, FIELD	mg/L as HCO_3
00447	CARBONATE, WATER, WHOLE, INCREMENTAL TITRATION, FIELD	mg/L as CO_3
00445	CARBONATE, WATER, WHOLE, FIXED ENDPOINT TITRATION, FIELD	mg/L as CO_3
99445	CARBONATE, INCREMENTAL TITRATION, FIELD	mg/L as CO_3
00419	ALKALINITY, WATER, WHOLE,TOTAL, INCREMENTAL TITRATION, FIELD	mg/L as $CaCO_3$
00410	ALKALINITY, WATER, WHOLE,TOTAL, FIXED ENDPOINT TITRATION, FIELD	mg/L as $CaCO_3$
29813	ALKALINITY, WATER, WHOLE, GRAN TITRATION, FIELD	mg/L as $CaCO_3$
99430	ALKALINITY, CARBONATE INCREMENTAL TITRATION, FIELD	mg/L as $CaCO_3$
00431	ALKALINITY	mg/L as $CaCO_3$
01082	STRONTIUM, TOTAL	μg/L as Sr
01084	STRONTIUM, TOTAL, RECOVERABLE IN WATER	μg/L as Sr
01007	BARIUM, TOTAL	μg/L as Ba
01009	BARIUM, TOTAL, RECOVERABLE	μg/L as Ba

00903 - NONCARBONATE HARDNESS, WATER, WHOLE, TOTAL, LAB (mg/L AS $CaCO_3$)

$$X1 = 0.0499\,(00916 \cup 00918) + 0.08229\ldots(00927 \cup 00921) + (0.00002283\,(01082 \cup 01084))$$

$$X2 = ((01007 \cup 01009) \times 0.00001456) \cup 0.0$$

$$X3 = (00449 \cup 00451 \cup 90440 \cup 95440) \times 0.01639$$

$$X4 = ((00446 \cup 00448 \cup 90445 \cup 95445) \times 0.03333) \cup 0.0002$$

$$X5 = \frac{00416 \cup 00417 \cup 00413 \cup 00418 \cup 00421 \cup 90410 \cup 90430 \cup 95410 \cup 95430}{50.05}$$

$$00903 = (X1 + X2 - ((X3 + X4) \cup X5)) \times 50.05$$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00916	CALCIUM, TOTAL, RECOVERABLE	mg/L as Ca
00918	CALCIUM, TOTAL, RECOVERABLE	mg/L
00927	MAGNESIUM, TOTAL	mg/L as Mg
00921	MAGNESIUM, TOTAL,RECOVERABLE	mg/L
00449	BICARBONATE, WATER, WHOLE, INCREMENTAL TITRATION, LAB	mg/L as HCO_3
00451	BICARBONATE, WATER, WHOLE, FIXED ENDPOINT TITRATION, LAB	mg/L as HCO_3
00440	BICARBONATE, INCREMENTAL TITRATION, LAB	mg/L as HCO_3
95440	BICARBONATE, TITRATION TO PH 4.5, LAB	mg/L as HCO_3
00446	CARBONATE, WATER, WHOLE, INCREMENTAL TITRATION, LAB	mg/L as CO_3
00448	CARBONATE, WATER, WHOLE, FIXED ENDPOINT TITRATION, LAB	mg/L as CO_3
90445	CARBONATE, INCREMENTAL TITRATION, LAB	mg/L as CO_3
95445	CARBONATE, TITRATION TO PH 8.3, LAB	mg/L as CO_3
00416	ALKALINITY, WATER, WHOLE, TOTAL, INCREMEMTAL TITRATION, LAB	mg/L as $CaCO_3$
00417	ALKALINITY, WATER, WHOLE, TOTAL, FIXED ENDPOINT TITRATION ,LAB	mg/L as $CaCO_3$
00413	ALKALINITY, WATER, WHOLE, GRAN TITRATION	mg/L as $CaCO_3$
00418	ALKALINITY, WATER, DISSOLVED, TOTAL,FIXED ENDPOINT TITRATION, FIELD	mg/L as $CaCO_3$
00421	ALKALINITY, WATER, DISSOLVED, TOTAL FIXED ENDPOINT TITRATION, FIELD	mg/L as $CaCO_3$
90410	ALKALINITY, TITRATION TO PH 4.5, LAB	mg/L as $CaCO_3$
90430	ALKALINITY, CARBONATE INCREMENTAL TITRATION, LAB	mg/L as $CaCO_3$
95410	ALKALINITY, TITRATION TO PH 4.5, LAB	mg/L as $CaCO_3$

95430	ALKALINITY, CARBONATE FIXED-PH ENDPOINT TITRATION, LAB	mg/L as $CaCO_3$
01082	STRONTIUM, TOTAL	μg/L as Sr
01084	· STRONTIUM, TOTAL, RECOVERABLE IN WATER	μg/L as Sr
01007	BARIUM, TOTAL	μg/L as Ba
01009	BARIUM, TOTAL, RECOVERABLE	μg/L as Ba

00904 - HARDNESS, NON-CARBONATE, WATER, DISSOLVED, FIELD, (mg/L AS $CaCO_3$)

$$X1 = (00915 \times 0.0499) + (00925 \times 0.08229\ldots)$$

$$X2 = ((1080 \times 0.00002283) \cup 0.0) + ((01005 \times 0.00001456) \cup 0.0)$$

$$X3 = ((00453 \cup 29804) \times 0.01639) + (((00452 \cup 29807) \times 0.03333) \cup 0.0002)$$

$$X4 = \frac{39086 \cup 39036 \cup 29802}{50.05}$$

$$00904 = (X1 + X2 - (X3 \cup X4)) \times 50.05$$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00915	CALCIUM, DISSOLVED	mg/L as Ca
00925	MAGNESIUM, DISSOLVED	mg/L as Mg
00453	BICARBONATE, WATER, DISSOLVED, INCREMENTAL TITRATION, FIELD	mg/L as HCO_3
29804	BICARBONATE, WATER, DISSOLVED, FIXED ENDPOINT TITRATION, FIELD	mg/L as HCO_3
00452	CARBONATE, WATER, DISSOLVED, INCREMENTAL TITRATION, FIELD	mg/L as CO_3
29807	CARBONATE, WATER, DISSOLVED, FIXED ENDPOINT TITRATION, FIELD	mg/L as CO_3
39086	BICARBONATE, WATER, DISSOLVED, INCREMENTAL TITRATION, LAB	mg/L as HCO_3
39036	ALKANLINITY, WATER, DISSOLVED, FIXED ENDPOINT, FIELD	mg/L as $CaCO_3$
29802	ALKANLINITY, WATER, DISSOLVED, GRAN TITRATION, FIELD	mg/L as $CaCO_3$
01080	STRONTIUM, DISSOLVED	μg/L as Sr
01005	BARIUM, DISSOLVED	μg/L as Ba

00905 - HARDNESS, NON-CARBONATE, WATER, DISSOLVED, LABORATORY, (mg/L AS $CaCO_3$)

$$X1 = (00915 \times 0.0499) + (00925 \times 0.08229\ldots)$$

$$X2 = ((1080 \times 0.00002283) \cup 0.0) + ((01005 \times 0.00001456) \cup 0.0)$$

$$X3 = ((29806 \cup 29805) \times 0.01639) + (((29809 \cup 29808) \times 0.03333) \cup 0.0002)$$

$$X4 = \frac{39087 \cup 29801 \cup 29803}{50.05}$$

$$00905 = (X1 + X2 - (X3 \cup X4)) \times 50.05$$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNIT
00915	CALCIUM, DISSOLVED	mg/L as Ca
00925	MAGNESIUM, DISSOLVED	mg/L as Mg
29806	BICARBONATE, WATER, DISSOLVED, INCREMENTAL TITRATION, LAB	mg/L as HCO_3
29805	BICARBONATE, WATER, DISSOLVED, FIXED ENDPOINT TITRATION, LAB	mg/L as HCO_3
29809	CARBONATE, WATER, DISSOLVED, INCREMENTAL TITRATION, LAB	mg/L as CO_3
29808	CARBONATE, WATER, DISSOLVED, FIXED ENDPOINT TITRATION, LAB	mg/L as CO_3
39087	ALKANLINITY, WATER, DISSOLVED, TOTAL, INCREMENTAL TITRATION, LAB	mg/L as $CaCO_3$
29801	ALKANLINITY, WATER, DISSOLVED, FIXED ENDPOINT TITRATION, LAB	mg/L as $CaCO_3$
29803	ALKANLINITY, WATER, DISSOLVED, GRAN TITRATION, LAB	mg/L as $CaCO_3$
01080	STRONTIUM, DISSOLVED	μg/L as Sr
01005	BARIUM, DISSOLVED	μg/L as Ba

00931 - SODIUM ADSORPTION RATIO

$$00931 = \frac{(00930 \times 0.0435)}{(((00915 \times 0.0499) + (00925 \times 0.08229...))/2)^{0.5}}$$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00915	CALCIUM, DISSOLVED	mg/L as Ca
00925	MAGNESIUM, DISSOLVED	mg/L as Mg
00930	SODIUM, DISSOLVED	mg/L as Na

00932 - SODIUM, PERCENT

$$00932 = \frac{100\,(00930 \times 0.0435)}{(00915 \times 0.0499) + (00925 \times 0.08229...) + (00930 \times 0.043500) + (00935 \times 0.02558)}$$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00915	CALCIUM, DISSOLVED	mg/L as Ca
00925	MAGNESIUM, DISSOLVED	mg/L as Mg
00930	SODIUM, DISSOLVED	mg/L as Na
00935	POTASSIUM, DISSOLVED	mg/L as K

70301 - SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)

$X1 = 0.4917 \times (99440 \cup 00440 \cup 90440 \cup 95440 \cup 00450 \cup 00453 \cup 29804 \cup 0.0)$

$X2 = 99445 \cup 00445 \cup 90445 \cup 95445 \cup 00447 \cup 00452 \cup 29807 \cup 0.0002$

$X3 = 0.59959\,(00410 \cup 90410 \cup 00419 \cup 29802 \cup 29813 \cup 39806 \cup 39036 \cup 99430 \cup 00431 \cup 0.($

$X4 = 00915 + 00925 + 00930 + 00935 + 00940 + 00945 + (00955 \cup 0.0)$

$X5 = (00631 \times 4.42660000) \cup ((00618 \times 4.4266) + (00613 \times 3.28619957)) \cup 0.0$

$X6 = ((00608 \times 1.28799761) \cup 0.0) + ((00671 \times 3.06618) \cup 0.0)$

$X7 = (71870 \cup 0.0) + (00746 \cup 0.0) + (00723 \cup 0.0) + (71830 \cup 0.0) + ((71865 \cup 0.0) + (00950 \cup 0.0)$

$X8 = (01000 \cup 0.0) + (01005 \cup 0.0) + (01010 \cup 0.0) + (01020 \cup 0.0) + ((01025 \cup 0.0) + (01030 \cup 0.0)$

$X9 = (01035 \cup 0.0) + (01040 \cup 0.0) + (01046 \cup 0.0) + (01049 \cup 0.0) + ((01056 \cup 0.0) + (01060 \cup 0.0)$

$X10 = (01065 \cup 0.0) + (01075 \cup 0.0) + (01080 \cup 0.0) + (01085 \cup 0.0) + ((01090 \cup 0.0) + (01100 \cup 0.0)$

$X11 = (01106 \cup 0.0) + (01120 \cup 0.0) + (01125 \cup 0.0) + (01130 \cup 0.0) + ((01135 \cup 0.0) + (01145 \cup 0.0)$

$X12 = (01150 \cup 0.0) + (01160 \cup 0.0) + (71890 \cup 0.0)$

$70301 = ((X1 + X2) \cup X3) + X4 + X5 + X6 + X7 + (0.001\,(X8 + X9 + X10 + X11 + X12))$

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
99440	BICARBONATE, INCREMENTAL TITRATION, FIELD	mg/L as HCO_3
00440	BICARBONATE, WATER, WHOLE, FIXED ENDPOINT TITRATION, FIELD	mg/L as HCO_3
90440	BICARBONATE, INCREMENTAL TITRATION, LAB	mg/L as HCO_3
95440	BICARBONATE, TITRATION TO PH 4.5, LAB	mg/L as HCO_3
00450	BICARBONATE, WATER, WHOLE, INCREMENTAL TITRATION, FIELD	mg/L as HCO_3
00453	BICARBONATE, WATER, DISSOLVED, INCREMENTAL TITRATION, FIELD	mg/L as HCO_3
29804	BICARBONATE, WATER, DISSOLVED, FIXED ENDPOINT TITRATION, FIELD	mg/L as HCO_3
00410	ALKALINITY, WATER, WHOLE, TOTAL, FIXED ENDPOINT TITRATION, FIELD	mg/L as $CaCO_3$
90410	ALKALINITY, TITRATION TO PH 4.5, LAB	mg/L as $CaCO_3$
00419	ALKALINITY, WATER, WHOLE, TOTAL, INCREMENTAL TITRATION, FIELD	mg/L as $CaCO_3$
29802	ALKALINITY, WATER, DISSOLVED, GRANS TITRATION, FIELD	mg/L as $CaCO_3$
29813	ALKALINITY, WATER, WHOLE, GRANS TITRATION, FIELD	mg/L as $CaCO_3$
39036	ALKALINITY, WATER, DISSOLVED, FIXED ENDPOINT TITRATION, FIELD	mg/L as $CaCO_3$

39086	BICARBONATE, WATER, DISSOLVED, INCREMENTAL TITRATION, FIELD	mg/L as $CaCO_3$
99430	ALKALINITY, CARBONATE, INCREMENTAL TITRATION, FIELD	mg/L as $CaCO_3$
00431	ALKALINITY	mg/L as $CaCO_3$
00915	CALCIUM, DISSOLVED	mg/L as Ca
00925	MAGNESIUM, DISSOLVED	mg/L as Mg
00930	SODIUM, DISSOLVED	mg/L as Na
00935	POTASSIUM, DISSOLVED	mg/L as K
00940	CHLORIDE, DISSOLVED	mg/L as Cl
00945	SULFATE, DISSOLVED	mg/L as SO_4
99445	CARBONATE, INCREMENTAL TITRATION, FIELD	mg/L as CO_3
00445	CARBONATE, WATER, WHOLE, FIXED ENDPOINT TITRATION, FIELD	mg/L as CO_3
90445	CARBONATE, INCREMENTAL TITRATION, LAB	mg/L as CO_3
95445	CARBONATE, TITRATION TO PH 8.3, LAB	mg/L as CO_3
00447	CARBONATE, WATER, WHOLE, INCREMENTAL TITRATION, FIELD	mg/L as CO_3
00452	CARBONATE, WATER, DISSOLVED, INCREMENTAL TITRATION, FIELD	mg/L as CO_3
29807	CARBONATE, WATER, DISSOLVED, FIXED ENDPOINT TITRATION, FIELD	mg/L as CO_3
00955	SILICA, DISSOLVED	mg/L as Si
00631	NITROGEN, NITRITE PLUS NITRATE, DISSOLVED	mg/L as N
00618	NITROGEN, NITRATE, DISSOLVED	mg/L as N
00613	NITROGEN, NITRITE, DISSOLVED	mg/L as N
00608	NITROGEN, AMMONIA, DISSOLVED	mg/L as N
71870	BROMIDE, DISSOLVED	mg/L as Br
00723	CYANIDE, DISSOLVED	mg/L as Cn
71830	HYDROXIDE ION	mg/L as OH
71865	IODIDE, DISSOLVED	mg/L as I
00950	FLUORIDE, DISSOLVED	mg/L as F
00671	PHOSPHOROUS, ORTHOPHOSPHATE, DISSOLVED	mg/L as P
01000	ARSENIC, DISSOLVED	μg/L as As
01005	BARIUM, DISSOLVED	μg/L as Ba
01010	BERYLLIUM, DISSOLVED	μg/L as Be
01020	BORON, DISSOLVED	μg/L as B
01025	CADMIUM, DISSOLVED	μg/L as Cd
01030	CHROMIUM, DISSOLVED	μg/L as Cr
01035	COBALT, DISSOLVED	μg/L as Co
01040	COPPER, DISSOLVED	μg/L as Cu
01046	IRON, DISSOLVED	μg/L as Fe
01049	LEAD, DISSOLVED	μg/L as Pb
01056	MANGANESE, DISSOLVED	μg/L as Mn
01060	MOLYBDENUM, DISSOLVED	μg/L as Mo
01065	NICKEL, DISSOLVED	μg/L as Ni
01075	SILVER, DISSOLVED	μg/L as Ag
01080	STRONTIUM, DISSOLVED	μg/L as Sr
01085	VANADIUM, DISSOLVED	μg/L as V
01090	ZINC, DISSOLVED	μg L as Zn
01100	TIN, DISSOLVED	μg/L as Sn
01106	ALUMINUM, DISSOLVED	μg/L as Al
01120	GALLIUM, DISSOLVED	μg/L as Ga
01125	GERMANIUM, DISSOLVED	μg/L as Ge
01130	LITHIUM, DISSOLVED	μg/L as Li
01135	RUBIDIUM, DISSOLVED	μg/L as Rb
01145	SELENIUM, DISSOLVED	μg/Las Se
01150	TITANIUM, DISSOLVED	μg/L as Ti
01160	ZIRCONIUM, DISSOLVED	μg/L as Zr
71890	MERCURY, DISSOLVED	μg/L as Hg

70302 - SOLIDS, DISSOLVED (TONS PER DAY)

70302 = ((70300 ∪ 70301) x (00061 ∪ 00060)) x 0.0027

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
70300	SOLIDS, RESIDUE ON EVAPORATION AT 180 C, DISSOLVED	mg/L
70301	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED	mg/L
00060	DISCHARGE	cubic feet per second
00061	DISCHARGE, INSTANTANEOUS	cubic feet per second

70303 - SOLIDS, DISSOLVED (TONS PER ACRE-FOOT)

70303 = (70300 ∪ 70301) x 0.00136

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
70300	SOLIDS, RESIDUE ON EVAPORATION AT 180 C, DISSOLVED	mg/L
70301	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED	mg/L

70949 - BIOMASS-CHLOROPHYLL RATIO, PLANKTON (UNITS)

70949 = ((81354 - 81353) x 1000.0) / 70953

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
81354	PLANKTON, BIOMASS, DRY WIEGHT	mg/L
81353	PLANKTON, BIOMASS, ASH WIEGHT	mg/L
70953	CHLOROPHYLL-A, PHYTO-PLANKTON, CHROMOTOGRAPHIC/FLUOROMETRIC	μg/L

70950 - BIOMASS-CHLOROPHYLL RATIO, PERIPHYTON (UNITS)

70950 = ((00573 - 00572) x 1000.0) / 70957

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00573	PERIPHYTON, BIOMASS, DRY WIEGHT	g/m^2
00572	PERIPHYTON, BIOMASS, ASH WIEGHT	g/m^2
70957	CHLOROPHYLL-A, PERIPHYTON, CHROMOTOGRAPHIC/FLUOROMETRIC	mg/m^2

71845 - NITROGEN, AMMONIA, TOTAL (mg/L AS NH_4)

71845 = 00610 x 1.2878

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00610	NITROGEN, AMMONIA, TOTAL	mg/L as N

71846 - NITROGEN, AMMONIA, DISSOLVED (mg/L AS NH_4)

71846 = 00608 x 1.2878

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00608	NITROGEN, AMMONIA, DISSOLVED	mg/L as N

71851 - NITROGEN, NITRATE, DISSOLVED (mg/L AS NO_3)

71851 = (00631 - 00613) x 4.4266

IF (71851 < 0) THEN 71851 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00631	NITROGEN, NITRITE PLUS NITRATE, DISSOLVED	mg/L as N
00613	NITROGEN, NITRITE, DISSOLVED	mg/L as N

71856 - NITROGEN, NITRITE, DISSOLVED (mg/L AS NO_2)

71856 = 00613 x 3.28619957

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
00613	NITROGEN, NITRITE, DISSOLVED	mg/L as N

71887 - NITROGEN, TOTAL (mg/L AS NO_3)

71887 = (00625 + 00630) x 4.4266

IF (71887 < 0) THEN 71887 = 0

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNIT
00625	NITROGEN, AMMONIA PLUS ORGANIC, TOTAL	mg/L as N
00630	NITROGEN, NITRITE PLUS NITRATE, TOTAL	mg/L as N

80155 - SEDIMENT DISCHARGE, SUSPENDED (TONS/DAY)

80155 = 80154 x $(00061 \cup 00060)$ x 0.0027

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
80154	SEDIMENT, SUSPENDED, CONCENTRATION	mg/L
00061	DISCHARGE, INSTANTANEOUS	cubic feet per second
00060	DISCHARGE	cubic feet per second

80156 - SEDIMENT DISCHARGE, TOTAL, SUSPENDED PLUS BED MATERIAL (TONS/DAY)

80156 = 80180 x $(00061 \cup 00060)$ x 0.0027

PARAMETERS REQUIRED FOR CALCULATION

CODE	NAME	UNITS
80180	SEDIMENT, TOTAL, CONCENTRATION	mg/L
00061	DISCHARGE, INSTANTANEOUS	cubic feet per second
00060	DISCHARGE	cubic feet per second

AGGREGATED WATER-USE PARAMETERS

The following is a list of the aggregated water-use parameters and an associated index number. The right-most column shows the algorithm in terms of index numbers, to use for the calculated parameters.

Record parameter	Index number	Algorithm
Total population	2	
PUBLIC SUPPLY:		
Population served:		
Ground water	3	
Surface water	4	
Total	5	3+4
Water withdrawals: Fresh		
Ground water	6	
Surface water	7	
Total fresh	8	6+7
Water withdrawals: Saline		
Ground water	9	
Surface water	10	
Total saline	11	9+10
Water withdrawals: Total		
Total total	12	6+7+9+10
Water deliveries:		
Public use and losses	13	12-21-30-44-57
Total deliveries	14	13+21+30+44+57
Per capita use:		
Total, Gal/d	15	12 x 1000. /5
Number of facilities:		
In state	16	
Water-use database	17	
COMMERCIAL:		
Self-supplied withdrawals:		
Ground water	18	
Surface water	19	
Total	20	18+19
Deliveries from water supply:		
Fresh	21	
Total:		
Withdrawals + deliveries	22	18+19+21
Consumptive use:	23	
DOMESTIC: SELF SUPPLIED		
Population:		
Thousands	24	2-5
Water withdrawals:		
Ground water	25	
Surface water	26	
Total	27	25+26
Per capita use:		
Gal/d	28	(25+26)1000. /24

DOMESTIC: PUBLIC SUPPLIED		
Population:		
Thousands	29	5
Deliveries from water supply:		
Fresh	30	
Per capita use:		
Gal/d	31	30 x 1000. /29
DOMESTIC: TOTAL		
Withdrawals and deliveries:	32	25+26+30
Consumptive use:	33	
INDUSTRIAL:		
Self-supplied withdrawals:		
Ground water, fresh	34	
Ground water, saline	35	
Ground water, total	36	34+35
Surface water, fresh	37	
Surface water, saline	38	
Surface water, total	39	37+38
Total, fresh	40	34+37
Total, saline	41	35+38
Total, total	42	34+35+37+38
Reclaimed Sewage	43	
Deliveries from water supply:		
Fresh	44	
Total: Withdrawal and deliveries		
Fresh	45	40+44
Total: Consumptive use		
Fresh	46	
Saline	47	
Total	48	46+47
Number of facilities:		
In state	49	
In water-use database	50	
THERMOELECTRIC POWER (ELECTRIC):		
All thermoelectric water use:		
Ground water, fresh	51	65+79+87
Surface water, fresh	52	66+88
Surface water, saline	53	67+89
Surface water, total	54	66+67+88+89
Total, fresh	55	65+66+79+87+88
Total, total	56	65+66+67+79+80+87+88+89
Deliveries from water supply:		
Fresh	57	71+93
Total: Withdrawal and deliveries		
Fresh	58	65+66+71+79+87+88+93
Total: Consumptive use		
Fresh	59	73+82+95
Saline	60	74+83+96
Total	61	73+74+82+83+95+96
Total power generated:		
Gigawatt-hours/year	62	76+84+98
Number of facilities:		
In state	63	77+85+99
In water-use database	64	78+86+100

THERMOELECTRIC POWER (ELECTRIC), FOSSIL FUEL:		
Fossil Fuel: Withdrawals		
Ground water, fresh	65	
Surface water, fresh	66	
Surface water, saline	67	
Surface water, total	68	66+67
Total, fresh	69	65+66
Total	70	65+66+67
Deliveries from water supply:		
Fresh	71	
Total: Withdrawal and deliveries		
Fresh	72	69+71
Total: Consumptive use		
Fresh	73	
Saline	74	
Total	75	73+74
Power generation:		
Gigawatt-hours/year	76	
Number of facilities:		
In state	77	
In water-use database	78	
THERMOELECTRIC POWER (ELECTRIC), GEOTHERMAL:		
Geothermal: Withdrawals		
Ground water, fresh	79	
Ground water, saline	80	
Total	81	79+80
Geothermal: Consumptive use:		
Fresh	82	
Saline	83	
Power generation:		
Gigawatt-hours/year	84	
Number of facilities:		
In state	85	
In water-use database	86	
THERMOELECTRIC POWER (ELECTRIC), NUCLEAR:		
Nuclear: Withdrawals		
Ground water, fresh	87	
Surface water, fresh	88	
Surface water, saline	89	
Surface water, total	90	88+89
Total, fresh	91	87+88
Total, total	92	87+88+89
Deliveries from water supply:		
Fresh	93	
Total: Withdrawal and deliveries		
Fresh	94	87+88+93
Total: Consumptive use		
Fresh	95	
Saline	96	
Total	97	95+96
Power generation:		
Gigawatt-hours/year	98	
Number of facilities:		
In state	99	
In water-use database	100	

MINING:		
Withdrawals:		
Ground water, fresh	101	
Ground water, saline	102	
Ground water, total	103	101+102
Surface water, fresh	104	
Surface water, saline	105	
Surface water, total	106	104+105
Total:		
Total, fresh	107	101+104
Total, saline	108	102+105
Total, total	109	101+102+104+105
Consumptive Use:		
Fresh	110	
Saline	111	
Total	112	110+111
LIVESTOCK:		
Stock: Withdrawals		
Ground water	113	
Surface water	114	
Total	115	113+114
Stock: Consumptive use	116	
Animal specialties: Withdrawals		
Ground water	117	
Surface water	118	
Total	119	117+118
Animal specialties: Consumptive use	120	
Total livestock: Withdrawals		
Ground water	121	113+117
Surface water	122	114+118
Total	123	113+114+117+118
Total livestock: Consumptive use	124	
IRRIGATION:		
Withdrawals:		
Ground water, fresh	125	
Surface water, fresh	126	
Reclaimed sewage	127	
Total, fresh	128	125+126
Irrigated land, type, in acres:		
Spray	129	
Flood	130	
Total	131	129+130
Conveyance losses:		
Total	132	
Consumptive use:	133	
HYDROELECTRIC POWER:		
Water use:		
Total		134
Power generation:		
Gigawatt-hours/year	135	
Number of facilities:		
In state	136	
In water-use database	137	
SEWAGE TREATMENT:		

Number of facilities:		
Public	138	
Industrial + other	139	
Total number	140	138+139
Returns from municipal systems:	141	
Number of facilities:		
In water-use database	142	
Reclaimed wastewater from a public waste-water facility	143	
RESERVOIR EVAPORATION:		
Evaporation loss, in 1000. acre-feet/year:		
Fresh	144	
Reservoir area, 100. acres:	145	
TOTALS:		
Ground water, fresh	146	6+18+25+34+65+79+87+101+113+117+125
Ground water, saline	147	9+35+80+102
Ground water, total	148	6+9+18+25+34+35+65+79+80+87+101+102+113+117+125
Surface water, fresh	149	7+19+26+37+66+88+104+114+118+126
Surface water, saline	150	10+38+67+89+105
Surface water, total	151	7+10+19+26+37+38+66+67+88+89+104+105+114+118+126
Total, fresh	152	8+20+27+40+69+79+91+107+115+119+128
Total, saline	153	11+41+67+80+89+108
Total, total	154	8+11+20+27+40+41+67+69+79+80+89+91+107+108+115+119+128
Reclaimed sewage	155	43+127
Consumptive use, fresh	156	23+33+46+73+82+95+110+116+120+133+144
Consumptive use, saline	157	47+74+83+96+111
Consumptive use, total	158	23+33+46+47+73+74+82+83+95+96+110+111+116+120+133+144
Conveyance losses	159	132

Other calculated elements that are not stored in the data base, but are calculated during certain retrievals.

Record parameter	Index number	Algorithm
COMMERCIAL	169	23 x 100. / 22
DOMESTIC	170	33 x 100. / 32
INDUSTRY - Fresh	171	46 x 100. / 45
INDUSTRY - Saline	172	47 x 100. / 41
INDUSTRY - Total	173	48 x 100. / (41+45)
MINING - Fresh	174	110 x 100. / 107
MINING - Saline	175	111 x 100. / 108
MINING - Total	176	112 x 100. / 109
LIVESTOCK -Total	177	124 x 100. / 123
LIVESTOCK - Stock	178	116 x 100. / 115
LIVESTOCK - Animal Specialties	179	120 x 100. / 119
TOTAL WATER USE - Fresh	180	156 x 100. / 152
TOTAL WATER USE - Saline	181	157 x 100. / 153
TOTAL WATER USE - Total	182	158 x 100. / 154
TOTAL THERMOELECTRIC - Fresh	183	59 x 100. / 58
TOTAL TERMOELECTRIC - Saline	184	60 x 100. / 53
TOTAL THERMOELECTRIC - Total	185	61 x 100. / (58+53)
FOSSIL FUEL - Fresh	186	73 x 100. / 72
FOSSIL FUEL - Saline	187	74 X 100. / 67
FOSSIL FUEL - Total	188	75 x 100. / (67+72)
GEOTHERMAL - Fresh	189	82 x 100. / 79
GEOTHERMAL - Saline	190	83 x 100. / 80
GEOTHERMAL - Total	191	(82+83) 100. / 81
NUCLEAR - Fresh	192	95 x 100. / 94
NUCLEAR - Saline	193	96 x 100. / 89
NUCLEAR - Total	194	97 x 100. / (89+94)
IRRIGATION	195	133 x 100. / 128
Percentage of domestic population self-supplied	196	24 x 100. / 2
THERMOELECTRIC: Water used to produce 1 Megawatt-hour	197	56 x 365. / 62 / 1000.
HYDROELECTRIC: Water used to produce 1 Megawatt-hour	198	134 x 365. / 135 / 1000.
Inches of water used to irrigate one acre	199	(128 x 1.121)12.0 / 131
Irrigation conveyance loss, in percent	200	132 x 100. / 128
PUBLIC WASTEWATER: Average withdrawal for a facility	201	141 / 138
INDUSTRIAL: Average withdrawal for a facility	202	42 / 49
THERMOELECTRIC: Average withdrawal for a facility	203	56 / 63
HYDROELECTRIC: Average withdrawal for a facility	204	134 / 136

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Appendix G: System-Defined Reference Lists

This appendix contains lists of system-defined reference lists used in verification and entry of data to NWIS-II as specified or extracted from each user requirements document. These lists are preliminary and changes or additions to these lists are probable. Section 5.1.3.1, Chapter 3, describes functionality of system-defined reference lists.

System-defined reference lists will become tables in the NWIS-II Data Dictionary, and only the NWIS staff in headquarters will be able to add to or change these tables. District users' requests to add entries to the lists must be approved at headquarters. Section 5.1.3.1, Chapter 3, describes functionality of user requests for additions to reference lists. Each user reference-list addition request will include the following:

Name of person requesting new entry to reference list
Office of person requesting new entry to reference list
Date of new entry to reference list

I. GENERAL INFORMATION REFERENCE LISTS

1. Item types
2. Personnel
3. Federal, State, and local agencies
4. Federal, State, and local agencies' offices
5. Data reliability
6. Experience of personnel. This list will be the responsibility of AIS.

II. SITE INFORMATION REFERENCE LISTS

A. GENERAL

1. NWIS site types
2. Source of site information
3. FIPS country identifications
4. FIPS U.S. State identifications
5. USGS, WRD district identifications
6. FIPS U.S. county identifications
7. WRD hydrologic unit
8. U.S. congressional district identifications
9. Network sites data use
10. Topographic setting of site
11. Latitude/longitude accuracy
12. Eco-regions
13. Geologic units
14. Physiographic provinces
15. Soil types
16. Miscellaneous site information types
17. Miscellaneous site information locations
18. Miscellaneous site information format
19. Material for conveyance pipe or well casing

B. GROUND-WATER TYPE FEATURES

1. Type of ground-water feature
2. Aquifer type of ground-water well
3. Method of construction of ground-water wells
4. Method of finishing ground-water wells
5. Method of development of ground-water wells
6. Special treatment for ground-water wells

7. Types of openings for ground-water wells
8. Types of materials for openings for ground-water wells
9. Types of fill materials used in ground-water wells
10. Types of lifts for ground-water wells
11. Types of lift power of ground-water wells
12. Nature of repair of ground-water wells

C. SPRING-TYPE SITES

1. Type of springs
2. Basis for variability of springs
3. Spring's improvements
4. Permanence of springs
5. Receptor types

D. WATER-USE TYPE SITES

1. Integrating SIC codes
2. Water-use categories
3. Sewage treatment facility classification
4. Size-indicator units for water-use facilities
5. Fixture/amenity types and their coefficients
6. Water-use facility institutional categories
7. Permit activity status options
8. Water-use permit type
9. Water-use facility type of change
10. Storage content of open bodies of water
11. Permit category
12. Possible reuse purposes
13. Type of power generation
14. Subcategories of fossil-fueled power plants

E. WATER-CONVEYANCE TYPE SITE

1. Conveyance types
2. Conveyance or reservoir use
3. Conveyance channel bottom material

F. STREAM-TYPE SITE

1. River reaches

III. SITE EVENT REFERENCE LISTS

A. GENERAL

1. Purpose of site visit
2. Site event type
3. Site event point-location type
4. Hydrologic conditions
5. Hydrologic events
6. Meteorologic conditions
7. Range of land-use observations
8. Land-use identifiers
9. Land-use local features
10. Land-use tract irrigation methods
11. Water source
12. Land-use extent of irrigation
13. Habitat identifications
14. Facility maintenance types

B. MEASUREMENT

1. Constituent identifier (part of extended constituent identifier system)
2. U.S. Environmental Protection Agency (EPA) parameter codes
3. Volume-amount units
4. Flow-rate units
5. Totalizer reading status
6. Sample medium or matrix
7. Sample matrix, first qualifier
8. Sample matrix, second qualifier
9. Biota tissue identifier
10. Phase qualifier
11. Weight-basis qualifier identifier
12. Matrix type
13. Filter/particle size
14. Analyte recovery identifier
15. Field laboratory computation identifier
16. Reporting form identifier
17. Reporting units
18. General physical/chemical grouping
19. Specific chemical/physical grouping
20. Method identifier
21. Remark codes
22. Security codes
23. Constituent value record
24. Method class code (or method type code)
25. Method use code (analytical method use code)
26. Analysis status (SMS)

27. Analysis source (SMS)
28. Add/delete/field/rerun code (SMS)
29. Hazardous sample type (SMS)
30. Priority handling code
31. USGS analytical method identifier
32. Result type
33. Data check type code
34. Alert type code
35. Algorithm index
36. Project status
37. Maintenance code
38. Cation/anion indicator
39. Fixed-value flag
40. EPA compatible flag
41. Do-not-run code
42. Percent recovery at concentration
43. Sample quality-assurance/quality-control identifier
44. Biological level identifier
45. Statistical representation of measured data
46. Water-level status during measurement in well
47. Well status during water-level measurement in well
48. Well conditions during drill-stem tests
49. Type of flow for ground-water well
50. Well source/sink indicator
51. Types of well log for ground-water wells
52. Available formats of well log for ground-water wells
53. Lithologic units
54. Lithology
55. Geologic units
56. Contributing geologic unit ground for well
57. Hydrogeologic units
58. National ground-water atlas aquifer designations
59. Discharge-measurement types
60. Discharge-measurement quality rating
61. Discharge-measurement control conditions
62. Measured discharge indicator
63. Discharge-measurement meter type
64. Discharge-measurement coefficient type
65. Stream bottom type
66. Discharge-measurement base flow
67. Discharge-measurement adjusted discharge
68. Drainage basin characteristic identifications
69. Crest-stage gage reference-point type
70. Type of gage height readings
71. Drainage basin characteristic determination methods
72. Drainage basin characteristic determination equipment

C. SAMPLE

1. Particle-size class
2. Sample purpose
3. Sampling frequency
4. Sample container
5. Sample preservation methods
6. Sample preservation equipment

D. ANALYSIS

1. Sample analysis location
2. Sample source type
3. Laboratory analysis request schedules
4. Special requests for water-quality lab work
5. Electronic Analytical Services Request (EASR) type
6. EASR completion status
7. Color measurements
8. Constituent presence
9. Analysis environment

E. IDENTIFICATION

1. Hydrological discipline groups
2. Data characterization groups
3. Secondary data characterization groups
4. Biological identification type
5. Taxonomic identifications
6. Morphometric classifications
7. Physiologic classifications
8. Metabolic classifications
9. Respiratory classifications
10. Trophic classifications
11. Assemblage classifications
12. Biochemical classifications
13. Genetic classifications

IV. NATIONAL MASTER WATER DATA INDEX REFERENCE LISTS

1. Master Water Data Index (MWDI) site types
2. MWDI basin descriptions
3. MWDI primary use of water
4. MWDI media storage data
5. MWDI unit frequency codes (interval/readings per day)
6. MWDI telemetry equipment used
7. MWDI purpose of station
8. MWDI recorder frequency (interval/readings per day)
9. MWDI network code
10. Organization type
11. Water-quality organizations
12. Water Data Sources Directory (WDSD) orientations of water activities
13. WDSD type options
14. WDSD office directory options
15. WDSD office coverage areas
16. WDSD office storage media

V. MISCELLANEOUS REFERENCE LISTS

1. District equipment list
2. Water-use aggregation categories
3. Types of source information
4. Water-use aggregation coefficients
5. Coefficient-application regionality

VI. SAMPLING, MEASUREMENT, PREPARATION, AND PRESERVATION METHODS

1. Latitude/longitude determination methods
2. Elevation determination methods
3. Depth determination methods
4. River mile determination methods
5. Constituent measurement methods
6. Methods of water-level measurement in well
7. Method of discharge measurement from well
8. Discharge velocity measurement method
9. Soil moisture measurement methods
10. Climatic-variable measuring instruments
11. Snow samplers
12. Shields and shelters used with climatic instruments
13. Preferred climate-related terms and synonyms
14. Timing types for measuring conveyance flow
15. Estimation techniques for water flow
16. Meter types for measuring conveyance flow
17. Sample collection
18. Biological identification methods

19. Preparation methods (user-modifiable)
20. Sample fate
21. Biota tissue types
22. Sample preparation equipment (user-modifiable
23. Biological identification equipment

VII.SAMPLING AND MEASUREMENT EQUIPMENT

1. Latitude/longitude determination equipment
2. Elevation determination equipment
3. Depth determination equipment
4. River-mile determination equipment
5. Constituent measurement equipment
6. Biological sample collection equipment
7. Saturation vapor pressure over water
8. Saturation vapor pressure over ice

Appendix H: Constituent Verification Checks

E.J. Wilson

This appendix is an example of a partial list of constituent verification checks, which are now in WATSTORE. As it stands, the appendix is taken mainly from the Biology User Group and the Water Quality User Group documents. The user groups have identified more constituent verification checks, but these checks are now being reviewed, and the list is expanding. A completed list will be incorporated into the design of NWIS-II and will be the responsibility of NWIS-II headquarters staff to manage and update.

I. NWIS-II Biology User Group Constituent Verification Checks

Each item in the list contains the parameter code, parameter name, and data verification checks to be done upon entry of the constituent into the NWIS-II data base. Each constituent will contain one or more verification checks. Each verification check consists of a relationship to numeric information or to other parameters within the same sample event. "X" will signify the values of the constituent, a five-digit parameter code in brackets will signify a value of another parameter code within the same sample.

00022 LENGTH OF EXPOSURE (DAYS)
$0 < X$

00023 SAMPLE WEIGHT (POUNDS)
$0 < X$

00024 SAMPLE LENGTH (INCHES)
$0 < X$

00030 SOLAR RADIATION, INCIDENTAL, INTENSITY (CAL/SQ CM/DAY)
$0 < X$

00031 LIGHT INCIDENT AT REMAINING DEPTH (PERCENTAGE)
$0 \leq X$

00034 LIGHT DEPTH TO 1% OF SURFACE LIGHT (FEET)
$[00198] < X$
$[00199] < X$

00074 LIGHT TRANSMISSION 1 METER PATHLENGTH (PERCENT)
$0 < X$

00077 TRANSPARENCY SECCHI DISK (INCHES)
$0 < X$

00078 TRANSPARENCY SECCHI DISK (METERS)
$0 < X$

00198 LIGHT DEPTH TO 10 PERCENT OF SURFACE LIGHT (FEET)
$0 < X$
$[00199] < X < [00034]$

00199 LIGHT DEPTH TO 50 PERCENT OF SURFACE LIGHT (FEET)
$X < [00034]$
$X < [00198]$

00200 LIGHT INCIDENT, 400-700NM, INTENSITY (UE/M2/SC)
$0 \leq X$

00201 LIGHT INCIDENT, 400-700NM, DAILY TOTAL (UE/M2)
$0 \leq X$

00310 BIOCHEMICAL OXYGEN DEMAND, 5-DAY AT 20 DEGREES CENTIGRADE (MG/L)
$0 < X$

00319 BIOCHEMICAL OXYGEN DEMAND ULTIMATE, ALL STAGES, 20 DEGREES CENTIGRADE (MG/L)
$0 < X$

00320 BIOCHEMICAL OXYGEN DEMAND ULTIMATE, 1ST STAGE, 20 DEGREES CENTIGRADE (MG/L)
$0 < X$

00321 BIOCHEMICAL OXYGEN DEMAND ULTIMATE, 2ND STAGE, (MG/L)
$0 < X$

00324 BIOCHEMICAL OXYGEN DEMAND, 20 DAY, 20 DEGREES CENTIGRADE (MG/L)
$0 < X$

00325 DEOXYGENATION CONSTANT K1 TO BASE E, 20 DEGREES CENTIGRADE (PER DAY)
$0 < X$

00330 REOXYGENATION CONSTANT K2 TO BASE E (PER DAY)
$0 < X$

00349 BIOCHEMICAL OXYGEN DEMAND, 30 DAY, 20 DEGREES CENTIGRADE (MG/L)
$0 < X$

00572 BIOMASS, PERIPHYTON ASH WEIGHT (G/SQ M)
$X < [00573]$

00573 BIOMASS, PERIPHYTON DRY WEIGHT TOTAL (G/SQ M)
$[00572] < X$

31501 COLIFORM, MEMBRANE FILTER, IMMEDIATE M-ENDO MEDIUM (COLONIES/100 ML)
$[31613] \leq X$; $[31616] \leq X$

31613 FECAL COLIFORM MEMBRANE FILTER, M-FC AGAR, 44.5C, 24HR.
$X \leq [31501]$

31616 COLIFORM, FECAL, MEMBRANE FILTER M-FC MEDIA AT 44.5 DEG. C (COLONIES/100 ML)
$X \leq [31501]$

31625 FECAL COLIFORM.7 UM-MF (COL./ 100 ML)
$X \leq [31501]$

31855 BACTERIA, SULFATE REDUCING (MPN)
CHECK AGAINST DISSOLVED OXYGEN LEVEL IN WATER, IF ITS GREATER THAN 0.2 A WARNING SHOULD BE DISPLAYED UPON DATA ENTRY

70940 INVERTEBRATES, BENTHIC, WET WEIGHT (G/SQ METER)
$[70941] < X$
$[70942] < X$

70941 INVERTEBRATES, BENTHIC, DRY WEIGHT (G/SQ METER)
$X < [70941]$
$[70942] < X$

70942 INVERTEBRATES, BENTHIC, ASH WEIGHT (G/SQ METER^
$X < [70940]$
$X < [70941]$

70947 ZOOPLANKTON, DRY WEIGHT (G/CU METER)
$[70948] < X$

70948 ZOOPLANKTON, ASH WEIGHT (G/CU METER)
X < [70947]

81353 PLANKTON, BIOMASS, ASH WEIGHT (MG/L)
X < [81354]

81354 PLANKTON, BIOMASS, DRY WEIGHT (MG/L)
[81353] < X

85328 LIGHT DEPTH TO 1% OF SURFACE LIGHT METERS
0 < X

90034 LIGHT DEPTH TO 1% OF SURFACE LIGHT, CROSS-SECTION AVERAGE (FEET)
[90198] < X
[90199] < X

90198 LIGHT DEPTH TO 10% OF SURFACE LIGHT, CROSS-SECTION AVERAGE (FEET)
X < [90034]
[90199] < X

90199 LIGHT DEPTH TO 50% OF SURFACE LIGHT, CROSS-SECTION AVERAGE (FEET)
X < [90034]
X < [90198]

90200 LIGHT, INCIDENCE AT 400-700NM INTENSITY, X-SECTION AVERAGE (U-EINSTEINS/SQ M/S)
0 < X

J. NWIS-II Water-Quality User Group Requirements SEPTEMBER 1, 1989

Attachment D.– Chemical logic tests

Chemical logic tests are presented in two categories. The first (D.1) includes tests of values of dissolved and suspended constituents against the "total" value for the constituent. The second category (D.2) contains miscellaneous tests which are not based on the dissolved, suspended distinction. Both lists of chemical logic tests are incomplete and not reviewed; it is expected that approximately 800 tests eventually will be identified. It should be noted that the current EPA STORET parameter code system has been used to identify constituents rather than the Constituent Identifier system proposed in this report.

Because of the difficulty in presenting a large number of tests using both parameter codes and lengthy parameter names, a simple visual expedient has been chosen to present the "dissolved, suspended, total" tests (D.1). Each test asks in general "is a part less than the whole?"; and asks specifically "is dissolved X less than total X?" or "is suspended X less than total X?" Constituents have been grouped so that the terms for a test or related set of tests are together, separated from other terms by a blank line. The total term is left justified, whereas the dissolved and suspended terms are indented. Each of the indented terms in a group is to be tested against each justified term. The ordering of terms within a group is not significant. In the following example, tests are intended for *01106 < 01104* and also for *01107 < 01104*.

01106 ALUMINUM DISSOLVED (UG/L AS AL)
01107 ALUMINUM SUSPENDED (UG/L AS AL)
01104 ALUMINUM TOTAL RECOVERABLE (UG/L)

The system is expected to respond when a test is not passed. In addition, each of the tests should be modified to increase the value of the "total" by the value of its unique precision of determination. In the previous example, if a precision of 10 UG/L was appropriate to 01104 (Aluminum, Total Recoverable), the tests would become 01106 < 01104 + 10 and 01107 < 01104 + 10.

D.1.–Dissolved/suspended/total tests.

01503 ALPHA DISSOLVED (PCI/L)
01505 ALPHA SUSPENDED (PCI/L)
01501 ALPHA TOTAL (PCI/L)

80029 ALPHA, GROSS TOTAL AS U NATURAL (UG/L)
80030 ALPHA, GROSS, DISSOLVED AS U NATURAL (UG/L)

01106 ALUMINUM DISSOLVED (UG/L AS AL)
01107 ALUMINUM SUSPENDED (UG/L AS AL)
01105 ALUMINUM, TOTAL (UG/L AS AL)
01104 ALUMINUM TOTAL RECOVERABLE (UG/L)

01212 ALUMINUM DISSOLVED FROM DRY DEPOSITION (UG/KG)
01214 ALUMINUM TOTAL IN DRY DEPOSITION (UG/KG)

83190 ALUMINUM, ATMOSPHERIC DEPOSITION, BULK, DISSOLVED, (UG/L)
83192 ALUMINUM, ATMOSPHERIC DEPOSITION, BULK, SUSPENDED, (UG/L)
83194 ALUMINUM, ATMOSPHERIC DEPOSITION, BULK, TOTAL RECOVERABLE, (UG/L)
83196 ALUMINUM, ATMOSPHERIC DEPOSITION, BULK, TOTAL, (UG/L)

83191 ALUMINUM, ATMOSPHERIC DEPOSITION, BULK, DISSOLVED, (UG/M2)
83193 ALUMINUM, ATMOSPHERIC DEPOSITION, BULK, SUSPENDED, (UG/M2)
83195 ALUMINUM, ATMOSPHERIC DEPOSITION, BULK, TOTAL RECOVERABLE, (UG/M2)
83197 ALUMINUM, ATMOSPHERIC DEPOSITION, BULK, TOTAL, (UG/M2)
82909 ALUMINUM, ATMOSPHERIC DEPOSITION, WET, DISSOLVED, (UG/M2)
82911 ALUMINUM, ATMOSPHERIC DEPOSITION, WET, SUSPENDED, (UG/M2)
82913 ALUMINUM, ATMOSPHERIC DEPOSITION, WET, TOTAL RECOVERABLE, (UG/M2)
82915 ALUMINUM, ATMOSPHERIC DEPOSITION, WET, TOTAL, (UG/M2)

82910 ALUMINUM, ATMOSPHERIC DEPOSITION, WET, SUSPENDED, (UG/L)
82912 ALUMINUM, ATMOSPHERIC DEPOSITION, WET, TOTAL RECOVERABLE, (UG/L)
82914 ALUMINUM, ATMOSPHERIC DEPOSITION, WET, TOTAL, (UG/L)

29867 AMERICIUM-241, WATER, DISSOLVED, PCI/L
29865 AMERICIUM-241, WATER, WHOLE, PCI/L

34221 ANTHRACENE DISSOLVED (UG/L)
34222 ANTHRACENE SUSPENDED (UG/L)
34220 ANTHRACENE TOTAL (UG/L)

01095 ANTIMONY DISSOLVED (UG/L AS SB)
01096 ANTIMONY SUSPENDED (UG/L AS SB)
01097 ANTIMONY TOTAL (UG/L AS SB)

29957 ANTIMONY-124, WATER, DISSOLVED, PCI/L
29955 ANTIMONY-124, WATER, WHOLE, PCI/L

29961 ANTIMONY-125, WATER, DISSOLVED, PCI/L
29959 ANTIMONY-125, WATER, WHOLE, PCI/L

34672 AROCLOR 1016 PCB DISSOLVED (UG/L)
34673 AROCLOR 1016 PCB SUSPENDED (UG/L)
34671 AROCLOR 1016 PCB TOTAL (UG/L)

34662 AROCLOR 1221 PCB DISSOLVED (UG/L)
34663 AROCLOR 1221 PCB SUSPENDED (UG/L)
34988 AROCLOR 1221 PCB TOTAL (UG/L)

34665 AROCLOR 1232 PCB DISSOLVED (UG/L)
34666 AROCLOR 1232 PCB SUSPENDED (UG/L)
39492 AROCLOR 1232 PCB TOTAL (UG/L)

34457 AROCLOR 1242 PCB DISSOLVED (UG/L)
34458 AROCLOR 1242 PCB SUSPENDED (UG/L)
39496 AROCLOR 1242 PCB TOTAL (UG/L) 39501

AROCLOR 1248 PCB DISSOLVED (UG/L)
39502 AROCLOR 1248 PCB SUSPENDED (UG/L)
39500 AROCLOR 1248 PCB TOTAL (UG/L)

39505 AROCLOR 1254 PCB DISSOLVED (UG/L)
39506 AROCLOR 1254 PCB SUSPENDED (UG/L)
39504 AROCLOR 1254 PCB TOTAL (UG/L)

39509 AROCLOR 1260 PCB DISSOLVED (UG/L)
39510 AROCLOR 1260 PCB SUSPENDED (UG/L)
39508 AROCLOR 1260 PCB TOTAL (UG/L)

01000 ARSENIC DISSOLVED (UG/L AS AS)
01001 ARSENIC SUSPENDED TOTAL (UG/L AS AS)
01002 ARSENIC TOTAL (UG/L AS AS)

83199 ARSENIC, ATMOSPHERIC DEPOSITION, BULK, DISSOLVED, UG/L
83201 ARSENIC, ATMOSPHERIC DEPOSITION, BULK, SUSPENDED, UG/L
83203 ARSENIC, ATMOSPHERIC DEPOSITION, BULK, TOTAL, UG/L

83202 ARSENIC, ATMOSPHERIC DEPOSITION, BULK, SUSPENDED, UG/M2
83200 ARSENIC, ATMOSPHERIC DEPOSITION, BULK, DISSOLVED, UG/M2
83204 ARSENIC, ATMOSPHERIC DEPOSITION, BULK, TOTAL, UG/M2

82917 ARSENIC, ATMOSPHERIC DEPOSITION, WET, DISSOLVED, UG/L
82919 ARSENIC, ATMOSPHERIC DEPOSITION, WET, SUSPENDED, UG/L
82921 ARSENIC, ATMOSPHERIC DEPOSITION, WET, TOTAL, UG/L

82920 ARSENIC, ATMOSPHERIC DEPOSITION, WET, SUSPENDED, UG/M2
82918 ARSENIC, ATMOSPHERIC DEPOSITION, WET, DISSOLVED, UG/M2
82922 ARSENIC, ATMOSPHERIC DEPOSITION, WET, TOTAL, UG/M2

34226 ASBESTOS (FIBROUS) DISSOLVED (UG/L)
34227 ASBESTOS (FIBROUS) SUSPENDED (UG/L)
34225 ASBESTOS (FIBROUS) TOTAL (UG/L)

01005 BARIUM DISSOLVED (UG/L AS BA)
01006 BARIUM SUSPENDED RECOVERABLE (UG/L AS BA)
01009 BARIUM TOTAL RECOVERABLE (UG/L)
01007 BARIUM TOTAL (UG/L AS BA)

01215 BARIUM DISSOLVED FROM DRY DEPOSITION (UG/KG)
01217 BARIUM TOTAL IN DRY DEPOSITION (UG/KG)

29869 BARIUM-140, WATER, DISSOLVED, PCI/L
28601 BARIUM-140, WATER, WHOLE, PCI/L
28602 BARIUM-140, WATER, WHOLE, PCI/L

34235 BENZENE DISSOLVED (UG/L)
34236 BENZENE SUSPENDED (UG/L)
34030 BENZENE, TOTAL (UG/L)

34239 BENZIDINE DISSOLVED (UG/L)
34240 BENZIDINE SUSPENDED (UG/L)
39120 BENZIDINE TOTAL (UG/L)

34248 BENZO A PYRENE DISSOLVED (UG/L)
34249 BENZO A PYRENE SUSPENDED (UG/L)
34247 BENZO A PYRENE TOTAL (UG/L)

34231 BENZO B FLUORANTHENE DISSOLVED (UG/L)
34232 BENZO B FLUORANTHENE SUSP. (UG/L)
34230 BENZO B FLUORANTHENE TOTAL (UG/L)

34243 BENZO K FLUORANTHENE DISSOLVED (UG/L)
34244 BENZO K FLUORANTHENE SUSPENDED (UG/L)
34242 BENZO K FLUORANTHENE TOTAL (UG/L)

01010 BERYLLIUM DISSOLVED (UG/L AS BE)
01011 BERYLLIUM SUSPENDED RECOVERABLE (UG/L AS BE)
01012 BERYLLIUM TOTAL (UG/L AS BE)
00998 BERYLLIUM TOTAL RECOVERABLE (UG/L)
29873 BERYLLIUM-7, WATER, DISSOLVED, PCI/L
29871 BERYLLIUM-7, WATER, WHOLE, PCI/L

34255 BETA BENZENE HEXACHLORIDE DISSOLVED (UG/L)
34256 BETA BENZENE HEXACHLORIDE SUSPENDED (UG/L)
39338 BETA BENZENE HEXACHLORIDE TOTAL (UG/L)

03503 BETA DISSOLVED (PCI/L)
03505 BETA SUSPENDED (PCI/L)
03501 BETA TOTAL (PCI/L)

80049 BETA, GROSS TOTAL AS STONTIUM/YTTRIUM-90 (PCI/L)
80050 BETA, GROSS, DISSOLVED AS STRONTIUM/YTTRIUM-90 (PCI/L)

01015 BISMUTH DISSOLVED (UG/L AS BI)
01016 BISMUTH SUSPENDED (UG/L AS BI)
01017 BISMUTH TOTAL (UG/L AS BI)

29875 BISMUTH-214, WATER, DISSOLVED, PCI/L
22383 BISMUTH-214, WATER, WHOLE, PCI/L
22384 BISMUTH-214, WATER, WHOLE, PCI/L

01020 BORON DISSOLVED (UG/L AS B)
01021 BORON SUSPENDED (UG/L AS B)
01022 BORON TOTAL (UG/L AS B)
00999 BORON TOTAL RECOVERABLE (UG/L)

34288 BROMOFORM DISSOLVED (UG/L)
34289 BROMOFORM SUSPENDED (UG/L)
32104 BROMOFORM TOTAL (UG/L)

01025 CADMIUM DISSOLVED (UG/L AS CD)
01026 CADMIUM SUSPENDED (UG/L AS CD)
01113 CADMIUM TOTAL RECOVERABLE IN WATER (UG/L)
01027 CADMIUM TOTAL (UG/L AS CD)

82489 CADMIUM DISSOLVED DRY DEPOSITION (UG/KG)
82491 CADMIUM TOTAL RECOVERABLE DRY DEPOSITION (UG/KG)

83206 CADMIUM, ATMOSPHERIC DEPOSITION, BULK, DISSOLVED, (UG/L)
83208 CADMIUM, ATMOSPHERIC DEPOSITION, BULK, SUSPENDED, (UG/L)
83210 CADMIUM, ATMOSPHERIC DEPOSITION, BULK, TOTAL RECOVERABLE, (UG/L)
83212 CADMIUM, ATMOSPHERIC DEPOSITION, BULK, TOTAL, (UG/L)

82924 CADMIUM, ATMOSPHERIC DEPOSITION, WET, DISSOLVED, (UG/L)
82925 CADMIUM, ATMOSPHERIC DEPOSITION, WET, DISSOLVED, (UG/M2)
82926 CADMIUM, ATMOSPHERIC DEPOSITION, WET, SUSPENDED, (UG/L)
82930 CADMIUM, ATMOSPHERIC DEPOSITION, WET, TOTAL, (UG/L)
82928 CADMIUM, ATMOSPHERIC DEPOSITION, WET, TOTAL RECOVERABLE, (UG/L)

82927 CADMIUM, ATMOSPHERIC DEPOSITION, WET, SUSPENDED, (UG/M2)
82929 CADMIUM, ATMOSPHERIC DEPOSITION, WET, TOTAL RECOVERABLE, (UG/M2)
82931 CADMIUM, ATMOSPHERIC DEPOSITION, WET, TOTAL, (UG/M2)

83207 CADMIUM, ATMOSPHERIC DEPOSITION, BULK, DISSOLVED, (UG/M2)
83209 CADMIUM, ATMOSPHERIC DEPOSITION, BULK, SUSPENDED, (UG/M2)
83213 CADMIUM, ATMOSPHERIC DEPOSITION, BULK, TOTAL, (UG/M2)
83211 CADMIUM, ATMOSPHERIC DEPOSITION, BULK, TOTAL, RECOVERABLE, (UG/M2)

07050 CALCIUM 45 DISSOLVED (PCI/L) 07052 CALCIUM 45 SUSPENDED (PCI/L)
07054 CALCIUM 45 TOTAL (PCI/L)

D.2 Miscellaneous tests.

MISCELLANEOUS TESTS

00625 Nitrogen, AMMONIA PLUS ORGANIC AS N, TOTAL > 00610 NITROGEN AMMONIA AS N, TOTAL
00625 Nitrogen, AMMONIA PLUS ORGANIC AS N, TOTAL > 00608 NITROGEN AMMONIA AS N, DISSOLVED
00666 PHOSPHORUS AS P, DISSOLVED > 00671 PHOSPHORUS, ORTHOPHOSPHATE AS P, DISSOLVED
00665 PHOSPHORUS AS P, TOTAL >70507 PHOSPHORUS, ORTHOPHOSPHATE, AS P, TOTAL
00631 NITROGEN, NITRATE PLUS NITRATE AS N, DISSOLVED > 00613 NITROGEN, NITRITE AS N, DISSOLVED
00623 NITROGEN, AMMONIA PLUS ORGANIC AS N, DISSOLVED > 00608 NITROGEN, AMMONIA AS N, DISSOLVED
00630 NITROGEN, NITRITE PLUS NITRATE AS N, TOTAL > 00613 NITROGEN, NITRITE AS N, DISSOLVED
00630 NITROGEN, NITRITE PLUS NITRATE AS N, TOTAL > NITROGEN, NITRITE AS N, TOTAL
00500 SOLIDS RESIDUE AT 105-110 C, TOTAL > SOLIDS, RESIDUE AT 180 C, DISSOLVED
00500 SOLIDS, RESIDUE AT 105-110 C, TOTAL > 00510 SOLIDS, NONVOLATILE, TOTAL
00500 SOLIDS, RESIDUE AT 105-110 C, TOTAL > 00505 SOLIDS, VOLATILE ON IGNITION, TOTAL
00530 SOLIDS, RESIDUE AT 105-110 C, SUSPENDED > 00540 SOLIDS, NONVOLATILE, SUSPENDED
00530 SOLIDS, RESIDUE AT 105-110 C, SUSPENDED > 00535 SOLIDS, VOLATILE ON IGNITION, SUSPENDED
70300 SOLIDS, RESIDUE AT 180 C, DISSOLVED > 00520 SOLIDS, VOLATILE ON IGNITION, DISSOLVED

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This is the format for output from STORET to NWDI. Only non-USGS data will be output in this manner.

Table 208. -- STORET station header output.

ATTRIBUTE	DATA TYPE	DESCRIPTION
Station Name	Text	Narrative description up to 52 characters
Station ID Code	Text	Alphanumeric identifier
Secondary Station Code	Text	Alias for station code
Tertiary Station Code	Text	Second alias for station code
Hydrologic Unit Code	Text	8-digit code
Latitude	Int/Fixed	Station latitude
Longitude	Int/Fixed	Station longitude
Reach Number	Char	3-digit code following hydrologic unit code
Mileage Point	Real	Miles from head of reach where station is located
Station Type	Bit (32)	Physical type of station, e.g., well, stream, or estuary
State Code	Integer	FIPS code
County Code	Integer	FIPS code
Agency Code	Char	Agency responsible for data

Table 209. -- STORET parameter data output.

ATTRIBUTE	DATA TYPE	DESCRIPTION
Parameter Code	Text	EPA 5-digit code, to be converted to Constituent Classification Index
Agency/Station Code	Text	Indexes data to header file
Region	Char(1)	EPA region where data were collected
State Code	Integer	FIPS code
Pipe_No	Integer	Discharge pipe number for stations located at industrial and municipal dischargers
Date	Integer	Date samples collected
Observations	Fixed Bin (15)	Number of observations of each parameter by date
Update transactions	Boolean	Add, delete, and edit existing NWDI data when affected by changes to STORET data base; may need conversion to NWIS-II protocol

Appendix I: STORET Formats

This appendix contains the formats of the data elements used to generate output files for converting NWIS-II data from and into STORET. Included are the desired formats of the data elements that are copied from STORET to the National Water Data Index, (NWDI), and the data elements and formats that STORET can accommodate from NWIS-II, such as station header files, parametric data, daily-values data and biological data. Also included are examples of STORET input formats. The capability to output NWIS-II data to these formats would significantly improve the capability to copy data to STORET.

[Note: These tables are current as of the writing of the SRS and may need to be updated as the design continues.]

The following tables contain the formats of the data elements necessary to create station header files in STORET and optional header-file data elements. All data can be entered and uploaded as an ASCII text file; STORET's storage software will make all necessary conversions to data types. With a few exceptions, the order in which information is coded does not matter. Data can be coded with as many data elements and values as will fit on a single 80-character line, or can be entered as one element and value per line. The only restriction is that each data value must be followed by a comma and that each data code be separated from its associated value by an equal sign (=). The column under "KEYWORD" contains the STORET keywords associated with each attribute.

Table 210. -- Minimum required by STORET

ATTRIBUTE	KEYWORD	DESCRIPTION
Agency Code	A	Agency responsible for data
Unlocking Key	UK	Unlocking key for agency, each agency has one unique code, must be included to add or change any data and access restricted or "locked" data
Station Name	LOCNAME	Narrative description of up to 52 characters
Station ID Code	NEWSTA	Alphanumeric identifier
Hydrologic Unit Code	CATUNIT	8-digit code, if Reach File indicator is stored, substitute keyword RCHMIL
Point	POINT	Indicator of which lat/long point is to follow
Latitude	LAT	Station latitude
Longitude	LONG	Station longitude
Precision Code	PREC	Lat/long precision
Station Type	TYPE	Physical type of station, e.g., well, stream, or estuary
State Code	ST	FIPS code
County Code	CO	FIPS code
Agency Code	A	Agency responsible for data (always same for USGS data)

Table 211. -- Not required by STORET but usually included

ATTRIBUTE	KEYWORD	DESCRIPTION
Lock Days	LOCKDAYS	Number of days (up to 360) after sample date that data for that sample are kept from public view; default is 000, no restrictions
Lock Date	LOCKDATE	Date (year and month) after which data for all samples are restricted from public view; default is 9999, no restrictions
Reach Number	RCHMIL	3-digit code following hydrologic unit code
Mileage Point	RCHMIL	Miles from head of reach where station is located
Basin Codes	BS	EPA major, minor, subbasin waterbody codes
On/Off Reach	ONRCH	Indicator whether site is on or off reach

Table 212. -- Other available data elements

ATTRIBUTE	KEYWORD	DESCRIPTION
Secondary Station ID Code	SECSTA1	Alias station ID code
Third Station ID Code	SECSTA2	Second alias station ID code
Fourth Station ID Code	SECSTA3	Third alias station ID code
Point	POINT	Indicator to additional lat/long points; up to three additional lat/longs can be stored for each station
Precision Code	PREC	Precision of additional lat/long points; one needed for each additional point
Latitude/Longitude	LAT/LONG	Additional lat/long points
Ecoregion	ECOREG	EPA Ecoregion
Elevation	ELEV	Site elevation above/below sea level in feet (F) or meters (M)
Depth	DEPTH	Depth of water at site in feet (F) or meters (M)
Aquifer	AQ	USGS-defined aquifer codes; up to five can be stored
Descriptive Paragraph	PARA	Narrative description of station; up to 5 lines of up to 72 characters per line

The next table is an example of a STORET input format that would be copied to STORET to create a new station. All coded information is fictitious and is included for demonstration purposes only.

Table 213. -- Example of a STORET input format for a new station

```
FORMAT=STATIONS,
A=11TRAIN,UK=CHOOCHOO,
NEWSTA=ABC123,TYPE=AMBNT/STREAM/BIO,
SECSTA1=XYZ789,
LOCNAME=GREEN RIVER NR. LITTLE LAKE,
POINT=1,
LAT=37 07 12.0,LONG=119 15 46.3,PREC=2,
STCO=06001,RCHMIL=18030201011/13.5,ONRCH=YES,
PARO1=COOPERATIVE MONITORING EFFORT BETWEEN STATE OF CALIFORNIA,
PARO2=AND U.S. ENVIRONMENTAL PROTECTION AGENCY,
ECOREG=06,ELEV=2320F,DEPTH=15M,LOCKDAYS=45,LOCKDATE=9999,
```

The following tables contain the formats of data elements used to copy parametric data to STORET. As with the station input format, all data can be entered as an ASCII text file, then copied to STORET. All data will be converted to proper data types by STORET's data storage software. All data values are separated from each other by commas with the exception of date and time, which are entered as a single field. Also, it is possible to enter new data, change existing data, or delete data in a single transaction.

Table 214. -- Minimum STORET parametric data elements

ATTRIBUTE	KEYWORD	DESCRIPTION
Agency Card	AC	Indicator that rest of line is information on the agency storing data
Agency Code	A	Agency code
Unlocking Key	UK	Unlocking key for agency storing data
Station ID Code		Alpha-numeric identifier, used to index header file
Sample Date		Date sample collected, year/month/day
Sample Time		Time of day sample collected, 24 hr. clock
Sample Depth	D	Depth of water where sample was collected, "D" is followed by an integer of up to 3 digits. See Table 335 for additional qualifiers
Parameter Code	P	5 digit STORET code, always preceded by "P" for new value, "PC" to correct or replace an existing value, or "PD" to delete the existing value.
Data Value		Analytical value, can be alpha/numeric depending on parameter type
Remark Code		One character qualifier for data value, see Table 336 for available values

Table 215. -- Additional data elements for storing sophisticated composite samples.

ATTRIBUTE	DESCRIPTION
Beginning Date	Date sampling event began
Beginning Time	Time of day sampling event began
Ending Date	Date sampling event ended
Ending Time	Time sampling event ended
Composite Type	Code for type of composite, see Table 337
Composite Value	Code for type of composite value that will be stored for each parameter, see Table 338
Sampling Method	Code for type of sample collected, see Table 339

Table 216. -- **Optional parametric fields for ground-water samples.**

ATTRIBUTE		DESCRIPTION
Media	MED	Usually set to GRWTR to distinguish ground-water samples
System Media Code	SMK	4-digit code that distinguishes Split/Replicate samples, see Table 340
User Media Code	UMK	User-defined code for sampling method

Table 217. -- Depth qualifiers

VALUE	DESCRIPTION
D	Sample depth in feet
DM	Sample depth in meters
DB	Bottom depth in feet
DMB	Bottom depth in meters
DV	Vertically integrated sample, value is the length of the column in feet
DMV	Vertically integrated sample, value is the length of the column in meters
DP	Pore sample, value is the length of the core from which the water was extracted in feet
DMP	Pore sample, value is the length of the core from which the water was extracted in meters
DD	Dredge sample, value is length of the dredge in feet
DMD	Dredge sample, value is length of the dredge in meters
DC	Core sample, value is the distance from the top of the core to middle of the sample analyzed in feet
DMC	Core sample, value is the distance from the top of the core to middle of the sample analyzed in meters

Table 218. -- Data value remark codes

VALUE	DESCRIPTION
A	Value reported is the mean of two or more determinations
B	Results based on colony counts outside the acceptable range
C	Value calculated
D	Indicates field measurement
E	Indicates extra samples taken at composite stations
F	In the case of species, F indicates female sex
G	Value reported is the maximum of two or more determinations
H	Value based on field kit determination; results may not be accurate
J	Estimated value, value not accurate
K	Actual value is known to be less than value given
L	Actual value is known to be greater than value given
M	Presence of material verified but not quantified. In the case of temperature or oxygen reduction potential, M indicates a negative value. In the case of species, M indicates male sex.
N	Presumptive evidence of presence of material.
O	Sampled, but analysis lost or not performed
P	Too numerous to count
Q	Sample held beyond normal holding time
R	Significant rain in the past 48 hours
S	Laboratory test
T	Value reported is less than criteria of detection
U	Indicates material was analyzed for but not detected. In the case of species, U indicates undetermined sex.
W	Value observed is less than lowest value reportable under "T" value
X	Value is quasi-vertical, integrated sample
Z	Too many colonies were present to count (TNTC), the numeric value represents the filtration volume

Table 219. -- Type of Composite Value

VALUE	DESCRIPTION
A	Average
H	Maximum
L	Minimum
N	Number of observations for the sample
S	Standard Deviation
U	Sum of the squares
V	Variance
C	Coefficient of error
X	Coefficient of variance
E	Skewness
F	Kurtosis
Z	Number of samples on composite exceeds established limit
%	Precision
$	Accuracy
B	None of the above
D	Indicates replicate sample

Table 220. -- Type of Composite

VALUE	DESCRIPTION
S	Space
T	Time
B	Both
F	Flow Proportional Composite
1-9	Replicate Number

Table 221. -- Sampling Method

VALUE	DESCRIPTION
C	Samples collected continuously
G	Grab samples, number comprising sample not reported
GNXX	Grab samples with XX indicating the number of samples
B	None of the above. Used with replicate samples

Table 222. -- SMK values for indicating ground-water split/replicate samples[1]

FIRST DIGIT CODE	MULTIPLE SAMPLE	FIELD REPLICATE	LAB REPLICATE
0	NO	NO	NO
1	NO	NO	YES
2	NO	YES	NO
3	YES	NO	NO
4	NO	YES	YES
5	YES	YES	NO
6	YES	NO	YES
7	YES	YES	YES

[1][For example, if the code 4000 is entered, no multiple samples were taken, but both field and lab replicates are present. The second digit indicates which replicate this is from the set of replicates taken at that site. The third digit indicates which field replicate is the sample and the fourth digit indicates whether the sample was divided in the lab and, if so, the sample number]

Following is an example of a STORET parametric data input format that would be copied to STORET. There are variations to this format; this example shows the most compatible format with intended NWIS-II output. This example shows how data would be entered, edited, or deleted for six fictitious stations: ABC1, data entry for a routine grab sample; ABC2, data entry for a sophisticated composite sample; ABC3, data entry for a split/replicate ground-water sample; ABC4, combining data entry, change, and delete requests in the same transaction; ABC5, deleting all data for a sample; ABC6, deleting all data for a station; and ABC7, deleting all data for a station and the station itself.

Table 223. -- Example of a STORET parametric data-input format.

```
FORMAT=WQS,
AC,A=11TRAIN,UK=CHOOCHOO,
SC,ABC1,9101081300,D5M,P00010,12.5,P01092,23,P01042,10U,
SC,ABC2,9101081200,9101091200,D0,A,T,GN25,P00300,7.2,P01002,52,
SC,ABC3,9101041000,MED=GRWTR,SMK=3100,UMK=1126205,P01002,2.5J,P00665,1.2,
P00900,34,P00010,9.5,
SC,ABC4,9101021055,D15,P0010,5.6,PC00300,8.2,PD00400,
SC,ABC5,9101101020,D0,DEL,
DELDATA=ABC6,
DELSTA=ABC7,
```

The following tables contain the data elements copied from the Daily-Values File to STORET. These data and software are identical to the existing Daily-Values system and may need to be modified to meet the requirements of NWIS-II.

Table 224. -- Daily-values data elements.

ATTRIBUTE	DATA TYPE	DESCRIPTION
State Code	Text	FIPS code
Agency Code	Text	NAWDEX agency code
Station ID Code	Text	Station identification code
Cross Section Indicator	Integer	Distance in feet from left bank facing downstream
Depth	Integer	Sampling depth from surface of water
Parameter Code	Int/Fixed	5-digit STORET code
Year	Integer	Water year for last month in record
Statistic Code	Int/Fixed	Statistical code for data
No Value Indicator	Text	Missing daily-value indicator
Daily Values	Text	Two-dimensional array of daily values for a 12-month period
District Code	Text	State code of district office or project office responsible for collecting and storing data
County Code	Text	FIPS code
Station Name	Text	Station name or local well number
Drainage Area	Integer	Drainage area (square miles)
Contributing Drainage Area	Integer	Square miles of contributing drainage area
Well Depth	Integer	Greatest depth at which water can enter the well
Elevation	Integer	Elevation of station above sea level
Hydrologic Unit Code	Integer	USGS hydrologic unit code
Month	Integer	Beginning month number - earliest month of the 12-month period of record for station
Site Code	Text	Site type code
Latitude	Int/Fixed	Latitude of station
Longitude	Int/Fixed	Longitude of station
Sequence number	Text	Identify site in relation to the earth's spherical quadrants
Aquifer code	Text	Aquifer code of site
Aquifer type	Text	Type of aquifer

The following table contains the data elements used for entering or copying biological data to STORET's BIOS Field Survey data base. BIOS is a hierarchical data base. Unlike water-quality data, keyed on by station and date and time of a sampling event, BIOS data can be keyed on by sample survey number, sample ID, sample batch ID, taxon identifiers, sampling gear type and individual organism identifiers.

Table 225. -- BIOS Field Survey data elements

ATTRIBUTE	KEYWORD	DESCRIPTION
Agency	A	Agency code
Unlocking Key	UK	Unlocking key for agency collecting data
Station ID Code	S	Identifier code for station
Survey	SURVEY	Survey number
Sample Date and Time	SAMPDT	Date and time sample was collected
Sample ID	SAMPID	Sample ID number
Collector	COLLECTOR	Identification code of individual collecting samples, must be registered in BIOS
Identifier	IDENTIFIER	Identification code of individual(s) identifying organisms collected, must be registered in BIOS
Community	COMMUNITY	Biological community sampled
Sample Notes	SAMPNOTE	Up to 4 lines of 72 characters each of text about the sampling event

Table 226. -- Sample data elements for sampling gear[1]

ATTRIBUTE	KEYWORD	DESCRIPTION
Gear	GEAR	Type of gear used for sample
Gear Mesh	GMESH	Size of mesh spaces for nets
Gear Length	GLEN	Length of net
Gear Width	GWIDTH	Width of net

[1][Additional data elements are available for other types of gear, e.g. electric shockers, different types of nets]

Table 227. -- Examples of taxon data elements

ATTRIBUTE	KEYWORD	DESCRIPTION
Taxon	TAXON	NODC Taxonomic code
Lifestage	LIFESTAGE	Lifestage of organisms for which data are being entered, e.g. adult, juvenile
Batch ID	BATCHID	Batch from sample for which data are being entered
ID Confidence	IDCONF	Code for identifier confidence of species identification
Count	CNT	Number of organisms in sample
Maximum Length	TLENMAX	Longest organism
Minimum Length	TLENMIN	Shortest organism
Maximum Fork Length	FLENMAX	Maximum fork length of organism in sample
Minimum Fork Length	FLENMIN	Minimum for length of organism in sample
Wet weight	WETWT	Total wet weight
Dry weight	DRYWT	Total dry weight
Ash weight	ASHWT	Total ash weight
Taxon Notes	TAXNOTE	Up to 4 lines of 72 characters each of text about the taxon

Table 228. -- Examples of additional data elements for individual organisms

ATTRIBUTE	KEYWORD	DESCRIPTION
Individual Number	INUM	Number of individual in sample for which data are being entered
Individual Age	IAGE	Estimated age of individual
Individual Condition	ICOND	Code for physical condition of organism
Individual Notes	INOTE	Up to 4 lines of 72 characters each of text about individual

Following is an example of a BIOS data input file.

Table 229. -- BIOS example input file

```
FORMAT=BIOSFS,
A=11TRAIN,UK=CHOOCHOO,
S=ABC123,
SURVEY=1,
SAMPDT=9101041300,
SAMPID=1,
COLLECTOR=5,IDENITFIER=2,COMMUNITY=FISH,
SAMPNOTE=SAMPLES COLLECTED AS PART OF POLLUTION ABATEMENT,
SAMPNOTE=PROGRAM BY XYZ INDUSTRIES,
GEAR=TRAWL,
GMESH=.25,GLEN=100,GWIDTH=15,
TAXON=CYPRINUS CARPIO,
LIFESTAGE=ADULT,BATCHID=1,IDCONF=A,CNT=500,
TLENMAX=125,TLENMIN=35,FLENMAX=100,FLENMIN=25,WETWT=600,DRYWT=350,ASHWT=300,
TAXNOTE=SOME DISEASED INDIVIDUALS NOTED,
INUM=1,IAGE=4,ICOND=3,IWETWT=34,IDRYWT=21,IASHWT=15,ITLEN=122,IFLEN=90,
INOTE=LESIONS NOTED ON TAIL,
TAXON=CHARCARODON CHARCARIUS,
LIFESTAGE=ADULT,BATCHID=1,IDCONF=A,CNT=1,
INUM=1,IAGE=4,ICOND=4,WETWT=8000,ITLEN=800,IFLEN=600,
INOTE=ATTACKED TRAWL NET AND BOAT,
INOTE=SAMPLING CURTAILED FOR OBVIOUS REASONS,
```


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Appendix J: Output Tables

This appendix contains lists of standard output tables from NWIS-II as specified in the User Group's requirements document. Definitive examples of output tables and their exact format will be developed during prototyping with the user groups in the design phase of NWIS-II. During the design phase, the NWIS-II designers shall also get approval from the WRD publications section on the format of the tables required to meet publication standards.

A. Interdisciplinary Tables

1. Summary of retrieval specifications.
2. Components for WDSD organization description.
3. Components for WDSD information about office(s) of an organization.

B. Water-Use Requirements for Standard Tables

1. Public-supply freshwater use, by county.
2. Public-supply water use, by county.
3. Commercial water use, in million gallons per day, by county.
4. Water withdrawal form for nonagricultural user.
5. Water withdrawal form for agricultural user.
6. Exports of water from hydrologic units.
7. Industrial water use, in million gallons per day, by county.
8. Industrial water use, by county.
9. Thermoelectric power water use, in million gallons per day, by county.
10. Fossil fuel power water use, in million gallons per day, by county.
11. Fossil fuel power water use, by county.
12. Geothermal power water use, by county.
13. Nuclear power water use, in million gallons per day, by county.
14. Nuclear power water use by county.
15. Mining water use, in million gallons per day, by county.
16. Livestock water use, in million gallons per day, by county.
17. Irrigation water use, by county.
18. Hydroelectric power water use, by county.
19. Sewage-treatment water releases, by county.
20. Reservoir evaporation water use, by county.
21. Total offstream water use, by county--withdrawals.
22. Total offstream water use, by county--water use.
23. Quick view of contents of data file.
24. AWUDS data by percentage — Report of all parameters for county, by category.
25. AWUDS data by percentage — Report of ground water for county, by category.
26. AWUDS data by percentage — Report of surface water for county, by category.
27. AWUDS data by percentage — Report of category for county, by category.
28. AWUDS data by percentage — Report of other for county, by category.
29. AWUDS data by percentage — Report of population for county, by category.
30. Report of population for county.
31. Other AWUDS data parameters — Consumptive use, in percent of water withdrawn, by State.

32. Ranked tables in ascending order, by data element index, for ground-water withdrawals.
33. Ranked tables in ascending order, by data element index, for surface-water withdrawals.
34. Ranked tables in ascending order, by data element index, for total withdrawals.
35. Ranked tables in ascending order, by data element index, for consumptive use.
36. Ranked tables in descending order, by data element index, for ground-water withdrawals.
37. Ranked tables in sequential order by area and data element index, for ground-water withdrawals.
38. AWUDS cumulative frequency for county.
39. Annual measurements (SA) file.
40. Extended data (SE) file--irrigation overlay.
41. Extended data (SE) file--production overlay.
42. Extended data (SE) file--power overlay.
43. Extended data (SE) file--public-supply/waste-treatment overlay.
44. Detailed water-user report, which includes extended data for water user, measurement-point data for water user, and annual measurements.
45. Special-purpose ASCII file.
46. Aggregated data reports.
47. Domestic freshwater use, by water-resources region.
48. Commercial freshwater use, by water-resources region.
49. Irrigation water use, by water-resources region.
50. Livestock freshwater use, by water-resources region.
51. Industrial water use, by water-resources region.
52. Mining water use, by water-resources region.
53. Thermoelectric power (electric utility generation) water use, by water-resources region.
54. Thermoelectric power water use, by energy source, by water-resources region.
55. Hydroelectric power water use, by region.
56. Sewage treatment water releases, by region.
57. Total water use for all offstream water-use categories, by water-resources region.
58. Summary of water withdrawals for offstream water-use categories, by water-resources region. This table is triplicated in the 5-year compilation of water use. The title changes to "Surface water withdrawals..." to "Ground-water withdrawals...".
59. Summary by State of freshwater withdrawals by source and category of use.
60. User-defined format. Two units of measure, three levels of accuracy, and two levels of aggregation shall be provided for retrieval and output.

C. Ground-Water Requirements for Standard Tables

1. Manuscript that contains text, tables, and figures--Ground-Water Summary; includes explanation of ground-water levels and well information
2. Ground-water record with 3-year hydrograph.
3. Ground-water levels, 12-column format.
4. Ground-water levels, 6-column format.
5. Data from pumping test

D. Water-Quality Requirements for Standard Tables

1. Transaction/audit file report.
2. Security access report.
3. Records processing report.
4. Quality-assurance message (chemical logic report, single station).
5. Multiple-station quality-assurance report.
6. Analytical results (WATLIST).
7. Edit validation (QWVALID).
8. All information stored for analyses (primary QW records) within a minimal format (QWDUMP).
9. Data inventory (LOGLIST).
10. Annual report tables.
11. QW station analysis
12. QW station description
13. General text formatting
14. User-defined tables
15. Standardized tables
16. Station history
17. Hydrologic extremes
18. Commentary system table
19. Sampling event summary
20. Nontarget organic compound report
21. Shift summary reports.
22. V-diagram tables
23. Load tables.
24. Continuous record table--primary printouts.
25. Continuous record tables--unit-values printouts.
26. Continuous record tables--daily-values printouts.
27. Site index file reports.

28. Measurement and sampling-point information tables.
29. Algorithm reports.
30. Constituent identifier reports.
31. Method identifier dictionary reports.
32. Laboratory catalog reports.
33. Sample Management System (SMS) computer-generated labels.
34. SMS computer-generated electronic analytical services request (EASR) form.
35. SMS sample shipment report.
36. SMS date report (list of samples by holding times).
37. SMS sample status report, brief.
38. SMS sample status report, detailed.
39. Accounting reports, such as LABWEEK, LABMONTH, LABYEAR
40. SMS district sample workload projection reports, such as analytical costs for procedures done on a sample and analytical laboratory services results.
41. Bottle requirements for a district analysis group.

E. Surface-Water Requirements for Standard Tables.

1. Form number 2 (formerly standard) for reservoir primary, elevation, or lake levels.
2. Form number 2 (formerly standard) for reservoir primary, gage height, and contents.
3. Form number 1 (formerly historic) for reservoir primary output, elevation, or lake levels.
4. Form number 1 (formerly historic) for reservoir primary, elevation, gage height, and contents.
5. Daily-values tables.
6. Daily-values table for a reservoir station.
7. Station description.
8. Station analysis.
9. Station manuscript.
10. Level summary table.
11. Streamflow measurement data to be included on output of primary computations.
12. Discharge measurement and rating analysis.
13. Tide summary.

F. Sediment Output Tables

1. Constituent reporting order.
2. Sediment sample.
3. Additional information for an automatic sampler.
4. Bed material output.
5. Suspended-sediment table.
6. Total sediment.

7. Bedload sample.
8. Interpretive, concentration-curve file (daily continuous site-unit value)--water year.
9. Sediment discharge measurements summary for each station--water year.
10. Suspended-sediment record output for a station, mean concentration and load--water year.
11. Suspended-sediment record, mean concentration, sediment, and water discharge--water year.
12. Particle-size distribution of suspended sediment--water year.
13. Station description, sediment record.
14. Station analysis, sediment--water year.

G. Master Water Data Index Output Tables

The tables of statistical summaries of water data for USGS, as found in the 1989 User Group document, were prepared cooperatively by the Office of Water Data Coordination (OWDC) and the National Water Data Exchange (NAWDEX). The statistical tables are currently used in OWDC, and will be standard defaults in NWIS-II. These tables also will be user definable.

1. Master Water Data Index listing--General information.
2. Number or sites for each State, country, or territory by type of site and type of data.
3. Number of sites for each State and county by type of data.
4. Number of sites by hydrologic unit and type of data.
5. Number of sites for each State, country, or territory by organization and type of data.
6. Number of sites for each State, country, or territory by organization and type of data, sorted by State, country, and territory.
7. Number of sites for each State, country, or territory by parameter and frequency of measurement. Listed for each State, country, or territory individually with the name of the area listed prior to any parameter names. Numbers for days measured will be determined by NAWDEX.
8. Number of all sites by water-data parameter and frequency of measurement. Numbers for days measured will be determined by NAWDEX.
9. Number of surface-water data sites for each State, country, or territory by type of site and period of record. Sorted by State, country, and territory. If total is listed in Type of site, all sites in that subcategory will be totaled and shown in the corresponding column.
10. Number of ground-water data sites for each State, country, or territory by type of site and period of travel, sorted by State, country, or territory.
11. Number of ground-water quality data sites for each State, country, or territory by type of site and period of record, sorted by State, country, and territory. If total is listed in Type of site, all the sites in that subcategory will be totaled and shown in the corresponding column.
12. Number of stream sites for each site, country, or territory by drainage area, sorted by State, country, and territory.
13. Number of sites by source organization and type of data.
14. Number of sites for each State and county by type of site--sorted by State and county within the State.
15. Number of sites for each State, country, or territory by organization and type of site--sorted by State, country, and territory.
16. Number of sites for each State, country, or territory by parameter and type of site.

H. Biological Output Tables

1. Laboratory experiment measured values associated with taxa, includes taxonomic name, starting condition, ending condition, and analysis dates.
2. Measured values and analyzed values associated with taxa.
3. Taxa and associated QW parameters.
4. Occurrence of specified taxonomic names from the data base.
5. Taxonomic-retrieval, including subtable that reads the NODC taxa checklist.
6. Taxonomic (biological) quantification, includes taxa names and counts and species diversity.
7. Project description (probably through AIS).

I. National Water-Quality Assessment Tables

1. Major metals and trace elements targeted for analysis in tissues collected in the NAWQA Program and currently analyzed in existing tissue analysis programs of national scope.
2. Synthetic organic compounds targeted for analysis in tissues collected in the NAWQA Program and currently analyzed in existing tissue analysis programs of national scope.
3. Semivolatile, methylene-chloride extractable target compounds to be determined in the <2 millimeter fraction of selected bed-material samples from the surface-water part of the NAWQA Program.
4. Target organochlorine compounds to be determined in the <2 millimeter fraction of selected bed-material samples from the surface-water part of the NAWQA Program.
5. Target acid-extractable organic compounds to be determined in selected surface-water samples of the NAWQA Program.
6. Target organophosphorus insecticides to be determined in selected surface-water samples of the NAWQA Program.
7. Target carbamate pesticides to be determined in selected ground-water samples of the NAWQA Program.
8. Target triazine and other nitrogen-containing herbicides to be determined in selected surface- and ground-water samples from the NAWQA Program.
9. Target chlorophenoxy acid herbicides to be determined in selected surface- and ground-water samples of the NAWQA Program.
10. Target volatile organic compounds to be determined in selected surface- and ground-water samples of the NAWQA Program.

J. Climatological Output

1. Rainfall summary
2. Snow course summary
3. Soil moisture survey

Appendix K: Annotated Entity List

For each high-level entity group shown on the entity-relationship diagram in the Data Base Description in Chapter 4, additional details of the NWIS-II Logical Data Model are listed below. For each high-level entity group, the list includes a description of the entity group, the list of relationships with the other entity groups, and the decomposition to low-level entities of the logical data model that are part of the entity group. The decomposition of the list of entities includes the major entities (kernel entities), association entities, entity subtypes (characteristic entities), and definitions of all of the entity types.

Entity Group Name

Description Description of the high-level Entity Group.

Relationships RELATIONSHIP NAME **nature of relationship (cardinality)** Related Entity Group

Decomposition Entity Name of lower-level data dictionary—Definition of Entity.
Association Entity Name [Association: first related entity name ⇔ second related entity name]—Definition of Association Entity.
Subtypes Characteristic Entity Name—Definition of Subtype Entity.

ACTIVITY

Description An Activity is a task done by WRD to accomplish its mission objectives. Activities relate to all of the other information in NWIS II. Each Activity has an activity record with one party and one project; each activity type employs one procedure. Types of activities range from simple ones like the collection of a water sample from a stream to complex ones like a multi-step lab process. Activity types can be combined with other activity types in an activity record, or activity records may be related to other activity records.

Relationships
IS RELATED TO **zero, one, or many** other Activities
OCCURS AT **zero, one, or many** Activity Locations
DETERMINES **one or many** Activity Locations
EMPLOYS **zero, one, or many** (pieces of) Equipment
MAINTAINS **zero, one, or many** (pieces of) Equipment
EMPLOYS **zero, one, or many** Features
CHARACTERIZES **zero or one** Feature
EMPLOYS **zero or one** Procedure of a Method
IS CONDUCTED BY **one or many** Parties
IS PART OF **one or many** Projects
ANALYSES **zero, one, or many** Samples
RESULTS IN **zero, one, or many** Samples
EMPLOYS **zero, one, or many** Values
RESULTS IN **zero, one, or many** Values

Decomposition
Activity Record—The time or time interval, party, and project associated with a specific WRD activity, such as sample collection or feature measurement.
Activity Record Association [Association: Activity Record ⇔ Activity Record]—The association of activity records to other activity records.
Construction—An activity for constructing facilities and structures at a feature event point.
Data Analysis—An activity for analyzing data relationships or of synthesizing other data that may characterize a feature.
Equipment Adjustment—An activity for adjusting a piece of equipment.
Equipment Maintenance—An activity for documenting the location and maintenance of a piece of equipment.
Event Point Determination—An activity during which the offset from a reference location (event point) is determined.
Feature Measurement—An activity for directly obtaining values from a feature at an event point.
Feature Test—An activity to affect a feature at a feature event point. A feature test may be associated to feature measurements with an activity record association.
Reference Location Determination—An activity during which the latitude, longitude, and altitude of a reference location are determined.
Sample Analysis—An activity that determines values from a sample. Associates a sample with an analytical method (relates the analytical services request and the procedure used for analysis).
Sample Collection—An activity for obtaining a sample from a feature at an event point.
Sample Preparation—An activity that subdivides, composites, or prepares a sample for analysis.
Shipment—An activity for transporting containers or contained samples from one party to another party.

ACTIVITY LOCATION

Description The location at which an activity occurs. Most Activities have an associated location, which is a Reference Location and an Event Point (an offset from the Reference Location). In many instances the Activity Location is quite specific, whereas in other instances the exact location is not required and the location is described by text.

Relationships IS THE LOCATION FOR **one or many** Activities
IS DETERMINED BY **zero, one, or many** Activities
CHARACTERIZES **one or many** Features
IS OWNED BY **zero, one, or many** Parties

Decomposition Event Point—A descriptive or quantitative offset from a reference location that defines the position at which sample collection, feature measurement, or other activity occurs. Offsets may be described in one of three ways: (1) as absolute displacements in 3-dimensional space, (2) as vectors (distance and direction), or (3) descriptively.

Event Point Ownership [Association: Event Point ⇔ Party]—The association between the land property at an event point and its legal owner(s). Includes the beginning and end dates of the period of ownership.

Feature Event Point [Association: Feature ⇔ Event Point]—The explicit association of a feature with an event point where the feature is measured or sampled, or where some other activity occurs with the feature as the subject of that activity.

Feature Event Point Name—A name or designation of a feature event point.

Grid—A 2- or 3-dimensional series of points, equally-spaced in a given direction, with orthogonal axes, at which samples are collected and/or measurements are made. 2-D grids may be oriented either tangential or normal to the earth's surface. The x-y plane of a grid is always tangential to the earth's surface, and the z-axis is always normal to the earth's surface. A grid's origin is always at a feature event point. A 2-D grid oriented normal to the earth's surface is a cross-section.

Network Node—The endpoint of a conveyance that is a point of inflow or outflow. All conveyances have two and only two network nodes, one at each end. A network node may have one or many conveyances starting and/or ending at it, so it is also a point of confluence. A network node that is only a "to" node is a sink, and a network node that is only a "from" node is a source.

Reference Location—A geographic location represented by a point at or near the earth's surface at which latitude, longitude, and altitude are determined.

Reference Map—A published map used to determine a reference location, other than a USGS quadrangle.

Sample Grid Location [Association: Sample ⇔ Grid]—The location (x-, y-, and z-nodes) on a grid at which a sample is collected.

Sample Transect Location [Association: Sample ⇔ Transect]—The location (node) on a transect at which a sample is collected.

Transect—A series of linear equally-spaced points originating at a feature event point at which samples are collected and/or measurements are made. Transects with unequal interval lengths may be created by computing the smallest common interval length for the entire transect and not associating any samples and/or values to the "blank" nodes or intervals.

USGS Quadrangle—A U.S. Geological Survey standard topographic-series quadrangle map.

Value Grid Location [Association: Value ⇔ Grid]—The location (x-, y-, and z-nodes) on a grid at which a value is obtained.

Value Transect Location [Association: Value ⇔ Transect]—The location (node) on a transect at which a value is obtained.

CONSTITUENT

Description A constituent is a physical, chemical, or biological variable, element, compound, or material that is observed measured, analyzed, or computed. Constituents characterize values; are part of parameters, control solutions, data checks, and reporting groups; and are associated with procedures. Analytical quality control limits and detection limits are related to constituent-procedures (constituents associated with the analytical procedures for determining them).

Relationships CHARACTERIZES **zero, one, or many** Values

Decomposition Algorithm Constituent [Association: Constituent ⇔ Algorithm]—The constituent used in an algorithm, for example, a cation used for cation-anion balance determination.

Analytical Interference [Association: Constituent ⇔ Constituent-Procedure]—A physical or chemical constituent that interferes with the analysis of a constituent analyzed by a procedure.

Analytical Services Request Control Solution [Association: Analytical Services Request ⇔ Control Solution]—A control solution associated with an analytical services request.

Constituent—A physical, chemical, or biological variable, element, compound, or material.

Subtypes Chemical Constituent—A constituent type for a chemical element or compound.

Constituent Name [Association: Constituent ⇔ Party]—The name of a constituent assigned by a party.

Constituent Procedure [Association: Constituent ⇔ Procedure]—The association of a constituent and a procedure, such as temperature measured by direct reading or benzene analyzed by mass-spectrometry.

Constituent Procedure Quality Control Limit [Association: Constituent-Procedure ⇔ Party]—The quality control (QC) limits established for a constituent procedure by a party. Includes such attributes as percent recovery of spike and the detection limit assigned.

Constituent Report Heading—A text field of the constituent name for a heading on a report.

Control Solution—A solution prepared by chemists in a laboratory for testing the accuracy and precision of results obtained from analysis of samples.

Data Check—The regulatory and quality control check assigned to a constituent by a party. A check may be a drinking water limit, a cancer risk limit, etc. There may be multiple checks per constituent.

Data Check Association [Association: Data Check ⇔ Data Check]—The association of data checks. Used to group data checks for project or logical reasons.

Data Check List [Associations: Data Check ⇔ Project ⇔ Feature Event Point]—The data check associated with a project at a feature event point.

Detection Limit—The minimum value of a constituent that can be quantitated for a procedure run on a piece of equipment.

Parameter [Association: Constituent ⇔ Sample Preservation Method, Sample Preparation Method, Reporting Units, Reporting Form]—A combination of constituent, matrix, phase, and other qualifiers that characterizes values in NWIS-I.

Reporting Group—A laboratory grouping of constituents done by one or more procedures for making quality control comparisons.

Reporting Unit—The dimensional unit of the value of a constituent-procedure. Examples: ug/L, ft/sec, pure number, ft.

Sample Preparation Control Solution [Association: Sample Preparation ⇔ Control Solution]—The control solution used in a sample preparation.

Solution Constituent [Association: Control Solution ⇔ Constituent]—A constituent used in a control solution.

CITATION

Description A document or personal communication that may describe the use of equipment types or provide a description of methods. A personal communication citation is provided by a party.

Relationships DESCRIBES **zero, one, or many** (pieces of) Equipment
DOCUMENTS **zero, one, or many** Methods
IS PROVIDED BY **zero or one** Party

Citation—A document or personal communication that may describe the use of equipment types or provide a description of methods. A personal communication citation is provided by a party.

Equipment Type Citation [Association: Equipment Type ⇔ Citation]—A citation associated with an equipment type.

EQUIPMENT

Description Equipment includes both general types of equipment and specific pieces of equipment. Documentation of equipment includes location, maintenance, and adjustment of pieces of equipment; and the pieces of equipment used for each activity.

Relationships IS MAINTAINED DURING **zero, one, or many** Activities
IS EMPLOYED DURING **zero, one, or many** Activities
IS DESCRIBED BY **zero, one, or many** Citations
IS EMPLOYED BY **zero, one, or many** Methods

Decomposition Equipment—A device or instrument employed or maintained during an activity that is characterized by an equipment type.

Equipment Adjustment Equipment [Association: Equipment Adjustment ⇔ Equipment]—A piece of equipment employed to adjust another piece of equipment.

Equipment Maintenance Equipment [Association: Equipment Maintenance ⇔ Equipment]—A piece of equipment used to maintain another piece of equipment.

Equipment Type—A category of instruments or devices that is employed for a procedure. Equipment types may be described in citations and may contain other equipment types.

Equipment Type Association [Association: Equipment Type ⇔ Equipment Type]—The association of an equipment type with another equipment type.

Event Point Determination Equipment [Association: Event Point Determination ⇔ Equipment]—A piece of equipment used for an event point determination.

Feature Measurement Equipment [Association: Feature Measurement ⇔ Equipment]—A piece of equipment employed during a feature measurement activity.

Feature Test Equipment [Association: Feature Test ⇔ Equipment]—The piece of equipment employed during a feature test.

Reference Location Determination Equipment [Association: Reference Location Determination ⇔ Equipment]—A piece of equipment used during the determination of a location.

Sample Analysis Equipment [Association: Sample Analysis ⇔ Equipment]—A piece of equipment used during a sample analysis activity.

Sample Collection Equipment [Association: Sample Collection ⇔ Equipment]—A piece of equipment used during a sample collection activity.

Sample Preparation Equipment [Association: Sample Preparation ⇔ Equipment]—A piece of equipment used during a sample preparation activity.

FEATURE

Description Information about physical, conceptual, political, or other objects that may be sampled or measured, or be the subject of any other activity. Intervals, logs, stratigraphic units, and associations with Activities and Parties are included.

Relationships
IS CHARACTERIZED DURING **zero, one, or many** Activities
IS EMPLOYED DURING **zero, one, or many** Activities
IS CHARACTERIZED AT **zero, one, or many** Activity Locations
IS RELATED TO **zero, one, or many** Features
IS OWNED BY **zero, one, or many** Parties
IS MANAGED BY **zero, one, or many** Parties

Decomposition
Casing Interval—Dimensions and description of an interval of casing installed in a well.
Control—The mechanism which governs the stage discharge relationship in a section of a stream.
Feature—A physical, conceptual, political, or other object that may be sampled or measured, or be the subject of any other activity.

Subtypes Borehole/Well—(1)A circular hole made by boring, in particular a deep hole of small diameter, such as an oil well or a water well. (2)A dug or drilled hole designed for the extraction of ground water. A well may extract oil or gas, or inject water into the ground, or be used for some other purpose. Describes generalized well characteristics. Includes well types such as collector, and interconnected.

Subtypes Collector Well—Generally a large diameter well with a number of horizontal laterals pushed out into the aquifer to tap it. A Ranney-type well.

Congressional District—Any of the districts of each state of the United States, entitled to one representative in Congress.

Country—The political nation for which the U.S. Geological Survey collects and maintains hydrologic information. Identified by the Federal Information Processing Standard code.

County—A political-territorial division of local government within a country or U.S. State. Identified by the Federal Information Processing Standard code.

Conveyance—A water-transporting feature along which distributed losses or gains may occur. Each conveyance is defined by points of inflow or outflow (network nodes). Measurements may be made at the endpoints of a conveyance, at any point along a conveyance, or may represent the entire conveyance. Many water features are composed of a series of conveyances in explicit association.

Drain Pipe—A tile or pipe installed to intercept the water table or potentiometric surface to either lower the ground-water level, or serve as a water supply.

Gage—A feature, physical structure, where hydrologic data are obtained on flowing or ponded bodies of water.

Subtypes Auxiliary Supplemental Gage [Association: Stage Gage ⇔ Stage Gage]—A alternate gage used with or in place of a main gage to compute discharge. A self-association entity on stage gage.

Stage Gage—A type of stream gage, where gage height and discharge data are obtained.

Subtypes Discharge Gage—A subtype of stage gage at which discharge data are computed.

Hydrogeologic Unit—(1) Any soil or rock unit or zone that by virtue of its hydraulic properties has a distinct influence on the storage or movement of ground water (after ANS, 1980). (2) Any soil or rock unit or zone that by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of ground water (10 CPR Part 6.2). Includes aquifers and confining units.

Hydrologic Unit—A geographic area representing parts or all of a surface-drainage basin used for the collection and organization of data dealing with the properties, distribution and circulation of water.

Interconnected Well Group—Also called connector well. Wells that are connected below the water table so as to essentially act as a single well. Typically used to recharge one aquifer from another under ambient head conditions.

Military Reservation—An area restricted for military use such as an Air Force Base.

Miscellaneous Facility—Man-made facilities or structures not documented by other facility types.

Municipality—A city, town, or other primary urban political unit having corporate status and usually powers of self government. Identified by the Federal Information Processing Standard code.

Open Interval—The open interval describes one instance of where and how the well is open to the surrounding earth, such as perforated or slotted pipe, screen, or open hole.

Pipe—A tubular conduit of substantial length with pumps, valves, and other control devices for conveying fluids, gasses, or finely divided solids.

Political Management Area—An entity identifying any organization of political features about which WRD collects information, such as Water Management Districts, Regional Planning Areas, etc.

Power-Generating Plant—A facility that produces electrical power from raw materials, such as a coal burning plant or nuclear power plant.

Reservoir—A storage place for water, either natural or created in whole or part by the building of engineering structures, from which water may be withdrawn. A constructed water body formed by impoundment for recreational use, storage, treatment, collection, or processing of water.

River Reach—An entity containing information about the EPA river reach

Spring—A type of water feature at which water either sometimes or continuously flows from underground to the surface.

State—A politically-organized body of people usually occupying a definite territory. Identified by the Federal Information Processing Standard code.

Stream—A linear body of water flowing on the Earth's surface (anabranch, arroyo, awawa, bayou, bend, branch, brook, canal, channel, creek, distributary, gut, fork, kill, pup, rio, river, run, slough) (U.S. Geological Survey, 1987, US GeoData Geographic Names Information System Data Users Guide, National Mapping Program Technical Instructions Data users Guide 6, 30 p.).

Study Area—An area defined by the user during a study for characterization of features, samples, or other objects.

Sub Basin Unit—An entity containing information about a subunit of a cataloging unit. The subbasin is a geographical area representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature.

Transportation Corridor—A linear feature used for transporting people and materials such as a highway or railroad.

Waste Disposal Site—An area where waste materials are placed.

Well Field—A feature in which wells located in close proximity and discharging to a single common outlet are grouped together. The well field identifies all the individual wells used in a particular hydrologic activity.

Wetland—Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.

Wildlife Area—A political- or species-bounded area for wild plants or animals.

Feature Employment [Association: Feature ⇔ Activity]—The employment of a feature during a WRD activity, such as the use of a well to collect a ground-water sample.

Feature Ownership [Association: Feature ⇔ Party]—The time-based association between the land property at a feature and its legal owner(s).

Fill Interval—Materials placed in a well, other than casing and screen, such as surface or casing seals, sand and gravel packs or envelopes, backfill, plugs, and packers. Terms included under fill are casing seal, surface seal, seal, plug, packer, and backfill; also gravel, sand, and filter pack or envelope.

Geologic Unit—A unit defined by the USGS to identify a geologic formation. Based on age.

Geologic Unit Open Interval [Association: Geologic Unit ⇔ Open Interval]—The association between geologic units and open intervals on a well.

Geologic Unit Hydrogeologic Unit Association [Association: Hydrogeologic Unit ⇔ Geologic Unit]—An association entity identifying the hydrogeologic units and the geologic units associated with that hydrogeologic unit.

Hole Diameter Interval—The geometry of the hole put down for the well, describing the hole for a particular interval.

Hydrogeologic Unit Open Interval [Association: Hydrogeologic Unit ⇔ Open Interval]—The association between hydrogeologic units and open intervals on a well.

Hydrogeologic Unit Spring [Association: Hydrogeologic Unit ⇔ Spring]—The association of hydrogeologic units and their percentage of contribution to a spring's discharge.

Interconnection [Association: Well ⇔ Interconnected Well Group]—The association of wells that are in an interconnected well group.

Lateral—A near-horizontal screened intake conduit for a collector or Ranney-type well. A collector well has a number of horizontal laterals pushed out into the aquifer to tap it.

Lithologic Modifier—An entity use to define a lithologic unit. The entity contains the identifier for the major unit and a modifier.

Lithology—An entity, reference list, identifying the possible lithologic units used to define a rock.

Measuring Section—A stream cross-section where a discharge measurement is made.

Subtypes Cable Way—A special type of measuring section located at a stream cross section, used during the making of a discharge measurement.

Stratigraphic Log—Information about the use and type of logs for interpretation of stratigraphy for wells and boreholes.

Subtypes Geologic Unit Log [Association: Stratigraphic Log ⇔ Geologic Unit]—An entity describing the geologic units for an interval

Hydrogeologic Unit Log [Association: Stratigraphic Log ⇔ Hydrogeologic Unit]—The association between the stratigraphic log and the hydrogeologic unit.

Lithology Log [Association: Stratigraphic Log ⇔ Lithology]—An entity identifying information on the lithology of an interval within a stratigraphic log.

Subbasin Association—An association entity that identifies subbasins which are part of other subbasins and which make up other subbasins.

METHOD

Description The information about algorithms, methods, procedures, groups of procedures, procedure replacements and call-ins; and associations between procedures and other entities including pieces of equipment used.

Relationships IS EMPLOYED DURING **zero, one, or many** Activities
IS DOCUMENTED BY **zero or one** Citation
EMPLOYS **zero, one, or many** (pieces of) Equipment

Decomposition Algorithm—A set of well-defined rules used to transform values in a number of steps (for example, a complete procedure for computing an arithmetic mean). An algorithm is identified by type and dates of use, and a bibliographic citation.

Analytical Interference Procedure [Association: Analytical Interference ⇔ Procedure]—The association of an analytical interference with a procedure.

District Analysis Group—A group of procedures for a district to document analyses to be performed for samples during a period of time.

District Analysis Group Procedure [Association: District Analysis Group ⇔ Procedure]—The association of a constituent procedure and a district analysis group.

District Analysis Group Projection [Association: District Analysis Group ⇔ Party ⇔ Feature Event Point]—The projected use of a district analysis group at a feature event point.

Equipment Procedure [Association: Equipment ⇔ Procedure]—The procedure performed by a piece of equipment.

Filter—The description and pore size of a filter.

Laboratory Procedure [Association: Organization (laboratory) ⇔ Procedure]—A procedure implemented by a laboratory.

Method—A set of instructions (usually approved by WRD) that has more than one procedure; a procedure is employed during an activity. A method may include use of equipment types and may be further described in a citation.

Subtypes Sample Preparation Method—A method used to subdivide or composite a sample, or to prepare a sample for analysis.

Sample Preservation Method—A method used by field personnel to preserve a sample.

WRD Analytical Method—A method identified by the USGS, WRD, NWQL for analyzing samples. Includes a general analytical method, a preservation method, and a preparation method; or a general analytical method, a matrix, and a phase.

Method Name—An name or designation given to a method.

Procedure—The part of an approved method that is used for a constituent or a reporting group.

Procedure Call In—The procedure called in by a laboratory for another procedure.

Procedure Replacement—The procedure selected by a laboratory to replace a requested procedure.

Reporting Group Procedure [Association: Reporting Group ⇔ Procedure]—The constituent-procedure combination that is part of a laboratory reporting group.

Sample Preparation Procedure [Association: Sample Preparation ⇔ Procedure]—The procedure associated with a sample preparation.

Standard Operating Procedure—A standard operating procedure (SOP) used for a procedure. SOP differs from a procedure in that it is an implementation of an established procedure (which is part of an approved method).

Supply Quality Control—The quality control done by the NWQL on supply materials.

Worksheet Line—A group of procedures established by a laboratory for production purposes.

Worksheet Line Procedure [Association: Worksheet Line⇔ Procedure]—The procedure associated with a worksheet line.

PARTY

Description Parties are individual persons, groups of people, or organizations who may conduct activities, own features or activity locations, provide citations, or participate in projects related to information maintained in the NWIS-II data base. Organizations, persons, and parties are associated with other entities.

Relationships
CONDUCTS **zero, one, or many** Activities
OWNS **zero, one, or many** Activity Locations
PROVIDES **zero, one, or many** Citations
MANAGES **zero, one, or many** Features
OWNS **zero, one, or many** Features
IS RELATED TO **zero, one, or many** other Parties
PARTICIPATES IN **zero, one, or many** Projects

Decomposition
Ad-hoc Party Association [Association: Ad-hoc Party ⇔ Ad-hoc Party]—An association of ad hoc parties.
Address—The location at which a particular organization or person can be contacted.
Equipment Analyst [Association: Party ⇔ Equipment]—The analyst who uses a piece of laboratory equipment during a period of time.
Laboratory Catalog—A catalog of laboratory information about sample analysis, preservation requirements, and supplies.
Membership [Association: Person ⇔ Party]—A person or persons who belong to a party.
Organization—A group of persons organized for a purpose. Includes international, federal, State, local, and other agencies; universities, non-profit organizations; and incorporated and unincorporated companies. This organization interacts with the USGS in some manner. Interactions may include performing work, paying for work, supplying data, owning property on which the USGS performs work, or being some part of the USGS.
Organization Address [Association: Organization ⇔ Address]—The association of an address and an organization.
Organization Association [Association: Organization ⇔ Organization]—An association of parent child organizations.
Party—A person, group of persons, or organization who may conduct activities, own features or event points, provide citations, or manage projects related to information maintained in the NWIS-II data base.
Subtypes Ad-hoc Party—A collection of people grouped together to perform an activity.
Person—A human being involved in any of the activities within the NWIS-II data base. Note: Privacy Act requirements may apply to any information about a person.
WRD Organization—The collection of attributes which are shared with the AIS system and describe DOI, USGS, and WRD organizations such as Districts, Regions, and offices.

PROJECT

Description A Project is an officially recognized and funded WRD task that is the basis for Activities. A Project authorizes Values and is conducted by a Party. Projects are associated with other Projects and with Persons.

Relationships
IS THE BASIS FOR **zero, one, or many** Activities
IS CONDUCTED BY **one** Party
IS RELATED TO **zero, one, or many** other Projects
AUTHORIZES **one or many** Values

Decomposition Project—An officially recognized and funded WRD task that is the basis for Activities. A project authorizes values and is conducted by a party.

Project Association [Association: Project ⇔ Project]—The association of a project with another project. Allows hierarchal or other relationships of projects.

Project Person [Association: Project ⇔ Person]—A person associated with a project.

SAMPLE

Description Sample information includes samples, containers, shipment of contained samples, samples used in Activities, analytical requests, special handling of samples, and status of samples.

Relationships RESULTS FROM **one** Activity
IS ANALYZED BY **zero, one, or many** Activities

Decomposition Analytical Request [Association: Analytical Services Request ⇔ Procedure]—The association of a sample sent to a laboratory (designated by an analytical services request) and an analytical procedure. Includes identification of status, due date, source of request, billed price, and release date.

Analytical Request Association [Association: Analytical Request ⇔ Analytical Request]—The association of analytical requests.

Analytical Services Request—A request sent to a laboratory for constituent analyses of a single sample (formerly SMS-EASR).

Analytical Services Request District Analysis Group [Association: Analytical Services Request ⇔ District Analysis Group]—The association of a District Analysis group with an analytical services request.

Contained Sample—A part of a sample put in a container.

Contained Sample Shipment [Association: Contained Sample ⇔ Shipment]—The containers of samples transported during shipments.

Contained Sample Supply Quality Control [Association: Contained Sample ⇔ Supply Quality Control]—The supply quality control(s) associated with contained sample(s).

Container Type—A type of container used to hold samples, such as a box, bottle, tube, or shipping carton.

Custody Record—A record of the dates and times that a sample was in the custody of a party.

Equipment Adjustment Sample [Association: Equipment Adjustment ⇔ Sample]—A sample used during the adjustment of a piece of equipment.

Procedure Container Type [Association: Procedure ⇔ Container Type]—A container type associated with a procedure.

Sample Preparation Sample [Association: Sample Preparation ⇔ Sample]—A sample used during a sample preparation activity.

Sample—A material or conceptual result of sample collection that may be representative of a feature. A sample may be prepared, and may be analyzed for values. A sample includes the concept of zero result for a sample collection attempt.

Sample Reporting Group Status—The status of a laboratory reporting group for a sample; e.g., logged, pending, analyzed, released, etc.

Special Handling—Documentation of actions requested by user for sample handling at a laboratory.

VALUE

Description Values are quantitative or qualitative results obtained from feature measurement, sample analysis, data analysis, or assignment of descriptor points.

Relationships IS THE RESULT OF **zero, one, or many** Activities
IS EMPLOYED DURING **zero, one, or many** Activities
IS CHARACTERIZED BY **one** Constituent
IS AUTHORIZED BY **one** Project

Decomposition Curve—A line or image that links points, usually as a 2-dimensional graph of two variables on a rectangular coordinate system.

Curve Descriptor Point [Association: Curve ⇔ Descriptor Point]—The association of a curve with a descriptor point.

Curve Offset—A value subtracted from the input constituent value throughout the range of the curve. Used only for curves defined with descriptor points and an interpolation type of log.

Data Analysis Value [Association: Data Analysis ⇔ Value]—The value used in a data analysis activity.

Descriptor Point—A point on a curve determined by the cartesian intersection of an x-axis value and a y-axis value. All of the descriptor points are the are the line-segment end-points of the curve. Descriptor points are not the values calculated by using the curve but rather the points that define it.

Descriptor Point Data Analysis [Association: Descriptor Point ⇔ Data Analysis]—The association of a descriptor point and a data analysis activity.

Effective Date—The dates for which a curve is used.

Laboratory Value Qualifier—Information about a value kept by the NWQL. Documents review, deletion approval, computer file status and position.

Laboratory Value Quality Control—The quality control (QC) of a value specifically used by the NWQL for in-house standard reference standards (SRS). Includes identification of the control solution used to obtain the value.

Value—The quantitative or qualitative characterization of a feature or sample resulting from a feature measurement, sample analysis, data analysis, or assignment of descriptor points.