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Quality-Assurance Plan for Water-Quality Activities of the U.S. Geological Survey Montana Water Science Center

Open-File Report 2006–1275

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

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Compiled by John H. Lambing

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Conversion Factors, Abbreviated Units, and Acronyms

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
foot per second (ft/s)	0.3048	meter per second (m/s)
inch (in.)	25.9	millimeter (mm)
inch (in.)	0.0259	micron (µm)

Abbreviated units used in this report:

°C	degrees Celsius
ft/s	foot per second
g	gram
µg/L	microgram per liter
µS/cm	microsiemens per centimeter
mg/L	milligrams per liter
mm	millimeter
ppb	parts per billion

Acronyms and definitions used in this report:

ADAPS	Automated Data Processing System
ASR	Analytical Services Request
ASTM	American Society for Testing and Materials
BQS	Branch of Quality Systems
DI	deionized
D.O.	dissolved oxygen
DQI	data-quality indicator

EDI	equal-discharge increment
EWI	equal-width increment
FISP	Federal Interagency Sedimentation Program
HIF	Hydrologic Instrumentation Facility
ID	identification
JHA	job hazard analysis
LIMS	Laboratory Information Management System, National Water Quality Laboratory
MCL	Maximum Contaminant Level, U.S. Environmental Protection Agency
MDEQ	Montana Department of Environmental Quality
MSD	Material-safety data
NADP	National Atmospheric Deposition Program
NASQAN	National Stream-Quality Accounting Network
NAWQA	National Water-Quality Assessment
NELAP	National Environmental Laboratory Accreditation Program
NFQA	National Field Quality Assurance
NIST	National Institute of Standards and Technology
NRP	National Research Program
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
OSW	Office of Surface Water
OWQ	Office of Water Quality
ppb	parts per billion
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
QW	quality of water
QWDATA	quality-of-water database program of the NWIS Water-Quality System
SHA	site hazard analysis
SOP	standard operating procedure
SRS	standard reference sample
TWRI	Techniques of Water-Resources Investigations
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WATLIST	water analyses list (processed through QWDATA program)
WRD	Water Resources Discipline (formerly Water Resources Division)

Quality-Assurance Plan for Water-Quality Activities of the U.S. Geological Survey Montana Water Science Center

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Abstract

In accordance with guidelines set forth by the Office of Water Quality in the Water Resources Discipline of the U.S. Geological Survey (USGS), a quality-assurance plan has been created for use by the USGS Montana Water Science Center in conducting water-quality activities. This quality-assurance plan documents the standards, policies, and procedures used by the USGS Montana Water Science Center for activities related to the collection, processing, storage, analysis, and publication of water-quality data. The policies and procedures presented in this quality-assurance plan for water-quality activities complement the quality-assurance plans for surface-water and ground-water activities and suspended-sediment analysis.

1.0 Introduction

The U.S. Geological Survey (USGS) was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to perform the systematic and scientific "classification of public lands, and examination of the geologic structure, mineral resources, and products of the national domain." The Water Resources Discipline (WRD, formerly Water Resources Division) of the USGS is the Nation's principal source of water-resources information. The objectives of the WRD programs are to collect and provide unbiased, scientifically based information that describes the quantity and quality of waters in the Nation's streams, lakes, reservoirs, and aquifers. Water-quality activities of the USGS Montana Water Science Center (also referred to as the Center) are part of the overall WRD mission of appraising the Nation's water resources.

To provide quality assurance (QA) of water-quality activities, the WRD has implemented policies and procedures designed to ensure that all scientific work conducted by or for the WRD is technically reliable, consistent, and of documented quality. The Office of Water Quality (OWQ) is responsible for providing nationally consistent guidelines for preparing a water-quality QA plan (Schroder and Shampine, 1995; Schertz and others, 2002) that documents the policies and procedures that apply to the water-quality activities of each USGS State Water Science Center.

A QA plan is a formal document that describes the management policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation procedures for ensuring quality. Quality assurance, quality control, and quality assessment are all components of a QA plan. The terms are defined as follows:

- **Quality assurance (QA)**—The systematic management of data-collection systems using prescribed guidelines and criteria for implementing technically approved methods and policies. Quality assurance is achieved through a comprehensive plan that outlines the overall process for providing a product or service that will satisfy the given requirements for quality.

- **Quality control (QC)**—The specific operational techniques and activities used to obtain the required quality of data. Quality control consists of the application of technical procedures to achieve prescribed standards of performance and to document the quality of collected data. Quality-control data that do not meet required standards are used to evaluate and implement corrective actions necessary to improve performance to acceptable levels.

- **Quality assessment**—The overall process of assessing the quality of environmental data by reviewing (1) the appropriate implementation of QA policies and procedures and (2) analyzing the QC data. Quality assessment encompasses both the measurable and unmeasurable factors that affect the quality of environmental data. Assessment of these factors may indicate limitations that require modifications to protocols or standard operating procedures for sample collection and analysis, or that affect the desired interpretation and use of the environmental data.

Quality-assurance, quality-control, and quality-assessment systems are integrated processes that jointly ensure that

data-quality objectives are identified and incorporated into all levels of water-quality activities. By integrating these components into a discipline-wide QA guidance document (Schertz and others, 2002), the OWQ hopes to enhance water-quality data collected by the USGS by providing for the following:

- **Consistency** in data quality across all levels of the WRD;
- **Accountability** to clients, the scientific community, regulatory agencies, and the general public;
- **Comparability** of results among samples, sites, and laboratories;
- **Traceability** from the end product back to its origins, and to all supplementary information, through written records;
- **Application** of appropriate and documented techniques that repeatedly lead to similar results;
- **Representativeness** of the data in describing the actual chemical composition of the biological or physical conditions at a sampling site for a given point or period in time; and
- **Adequacy** of the amount of data obtained to meet data objectives.

1.1 Purpose and Scope

The purpose of this QA plan for water-quality activities of the USGS Montana Water Science Center is to document the standards, policies, and procedures used by the Center for activities related to the collection, processing, management, analysis, and publication of water-quality data. This plan identifies responsibilities for ensuring that stated policies and procedures are carried out. The plan also serves as a guide for all Center personnel who are involved in water-quality activities and as a resource for identifying memoranda, publications, and other literature that describe associated techniques and requirements in more detail.

The scope of this QA plan includes discussions of the policies and procedures followed by the Center for the collection, processing, analysis, storage, and publication of water-quality data. Although procedures and products of interpretive investigations are subject to the criteria discussed in this plan, some interpretive investigations may be required to have separate and complete QA plans. The policies and procedures documented in this QA plan for water-quality activities are intended to update the previous Center QA plan for water-quality activities (Knapton and Nimick, 1991). This report also complements the QA plans for surface-water (White and others, 1998) and ground-water (Brunett and others, 1997) activities and suspended-sediment analysis (Dodge and Lambing, 2006), and supplements the overall QA plan for all activities of the Center (Moreland, 1995).

2.0 Organization and Responsibilities

Quality assurance is an active process of achieving and maintaining high-quality standards for water-quality data. Consistent data quality requires specific actions that are carried out systematically in accordance with established policies and procedures. Errors and deficiencies can result when individuals fail to carry out their responsibilities. Clear and specific statements of responsibilities promote an understanding of each person's duties in the overall process of ensuring the quality of water-quality data.

2.1 Organizational Chart

The organizational structure of the USGS Montana Water Science Center is similar to those of other Centers, but different program requirements among Centers contribute to the uniqueness of these organizational structures. The following chart illustrates the organization of personnel in the USGS Montana Water Science Center as of July 2006 (fig. 1).

2.2 Responsibilities

The final responsibility for the preparation, implementation of, and adherence to the QA policies that are described in this QA plan lies with the Director of the USGS Montana Water Science Center (Schroder and Shampine, 1992, p. 7). Following is a list of responsibilities for selected Center personnel who are involved in the collection, processing, management, analysis, and publication of water-quality data:

The Center Director and designated management personnel (Chief of the Hydrologic Investigations Section and Chief of the Hydrologic Surveillance and Analysis Section) are responsible for:

1. Managing and directing the Center program, including designation of personnel responsible for managing all water-quality activities;
2. Ensuring that water-quality activities in the Center conform to the mission of the USGS and meet the needs of the Federal government, cooperators, and the general public;
3. Ensuring that all aspects of this QA plan are understood and followed by Center personnel. This goal is accomplished by direct involvement of the Center Director or through clearly stated delegation of responsibility to other personnel in the Center;
4. Providing final resolution, in consultation with the Water-Quality Specialist, of any conflicts or disputes related to water-quality activities within the Center;
5. Keeping Center staff briefed on procedural and technical communications from Regional and Headquarters offices;

U.S. GEOLOGICAL SURVEY
MONTANA WATER SCIENCE CENTER

Robert Davis	Director
John Kilpatrick	Asst Director
Dave Briar	Hyd
James Pollard	InfoTechSpec

HYDROLOGIC SURVEILLANCE AND ANALYSIS SECTION

Wayne Berkas	SupvHyd

DATA MANAGEMENT UNIT

Mel White	HydTech
Pat Ladd	HydTech
Evonne Mitton	HydTech

WATER-QUALITY UNIT

Kent Dodge	HydTech
Terry Heinert	HydTech

INTERNATIONAL WATERS UNIT

Norm Midtlyng	HydTech
Don Bischoff	HydTech
Wayne Tice	HydTech

BILLINGS FIELD HEADQUARTERS

Tim Morgan	HydTech
Bruce Bochy	HydTech
Stacy Kinsey	HydTech
Kurt Ehrenberg	HydTech
Aroscott Whiteman	HydTech

FORT PECK FIELD HEADQUARTERS

John French	HydTech
Art Johnson	HydTech
Robert Legare	HydTech
Virginia Redstone	HydTech
Tyrel Brandt	HydTech

HELENA FIELD HEADQUARTERS

Steve Lynn	SupvHydTech
Phil Karper	HydTech
Kevin Sattler	HydTech
Steve Nichols	HydTech
Todd Schmitt	HydTech
Andy Skerda	HydTech

KALISPELL FIELD HEADQUARTERS

Lucky Sultz	HydTech
Jim Finley	HydTech
Greg Trunkle	HydTech
Kari Finley	HydTech

ADMINISTRATIVE SERVICES SECTION

Luanne Romasko	Admin Officer
Dorothy Barnett	Admin Ops Asst
Adrienne Jose	Budget Analyst

DISCIPLINE SPECIALISTS/MANAGEMENT

Ground Water	Mike Cannon
Surface Water	Wayne Berkas
Water Quality	John Lambing/David Nimick
Sediment	John Lambing
Flood Coordinator	Wayne Berkas/Mel White
Computer	Jim Pollard
Publications	Lori Tuck
Water Use	Mike Cannon
Real Time Data	Mel White
Aquifer Tests	Mike Cannon
Cableways	Steve Holnbeck
GeoInfoSystems	Dave Briar
Safety Officer	Craig Bowers
Training Officer	Dorothy Barnett
Contracting Officer	Dorothy Barnett

Database Managers:

Surface Water	Mel White
Ground Water	Joanna Thamke
Water Quality	Patricia Ladd
Water-Quality Lead Technician	Kent Dodge
Chemical Hygiene Officer	Craig Bowers

Abbreviations:
Admin, Administrative
Admin Ops Asst, Administrative Operations Assistant
Asst, Assistant
GeoInfoSystems, Geographic Information Systems
Hyd, Hydrologist
HydTech, Hydrologic Technician
InfoTechSpec, Information Technology Specialist
SupvHyd, Supervisory Hydrologist
SupvHydTech, Supervisory Hydrologic Technician

HYDROLOGIC INVESTIGATIONS SECTION

John Kilpatrick	SupvHyd

PUBLICATIONS UNIT

Lori Tuck	Hyd

ENVIRONMENTAL SCIENCES UNIT

John Lambing	Hyd
David Nimick	Hyd
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HYDRAULICS AND HYDROLOGY UNIT

Kathy Chase	Hyd
Steve Holnbeck	Hyd
Steve Sando	Hyd
Peter McCarthy	Hyd
Fred Bailey	HydTech
Bill Stotts	HydTech

Figure 1. U.S. Geological Survey Montana Water Science Center organizational chart, September 2006.

6. Participating in technical reviews of all water-quality projects on a quarterly basis;
7. Ensuring that all publications and other technical communications released by Center personnel are accurate and comply with USGS policy.

The Water-Quality Specialist or designated representative is responsible for:

1. Ensuring that water-quality activities in the Center conform to the mission of the USGS and meet the needs of the Federal government, cooperating State and local agencies, and the general public;
2. Preparing and implementing the Center water-quality QA plan;
3. Providing general oversight of operations in the Water-Quality and Sediment Laboratory;
4. Keeping Center personnel briefed on procedural and technical communications from Regional and Headquarters offices;
5. Providing detailed sampling instructions for all stations in the water-quality data program that outline the sample types, collection schedule, and QA samples to be submitted for quality control;
6. Providing assistance and oversight of water-quality activities during the planning stages of projects;
7. Participating in technical reviews of Center water-quality projects on a quarterly basis and basic-data programs on an ongoing basis;
8. Ensuring that all publications and other technical communications released by the Center that relate to and include water-quality information are accurate and comply with USGS policy; and
9. Ensuring that the Center water-quality QA plan is reviewed and revised at least once every 3 years to document current responsibilities, methodologies, and ongoing procedural changes.

Project chiefs are responsible for:

1. Managing and directing the project's field and laboratory water-quality activities;
2. Ensuring that the project's field and laboratory water-quality activities conform to the USGS mission and meet the needs of the Federal government, cooperating State and local agencies, and the general public;
3. Ensuring that all aspects of this QA plan that pertain to the project's field and laboratory water-quality activities are understood and followed by project personnel;
4. Obtaining guidance, as appropriate, for project quality-assurance/quality-control (QA/QC) activities from the Water-Quality Specialist;
5. Ensuring that QA/QC activities are properly carried out by the project staff.

The Water-Quality Database Manager is responsible for:

1. Maintaining a computerized record of all water-quality measurements and laboratory analyses in an organized, accessible, and secure manner;
2. Maintaining paper files of all records associated with water-quality results, activities, site information, and relevant data needed to ensure complete documentation;
3. Preparing site history files and archives to provide a systematic inventory of past data-collection activities;
4. Interacting with the National Water Quality Laboratory (NWQL) to track sample status, retrieve data, request reruns, and make updates; and
5. Interacting with project chiefs and the public by compiling data for various data inquiries and searches.

The Water-Quality Lead Technician is responsible for:

1. Ordering and distributing all water-quality supplies and equipment for the Center;
2. Maintaining an inventory of major water-quality equipment, including identification numbers, purchasing records, and location of items;
3. Implementing the annual National Field Quality Assurance (NFQA) Program and reporting results to the Water-Quality Specialist and Center management;
4. Providing day-to-day oversight of operations in the Water-Quality and Sediment Laboratory;
5. Providing assistance to projects and data programs in organizing necessary sampling materials, researching sources for specialized equipment, and testing of new instruments;
6. Training new employees, project personnel, and observers in basic water-quality procedures or the operation of water-quality instruments; and

7. Preparing observer contracts that specify the manner and frequency for collecting water-quality samples and payment rates.

2.3 References for the Organization and Responsibilities Section

Table 1 lists one report referred to in Section 2.0. For a complete citation, refer to Section 13.0 of the report.

Table 1. Summary of reference for organization and responsibilities related to quality assurance.

Reference	Subject
Schroder and Shampine, 1992	Guidelines for preparing a quality-assurance plan.

3.0 Project Planning

The Director of the USGS Montana Water Science Center has primary responsibility for overall program planning and is responsible for ensuring that projects support Center and national priorities. All water-quality project proposals require review and approval prior to the commencement of work. Quality-assurance requirements are integrated into the project proposal, either directly or by referencing publications and memoranda describing standard USGS protocols. Whether or not a separate QA plan will be required for a water-quality project will depend on the complexity of the work, the needs of the Center or cooperator, or other criteria as described in Shampine and others (1992).

3.1 Project Proposals

Project proposals are developed by Center personnel in response to requests by cooperating agencies (Federal, State, Tribal, or local governments); long-term or immediate information needs of resource-management agencies; or data needs for regional and national monitoring programs. Center project proposals conform to the format required by WRD's Central Region office located in Denver, Colo., as set forth on November 7, 2000, and amended on July 26, 2004.

Consultation with Regional Discipline Specialists is encouraged in the preparation of proposals and in the execution of projects. Each proposal must contain:

1. Summary of the project;
2. Statement of the problem or need for the study;
3. List of defined objectives—what will be done to help solve the problem;
4. Description of the relevance and benefits—how will the work support the goals of both the cooperator and the USGS;
5. Description of the approach to accomplish the objectives. The approach consists of a detailed outline of the data-collection activities to be carried out (if new data are needed), the QA plans, the QC information needed, the laboratory analytical techniques to be used, and the level of data analysis to be performed;
6. Description of products;
7. List of references;
8. Project time line that lists the major tasks and shows the duration of each activity and expected completion dates;
9. List of personnel requirements;
10. Budget; and
11. Description of safety issues, including job hazard analyses (JHAs).

Review of project proposals is given high priority. Project proposals are reviewed by the Chief of the Hydrologic Investigations Section and, at the discretion of the Center Director, may be sent to the Chief of the Hydrologic Surveillance and Analysis Section and to other Centers for review. Personnel in the Central Region Program Office for Water provide final review and approval of all project proposals generated by the Center.

3.2 Project Workplans

Project workplans are developed for each project proposal. The project chief prepares a detailed description of all project activities and the related technical methods and approaches that are necessary to satisfy project objectives. The workplan links project personnel, tasks, and functions with associated funds and indicates the projected dates for on-time completion of each activity and, ultimately, the project. Workplans for projects having water-quality components need to include references to the Center's QA Plan for Water-Quality Activities as the guideline for standard QA practices. Variations in standard practices will be identified and clearly described.

Descriptions of the methods and approaches to be used for the technical elements of the project include, for example, the design of a strategy and schedule for environmental sample collection to meet the study objectives. Any new or unapproved field and laboratory methods that will be used must be described in detail. The workplan lists the environmental sampling locations, frequency of sampling, a description of the sample types and laboratory analyses to be performed, and the expected uses of the information to address the technical issues of the project. Workplans state anticipated methods for

data analysis and presentation, including plans for any report products.

Workplans also include a description of the design of QC sampling (Shampine and others, 1992) that is needed to document bias and variability in the environmental data. The workplan lists QC sample types, the frequency of collection, and their intended uses. The types of QC samples that typically are collected include blanks to estimate bias and replicates to estimate variability (Mueller and others, 1997). Spikes also are used in selected projects to assess recovery efficiency associated with possible matrix interference or instability of constituents.

Workplans state anticipated methods for data analysis and presentation, including report plans. Accurate cost estimates are needed for personnel, materials, and services related to planned activities conducted within an established period of time in order to properly budget for the project. Assuring the availability of project personnel is often difficult and can impose serious constraints on completing project tasks; therefore, Center management needs to be consulted to ensure that adequate staff resources with appropriate expertise are available and that over-commitment of individuals to multiple projects is avoided.

3.3 Project Reviews

Project reviews are conducted periodically during the project by Center management, technical advisors, or discipline specialists to track progress and expenses, and to ensure compliance with the project workplan or proposal. Project reviews are used to ensure that data collection, analysis, and reporting are being done in accordance with the workplan and with broader WRD policies and requirements. Quality-assurance activities with respect to project reviews are outlined in the following sections.

3.3.1 Review Schedules

The Center implements a systematic review schedule for evaluating the progress of water-quality projects. Project reviews are routinely conducted on a quarterly schedule by the Chief of the Hydrologic Investigations Section, and may be supplemented by additional reviews at selected project-completion milestones. Regularly planned reviews help ensure that water-quality activities are conducted efficiently to produce quality products on time and within budget. Informal, ongoing reviews also are an important part of quality assurance, whereby problems and related issues are addressed as they arise. A formal technical review of water-quality projects in the Center is conducted once every 3 years by the OWQ and Regional Discipline Specialists.

3.3.2 Review Documentation

The Center policy for documenting project reviews is to include the following information for each review:

- Date of review
- Names of reviewers and/or attendees
- Responses to recommended action items from the last review
- Progress, plans, and problems with data collection, data analysis, and report writing
- Major findings
- Status of project budget
- Cooperator/customer contacts
- Project-related training needs
- Recommended follow-up or action items
- Date for next review.

The Center archives all review comments that address the presence or absence of project deficiencies, all actions or recommendations for resolving deficiencies, or documentation explaining why other actions were taken. Review comments are archived in the project files maintained by the Chief of the Hydrologic Investigations Section.

3.4 References for the Project Planning Section

Table 2 lists reports referred to in Section 3.0. For a complete citation, refer to Section 13.0 of the report.

Table 2. Summary of references for project planning.

Reference	Subject
Mueller and others, 1997	Example of quality-control sample design used by the National Water-Quality Assessment Program for surface-water sampling.
Shampine and others, 1992	Integrating quality assurance into project workplans.

4.0 Water-Quality Analytical Laboratories

Water-quality analytical laboratories used by the USGS must be capable of providing accurate and technically defensible quantitative measurements of environmental samples. Two of the most critical issues for long-term water-quality programs conducted at large spatial scales (regional or national) are data comparability and data consistency over time and between study areas. Because of the inherent variability among laboratories, one of the best ways to provide comparability and consistency is to use a single laboratory as much as is practical, and to have the laboratory conform to well-documented QA practices.

4.1 Selection and Use of an Analytical Laboratory

The USGS National Water Quality Laboratory (NWQL) in Denver, Colo., was established as the laboratory to meet the needs of the WRD, and it is the required laboratory for use in all WRD national water-quality programs (WRD Memorandum 92.036). However, a laboratory other than the NWQL can be selected under certain conditions.

4.1.1 Selection

Contract or cooperator laboratories can be used when the cooperative agreement designates a laboratory other than the NWQL or when analytical services are required that cannot be provided by the NWQL. Research laboratories, including those of the USGS National Research Program (NRP), can be used for developing analytical techniques or to provide data for research purposes, and these laboratories are generally exempt from approval requirements that other laboratories must meet (OWQ Technical Memorandum 98.03). USGS State Water Science Center laboratories generally can be used when analyses must be done within a few hours of sample collection or cannot be done conveniently in the field.

4.1.2 Requirements for Use

All laboratories that provide analytical services to the WRD for non-research purposes must meet the requirements of the WRD as described in OWQ Technical Memorandum 98.03 before any analytical data can be stored in the WRD National Water Information System (NWIS) database (discussed in Section 10) or published by the WRD. Laboratories affected by this policy include those that provide chemical, biological, radiochemical, stable isotope, or sediment analytical services. The Water-Quality Specialist, in consultation with the project chief and WRD Branch of Quality Systems (BQS), is responsible for assuring that all non-research laboratories providing analytical services to the Center have met the requirements for approval. These laboratories must do the following:

1. Use approved and published analytical methods—Analytical methods must be approved and published by one of the following sources: USGS; U.S. Environmental Protection Agency (USEPA); American Public Health Association, American Water Works Association, and Water Environmental Federation (Standard Methods); or American Society for Testing and Materials (ASTM). The publication of the method must include documentation for the analytical techniques and chemical processes, plus the expected data quality. If a specific analytical method not published by the sources listed above is requested for a specific project, it is the responsibility of the Center requesting the analysis to have the method approved based on requirements specified in OWQ Technical Memorandum 04.01 before the analytical data from this method are published and/or stored in the USGS national database.

2. Have an approved laboratory QA plan—The laboratory must have an approved QA plan that is supplied to WRD customers upon request. The laboratory QA plan needs to provide internal guidance and documentation that will ensure the laboratory is operating under a standardized, rigorous QA program and is producing analytical results of a known and documented quality. The laboratory QA plan needs to describe QA activities, QC procedures and requirements, performance acceptance criteria, and required corrective actions that will be taken if the criteria are not met.

3. Have standard operating procedures (SOPs) for analytical methods—All analytical methods must have documented SOPs that are approved in accordance with procedures contained in the laboratory QA plan.

4. Have a documented QC program that provides the data necessary to continuously track the bias and variability of analytical data. All QC information, such as QC charts, analysis of laboratory QC samples, calibration records, and analyst bench logs need to be maintained for at least 5 years and be available upon request to WRD customers.

5. Demonstrate the ability to provide the analytical services required—Laboratories can demonstrate the ability to provide the required analytical services by participation in existing USGS or non-USGS certification/evaluation/round-robin programs or by documentation of similar projects (OWQ Technical Memorandum 98.03). Participation in the USGS Standard Reference Sample (SRS) round-robin program is required for outside laboratories providing analytical results to the USGS.

4.2 Analytical Laboratories Used by the U. S. Geological Survey Montana Water Science Center

The Center typically uses the NWQL for chemical analyses of samples collected in routine data programs and projects. Several outside laboratories currently (2006) are, or recently have been, used for specialized biological analyses or research programs. The outside laboratories that have been used for analytical services by Center projects within the past 5 years are shown in table 3. The name of the laboratory, type of analyses provided, the person who has been the primary contact at the laboratory, and the dates the laboratory has been used are provided in the table.

4.3 Documentation for Laboratories Used by the U.S. Geological Survey Montana Water Science Center

4.3.1 National Water Quality Laboratory

1. Methods used—The NWQL uses approved methods for determination of organic, inorganic, and radioactive substances in water, sediments, and biological tissues. These methods are approved by the USGS, USEPA, the American Public Health Association, the American Water Works Association, the Water Environmental Federation, and the ASTM. A list of published reports on analytical methods currently (2006) used at the NWQL can be found on the World Wide Web at ***http://nwql.cr.usgs.gov/Public/ref_list.html/***. Analytical methods from the USEPA that are used at the NWQL can be found on the World Wide Web at *http://www.epa.gov/epahome/publications.html/*. Analytical methods from the ASTM that are used at the NWQL can be found on the World Wide Web at *http://www.astm.org/*.

2. QA plan—The NWQL quality-assurance plan is contained in Pritt and Raese (1995). A copy of this report can be obtained by sending an Email request to *nwqlqc@usgs.gov*. The policies and procedures associated with the internal management of the NWQL are designed to meet the requirements of the National Environmental Laboratory Accreditation Program (Maloney, 2005).

3. QC program—Quality control at the NWQL is monitored by three programs: (1) the internal blind-sample program, (2) the external blind-sample program, and (3) bench-level QC samples. Information about the internal blind-sample program and bench-level QC samples can be obtained by sending an Email request to *nwqlqc@usgs.gov*. Information about the external blind-sample program can be found at *http://bqs.usgs.gov/bsp/Fact.Sheet.html/*.

Table 3. Outside analytical laboratories used by the U.S. Geological Survey Montana Water Science Center.

[Abbreviations: NRP, National Research Program, U.S. Geological Survey; USGS, U.S. Geological Survey]

Project	Analytical laboratory	Analyses provided (by general category)	Laboratory contact	Dates used
Monitoring data	USGS Iowa Sediment Laboratory, Iowa City, Iowa	bottom sediment	Pamela Smith 319-358-3602	1975-2006
Monitoring data	USGS Montana Sediment Laboratory, Helena, Mont.	suspended sediment	Kent Dodge 406-457-5937	1985-2006
Biological baseline for coal-bed methane areas	Hannaea, Helena, Mont.	periphyton	Dr. Loren Bahls 406-443-2196	2003
Biological baseline for coal-bed methane areas	RD Aquatics, Hamilton, Mont.	invertebrates	Richard Durfee 406-375-0064	2003
Biological baseline for coal-bed methane areas	Utah State University, Logan, Utah	invertebrates	Mark Vinson 435-797-3945	2005
Diel metals cycling	NRP Research Laboratory, Boulder, Colo.	trace elements	Kirk Nordstrom 303-541-3037	2001-2006
Diel organic-carbon cycling	NRP Research Laboratory, Boulder, Colo.	dissolved organic carbon	George Aiken 303-541-3036	2005
Clark Fork Superfund	NRP Research Laboratory, Menlo Park, Calif.	trace elements in tissue and bottom sediment	Michelle Hornberger 650-329-4467	1993-2006
Diel zinc cycling	USGS Geology Discipline, Denver, Colo.	zinc isotopes	Rich Wanty 303-236-1819	2005
Tongue River mercury	USGS Wisconsin Mercury Laboratory, Madison, Wis.	low-level mercury	David Krabbenhoft 608-821-3843	2005

4. Performance-evaluation studies and certification programs—The NWQL participates in performance-evaluation studies and laboratory-certification programs, including the National Environmental Laboratory Accreditation Program (NELAP), which accredits the NWQL. A list of the current programs and a description of each can be obtained by sending an Email request to *nwqlqc@usgs.gov*.
5. Laboratory reviews—External agencies and customer organizations audit the NWQL to assess analytical methods and QA/QC programs. A table of audits that shows the year reviewed, reviewing agency, and purpose of the review can be obtained by sending an Email request to *nwqlqc@usgs.gov*.
6. Miscellaneous services—Other services or materials offered by the NWQL include, but are not limited to, the following:
    - Biological analyses
    - Chain-of-custody procedures
    - Contract services
    - External performance evaluations
    - Laboratory-services catalogue
    - Methods Research and Development Program
    - Organic spike kits
    - Publications
    - Quality assurance of selected field supplies
    - Laboratory Information Management System (LIMS)
    - Technical memoranda

4.3.2 Outside Analytical Laboratories

The outside analytical laboratories listed in table 3 that analyze suspended sediment and bottom sediment (USGS Montana Sediment Laboratory and USGS Iowa Sediment Laboratory) provide concentration and particle-size data according to methods described in Guy (1969). Quality-assurance practices are described in Dodge and Lambing (2006) and Matthes and others (1992). Both laboratories participate in the OWQ/BQS Sediment Laboratory Quality Assurance Program and are reviewed every 3 years by the USGS Office of Surface Water (OSW).

Outside analytical laboratories listed in table 3 that provide biological or research-related chemical analyses are generally exempt from USGS laboratory approval requirements. These laboratories utilize methodologies that meet standard taxonomic identification and enumeration criteria (biological laboratories), are under development, or are used to research unique environmental processes for non-routine investigations. The protocols and QA utilized by each respective laboratory can be obtained by contacting the person listed in table 3.

4.4 References for the Water-Quality Analytical Laboratories Section

Table 4 lists reports and/or memoranda referred to in Section 4.0. For a complete citation, refer to Section 13.0 of this report.

Table 4. Summary of references for selecting and using water-quality analytical laboratories.

[Abbreviations: OWQ, Office of Water Quality; USGS, U.S. Geological Survey; WRD, Water Resources Division]

Reference	Subject
Guy, 1969	Laboratory theory and methods for sediment analysis.
Dodge and Lambing, 2006	Quality assurance for sediment analysis in USGS Montana Water Science Center.
Maloney, 2005	Quality management system, National Water Quality Laboratory.
Matthes and others, 1992	Quality assurance for sediment analysis in USGS.
OWQ Technical Memorandum 98.03	Policy for the evaluation and approval of production analytical laboratories.
OWQ Technical Memorandum 04.01	Policy for the approval of USGS water-quality analytical methods.
Pritt and Raese, 1995	Quality assurance/quality control manual, National Water Quality Laboratory.
WRD Memorandum 92.036 (USGS)	Policy of the Water Resources Division on the use of laboratories by national water-quality programs.

5.0 U.S. Geological Survey Montana Water Science Center Water-Quality and Sediment Laboratory, Field Service Units, and Water-Quality Field Vehicles

The Center maintains a variety of laboratory or support facilities such as field service units or field vehicles, used in preparing equipment for field sampling, processing samples, preparing samples for shipment to analytical laboratories, and analyzing suspended-sediment samples. This section documents the Center's criteria for maintaining and operating these facilities.

5.1 Water-Quality and Sediment Laboratory and Field Service Units

The Water-Quality Laboratory is located in the Center office in Helena, Mont., and also serves as the field service unit for the Helena field office. The Sediment Laboratory jointly occupies a portion of the Water-Quality Laboratory in Helena. Each outlying field office in the Center (located in Billings, Kalispell, and Fort Peck) maintains a field service unit for basic operations needed to support water-quality field activities. The Water-Quality Laboratory in Helena has more extensive features for processing samples, preparing solutions, and storing chemicals than the field service units in the field offices.

The Water-Quality Laboratory is under the general supervision of the Water-Quality Specialist, with day-to-day oversight of operations under the supervision of the Water-Quality Lead Technician. The Water-Quality Lead Technician administers the QC checks on equipment and processing, maintains QC records in logbooks, and manages the sediment data provided by the Sediment Laboratory. The field service units in outlying offices are under the supervision of designated technicians who are responsible for maintenance and QA of water-quality equipment and supplies, as well as the space used for storage and processing of water-quality samples and related materials.

A Chemical Hygiene Officer has been designated in the Center to convey information regarding safe chemical storage and waste disposal in accordance with guidance provided by the Regional Safety Officer. The Chemical Hygiene Officer, in consultation with the Water-Quality Lead Technician and Water-Quality Specialist, oversees the chemical storage and waste-disposal practices to ensure that procedures are in compliance with the Center's Chemical Hygiene Plan, as well as State and Federal safety regulations, using guidance outlined in OWQ Technical Memorandum 92.11 and Horowitz and others (1994). The Chemical Hygiene Officer works closely with the Water-Quality Lead Technician and Water-Quality Specialist to review chemical inventories and storage facilities used in the Center.

5.1.1 Facilities

5.1.1.1 Water-Quality and Sediment Laboratory

The Water-Quality Laboratory in Helena serves as a support facility for the field service units by centralizing the procurement and distribution of equipment and supplies, preparing solutions using chemicals (typically acids) for subsequent distribution to field offices, and housing the Sediment Laboratory for the analysis of suspended-sediment samples. The Water-Quality and Sediment Laboratory contains laboratory benches, glassware, sinks, chemical storage cabinets, fume hood, ovens, balances, and other equipment and instruments listed in table 5. The facility is maintained in accordance with standards set forth in the Chemical Hygiene Plan and the Branch of Operations Technical Memorandum 91.01.

5.1.1.2 Field Service Units

Each field service unit is managed by the local staff and used to support water-quality activities by providing a staging area for field instrument maintenance and calibration, equipment cleaning, preparations for sample collection, clean storage of supplies needed for sampling operations, and use of commercially prepared cartridges for the production of deionized water. The field service units contain laboratory benches, glassware, sinks, chemical storage cabinets, and other equipment and instruments as listed in table 6. A limited, short-term supply of instruments, equipment, and expendable items needed by field personnel for upcoming water-quality sample collection is stocked and replenished, as necessary. The field service units are maintained in accordance with standards set forth in the Chemical Hygiene Plan.

5.1.2 Procedures

The Water-Quality Lead Technician supervises two personnel (one full-time, one part-time) in the Water-Quality and Sediment Laboratory. The Water-Quality Lead Technician establishes daily operational instructions and analytical priorities for the Sediment Laboratory, organizes water-quality supplies and equipment within the laboratory, implements QA procedures, and maintains QA records for laboratory equipment and supplies. An extensive set of QA logbooks are maintained to document various procedural checks of equipment performance, servicing and calibration records, replenishment of expired chemicals, and testing of laboratory safety features. In addition, the Water-Quality Lead Technician researches vendor literature to locate sources of specialized equipment and instruments for use in projects, assists staff with the repair and maintenance of project water-quality equipment and instruments, and arranges for manufacturer servicing. In consultation with the Chemical Hygiene Officer, the Water-Quality Lead Technician compiles an inventory of chemicals stored in the Water-Quality and Sediment Laboratory and assists in preparation of the Chemical Hygiene Plan.

Table 5. Laboratory equipment and quality-assurance procedures maintained by the Water-Quality and Sediment Laboratory of the U.S. Geological Survey Montana Water Science Center.

[Abbreviation: OWQ, Office of Water Quality. Symbol: °C, degrees Celsius]

Laboratory equipment	Quality-assurance procedures
Laboratory balances	Calibration checked with every usage; annually cleaned and tested with certified standards.
Refrigerator	Temperature (4°C) monitored weekly.
Fume hood	Air flow rates tested annually.
Deionized water system	Maintained per OWQ Technical Memorandum 92.01.
Ventilated acid cabinets	Inspected regularly for corrosion.
Wash sink with drying rack	Potentially contaminating materials restricted from washing area.
Vacuum pump	Pressure gage inspected regularly for proper setting.
Drying oven	Temperature calibration monitored weekly.
Autoclave	Maintained per manufacturer's instructions.
Incubators	Temperature calibration monitored as Center use warrants.
Freezer	Temperature monitored as Center use warrants.
Laboratory pH and specific conductance meter	Calibrated each use.
Chemical shower	Water supply monitored biweekly.
Chemical eye-wash fountain	Water supply monitored biweekly.

Table 6. Laboratory equipment and quality-assurance procedures maintained by field service units of the U.S. Geological Survey Montana Water Science Center.

[Abbreviation: OWQ, Office of Water Quality. Symbol: °C, degrees Celsius]

Laboratory equipment	Quality-assurance procedures
Refrigerator	Temperature (4°C) monitored as office use warrants.
Deionized water cartridges	Maintained per OWQ Technical Memorandum 92.01.
Ventilated acid cabinets	Inspected regularly for corrosion.
Wash sink with drying rack	Potentially contaminating materials restricted from washing area.
Vacuum pump	Pressure gage inspected regularly for proper setting.
Autoclave	Maintained per manufacturer's instructions.
Incubators	Temperature calibration monitored as office use warrants.
Freezer	Temperature monitored as office use warrants.
Laboratory pH and specific conductance meter	Calibrated each use.
Chemical eye-wash fountain	Water supply monitored biweekly.

The operation of the Water-Quality Laboratory is reviewed on an ongoing basis by the Water-Quality Lead Technician, and jointly by the Water-Quality Specialist and Chemical Hygiene Officer on an annual basis. The Water-Quality Laboratory is formally reviewed every 3 years by the OWQ; the Sediment Laboratory is formally reviewed every 3 years by the OSW.

Designated technicians in field offices are responsible for maintaining, or delegating the responsibility to maintain, the field service unit space, supplies, and equipment. Sampling instructions for water-quality sites operated by each respective field office are reviewed by the designated field-office technician on an ongoing basis to determine the supplies needed to collect and process required samples. Anticipated needs for sampling equipment and supplies are conveyed to the Water-Quality Lead Technician, who then places the orders for purchase. Individual field staff are responsible for maintenance and minor repairs of their water-quality instruments and equipment. Extensive repairs are handled by the manufacturer. It is the responsibility of the designated field-office technician to assure that calibration standards and other supplies that have expiration dates are discarded on time, and that necessary supplies are replenished prior to the next field trip. The designated field-office technician oversees chemical storage and waste-disposal practices in the field service unit in accordance with guidelines outlined in the Chemical Hygiene Plan. The operation of the field service units is reviewed annually by the Water-Quality Specialist or Water-Quality Lead Technician.

5.1.3 Equipment and Supplies

Equipment and supply needs for the Center are evaluated on an ongoing basis to ensure that there is no disruption in the availability of essential items for conducting water-quality activities. The Water-Quality Lead Technician, in consultation with project chiefs, the Water-Quality Specialist, and field-office personnel, procures and distributes the necessary equipment and supplies for Center water-quality programs. Stocks of routine equipment and supplies are maintained in the Water-Quality Laboratory or designated clean storage areas for use by field personnel; requests for additional supplies are sent to the Water-Quality Lead Technician with adequate advance notice to prevent depletion of the stock. It is the responsibility of the Water-Quality Lead Technician to order and quality assure the field equipment and supplies listed in table 7 that commonly are used by field personnel. Non-routine types of equipment may need to be evaluated by the Water-Quality Specialist or project chief prior to purchase to ensure that performance capabilities will meet data-quality and program objectives. Proper storage of equipment and supplies is the responsibility of staff in each Center office. Supplies are discarded when the expiration date is exceeded. Adequate backup quantities of equipment and supplies are maintained to enable prompt replacement of crucial items necessary to accomplish data-collection tasks.

5.2 Water-Quality Field Vehicles

Water-quality field vehicles need to provide a non-contaminating environment for the constituents being analyzed. The primary type of water-quality field vehicle used in the Center is a mobile laboratory, which is typically a truck-mounted, custom camper that has been designed and outfitted with specialized laboratory features for use during sample collection and onsite sample processing. The Center maintains mobile laboratories in each office for water-quality sample collection and processing. If a non-laboratory vehicle must be used for water-quality work associated with constituents having typical environmental concentrations in the range of 10 parts per billion (ppb) or less, portable processing and preservation chambers are used for sample processing, and extra QC samples are collected to document that the data have not been compromised. The National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated, chap. A1-A9) provides guidelines on procedures and associated equipment for collecting and processing water-quality samples.

Some general specifications for vehicles used as processing areas for water-quality samples are discussed by Horowitz and others (1994) and in U.S. Geological Survey (variously dated, chap. A2) and include the following:

1. Materials used for work surfaces and storage compartments, including counter tops, drawers, cabinets, and flooring, must be easy to maintain, made of or covered with non-contaminating materials, and capable of being easily cleaned with water or solvents as appropriate.

2. Cargo must be restricted to equipment and supplies related to water-quality sample collection, unless stored in a separate compartment—preferably an exterior compartment isolated from the sample processing area. No potentially contaminating equipment or supplies, such as sounding weights, solvents, and fuel, may be transported in the laboratory compartment of the vehicle.

3. A dust barrier must exist between the sample-processing area and the external environment (or cab area of an integrated laboratory/vehicle unit, such as a van).

4. Chemical solutions, such as preservatives, must be safely and securely stowed to prevent leakage or rupture of containers during transit. Material-safety data (MSD) sheets listing the chemicals carried in the water-quality field vehicles are posted in the vehicles.

All vehicle operators share in the responsibility for vehicle maintenance, for maintaining the cleanliness of the mobile laboratory or sample-processing area, and for keeping the vehicle stocked with adequate supplies or backup equipment to accomplish the sampling.

Table 7. Summary of information on supplies, equipment, and instruments used in water-quality activities of the U.S. Geological Survey Montana Water Science Center.

[Abbreviations: DI, deionized; FISP, Federal Interagency Sedimentation Program; NIST, National Institute of Standards and Technology; NWQL, National Water Quality Laboratory; OWQ, Office of Water Quality; QA, quality assurance]

Supplies, equipment, and instruments	Source and guidelines for QA	Responsible personnel
Sample bottles	Purchased from NWQL	Water-Quality Lead Technician.
Coolers/shipping containers	Purchased from local suppliers, materials meet criteria listed in OWQ Technical Memorandum 92.06	Water-Quality Lead Technician or project chief.
Sample preservatives	Purchased from NWQL	Water-Quality Lead Technician.
pH calibration standards	Commercially prepared buffers, traceable to NIST Standard Reference Materials	Water-Quality Lead Technician.
Specific conductance calibration standards	Purchased from NWQL	Water-Quality Lead Technician.
DI water	Certified inorganic-free and organic-free DI water purchased from NWQL. DI water conforms to criteria listed in NWQL Memorandum 92.01. This DI water is used for blank samples	Water-Quality Lead Technician.
DI water	DI water produced in-house using commercially manufactured cartridges. This DI water is primarily used for rinsing of equipment or preparation of stock solutions. Both standard DI and ultra-pure DI production cartridges are used in the Water-Quality Laboratory in Helena. DI water for rinsing conforms to criteria listed in OWQ Technical Memorandum 92.01	Water-Quality Lead Technician.
Concentrated acid, bulk	Acids (nitric, hydrochloric) are purchased from scientific materials vendors and shipped under U.S. Department of Transportation regulations to the Water-Quality Laboratory in Helena. Concentrated acids are used to prepare dilute (5-percent) acid solutions for field rinsing of equipment. Dilute acid solutions are prepared in the Water-Quality Laboratory in Helena under the fume hood and using standard safety procedures outlined in the Chemical Hygiene Plan. Dilute acid is distributed to field offices or project personnel, as needed	Water-Quality Lead Technician.
Isokinetic water-quality samplers	Type and number of samplers are determined by the Water-Quality Specialist to conform to site conditions and program requirements. Samplers are purchased from the FISP; documentation of sampler characteristics and design criteria are available from FISP	Water-Quality Specialist and Water-Quality Lead Technician.
Splitting devices	Churn and cone splitters purchased from Bel-Art Products, Pequannock, N.J.	Water-Quality Lead Technician.
Autosamplers (pumping units for collecting point samples)	Purchased from scientific-supply manufacturers. Design criteria provided by the manufacturer are reviewed to evaluate sampler capabilities for meeting data-quality and program objectives	Water-Quality Specialist and project chief.
Specific conductance meters	Purchased from scientific-supply manufacturers. Manufacturer literature is reviewed prior to purchase to ensure meter capabilities can meet data-quality and program objectives	Water-Quality Specialist and Water-Quality Lead Technician.
pH meters	Purchased from scientific-supply manufacturers. Manufacturer literature is reviewed to ensure that meter capabilities meet data-quality and program objectives	Water-Quality Specialist and Water-Quality Lead Technician.
Water-quality continuous monitors	Purchased from scientific-supply manufacturers. Design criteria provided by manufacturers are reviewed to evaluate capabilities of sensors to meet data-quality and program objectives	Water-Quality Specialist and project chief.

5.3 References for the U.S. Geological Survey Montana Water Science Center Water-Quality and Sediment Laboratory, Field Service Units, and Water-Quality Field Vehicles Section

Table 8 lists reports and/or memoranda referred to in Section 5.0. For a complete citation, refer to Section 13.0 of the report.

6.0 Water-Quality Instruments

The Center complies with the WRD policy of providing personnel with high-quality equipment and field instruments that are safe, durable, accurate, and capable of performing required tasks (WRD Memorandum 95.35). Accordingly, appropriate instruments for use in water-quality projects need to be selected based upon the specifications described in the National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated, chap. A6) and the requirements of the project. The Hydrologic Instrumentation Facility (HIF), which provides analyses of precision and bias for various water-quality field instruments, also needs to be consulted for recommendations when appropriate. The Water-Quality Specialist or Water-Quality Lead Technician needs to be consulted if project personnel need assistance with the selection or use of equipment.

6.1 Field Meters

All field meters used by Center personnel for water-quality measurements are to be properly operated, maintained, and calibrated. For correct operation of any water-quality equipment, the manufacturer's operating guidelines need to be carefully followed. Most instruments will be calibrated in the field prior to making the sample measurements. Calibration standards must be fresh; standards that exceed expiration dates are to be discarded. Calibration standards need to bracket ambient environmental values to ensure accuracy within the measurement range.

Thorough documentation of all calibration activities associated with water-quality data collection is a critical element for maintaining data quality. Calibration and maintenance records of field meters, including the manufacturer, make, model, and serial or property number are to be kept. Water-quality field forms or meter log books are the primary modes of storage for calibration data, which are recorded in the field immediately prior to a sample measurement. These calibration data constitute a chronological record of meter performance associated with each sample measurement; forms are filed in individual station folders in the Data Management Unit that can be reviewed for investigation of anomalous environmental values or potential problems in meter performance. Log books are kept with the meters and also contain maintenance records for routine servicing, battery and probe replacement, and annual checks of thermistor accuracy. Similar records for meters used in the Water-Quality Laboratory are kept by the Water-Quality Lead Technician.

6.2 Continuous Monitors

Continuous monitors are used in the Center for electronically recording frequent measurements of water-quality properties that either can vary substantially on a seasonal or diurnal basis, or which represent a surrogate measure of an important water-quality constituent. The monitors typically record measurements at a frequency of every 15-60 minutes. The two most common water-quality properties measured in the Center on a continuous basis are water temperature and specific conductance.

Table 8. Summary of references for U.S. Geological Survey Montana Water Science Center Water-Quality and Sediment Laboratory, field service units, and water-quality field vehicles.

[Abbreviations: NWQL, National Water Quality Laboratory; OWQ, Office of Water Quality; USGS, U.S. Geological Survey]

Reference	Subject
Branch of Operations Technical Memorandum 91.01	Safety—Chemical hygiene plan.
Horowitz and others, 1994	Protocol for collecting and processing samples for inorganic analysis of dissolved constituents in the parts-per-billion concentration range.
NWQL Memorandum 92.01	Availability of equipment blank water for inorganics and organics.
OWQ Technical Memorandum 92.01	Distilled/deionized water for Center operations.
OWQ Technical Memorandum 92.06	Recommended guidelines for shipping samples to the NWQL.
OWQ Technical Memorandum 92.11	Shipment of spent mercury and dichromate to the NWQL.
USGS, variously dated (National Field Manual, chap. A1-A9)	Collection of water-quality data.
USGS, variously dated (National Field Manual, chap. A2)	Guidelines for field vehicles.

Water temperature and specific conductance monitors are available from a number of manufacturers. The specific models selected for purchase must provide sufficient resolution to meet USGS data-quality standards, and must be durable enough to withstand harsh stream environments. Additionally, the electronic configuration of the monitor output needs to be compatible with real-time telemetry equipment that is becoming increasingly common for displaying USGS provisional hydrologic data on the World Wide Web (*http://waterdata.usgs.gov/nwis/*). The onsite installation of such equipment is supervised by field staff who are familiar with construction requirements for securely and safely mounting pipes, cables, and storage shelters in a wide variety of physical settings. Any permits needed to encroach upon roadways or bridges must be obtained from the Montana Department of Transportation and any other authorities, as appropriate, prior to installation.

Servicing of continuous water-quality monitors is done in accordance with Wagner and others (2006). That report presents guidelines and standard procedures for operating monitors, including site selection considerations, field operation, calibration, record computation, and reporting of data. An example of an inspection form used for continuous-conductance monitors operated in the Center is shown in figure 2.

In some cases, continuous-monitor sensors can be fouled by sediment, salts, or biofilms, which can cause excessive drift of monitor readings that cannot be adequately corrected by servicing and calibration at the typical frequency of site visits conducted by most field offices. In those cases, a local observer may need to be hired to provide more frequent cleaning of the sensor, especially at remote sites that are impractical for USGS staff to visit more frequently. Personnel of the local field office are responsible for training the observer in proper cleaning procedures and recording of data in order to track any changes resulting from the cleaning. Monthly inspection forms filled out by the observer are sent to the field office and included in the station water-quality folder for reference during subsequent record computations.

6.3 Calibration and Maintenance of Water-Quality Instruments

Information that is required to be included with the calibration and maintenance records of water-quality field meters includes the date, name of the individual performing the activity, results of calibration or equipment check, and any actions taken. Calibration and maintenance records are assessed on an ongoing basis during each field trip to identify potential problems immediately and to take corrective action. The calibration data also are reviewed by the project chief and Water-Quality Specialist after each field trip during the review of laboratory analytical results.

Prior to leaving for a field trip, fresh calibration standards need to be obtained and at least one standard checked to verify that the meter is functioning properly. Poor meter performance must be identified, evaluated, and corrected promptly to ensure data quality. Continued use of meters or probes of questionable quality is not acceptable; faulty equipment needs to be repaired or replaced as soon as practical. If available, backup meters are to be carried on extended field trips to obtain reliable field measurements in the event of equipment problems. If backup meters are not available, an alternative action is to bring water samples back to the office for measurement of properties that are generally stable. Table 9 provides summary information regarding the calibration methods, acceptance criteria, calibration frequency and location where calibration is done, responsible persons, and references for specific instructions regarding the calibration and use of water-quality instruments to measure selected water-quality properties in the Center.

6.4 References for the Water-Quality Instruments Section

Table 10 provides a list of reports and/or memoranda referred to in Section 6.0. For a complete citation, refer to Section 13.0 of the report.

7.0 Site Selection and Documentation

Deciding where to sample is an important initial step toward achieving project objectives of obtaining environmentally representative data at the appropriate location to reliably characterize conditions. After a site is selected, thorough documentation of site location and features, usually in the form of a station description, is required.

7.1 Site Selection

Site selection for sampling is important to the validity of water-quality data. Selection of a suitable site can be made only after considering a number of factors, including the need for information in a particular location, the suitability of a site for obtaining environmentally representative samples through a range of hydrologic conditions, and site accessibility and safety. Specific guidelines for site selection are contained in U.S. Geological Survey (variously dated, chap. A1). The project chief is responsible for the selection of sampling sites, after consultation with the Water-Quality Specialist and the Surface-Water or Ground-Water Specialist, as appropriate.

7.1.1 Surface Water

If possible, water-quality stations are located at or near streamflow-gaging stations in order to have concurrent information on hydrologic conditions. If this is not possible, the water-quality station needs to be located where the stream discharge can be measured and water samples can be collected at

FIELD INSPECTION FOR CONTINUOUS-CONDUCTANCE MONITOR
USGS Montana Water Science Center

Station Name _____ **Station No.** _____

Date: _____ **Time maintenance started:** _____ **Time maintenance finished:** _____

Inspected by: _____ Gage height @ time: _____ @ _____

EDL Model: _____ EDL Operational? NO YES Battery Volt. _____ Battery Replaced? NO YES

Program Altered? NO YES Data Downloaded? NO YES File Name: _____

Cross-Section Survey done? NO YES (if Yes, see measurement form) X-SECTION coefficient _____

SENSOR MAINTENANCE RECORD **% Difference, Fouling = [(SA-SB) – (FA-FB) / SB] * 100**

Readings of stream conductance	Time	Temp (°C)	Specific conductance (µS/cm)	Diff.	% Diff. (see eq)	REMARKS
Field meter, before sensor cleaning **(FB)**						At/near sensor ( )
EDL before sensor cleaning **(SB)**						Sensor condition:
EDL after sensor cleaning **(SA)**				**(SA-SB)**		
Field meter, after sensor cleaning **(FA)**				**(FA-FB)**		= FOULING Correction (%)
Proceed to calibration check, see CALIBRATION RECORD below -OR- Calibration not checked ( )						
EDL after calibration check						
Field meter reading, final						
Cross-section average SC						QW sample from churn

CALIBRATION RECORD **% Difference, Calibration = [(Standard – Sensor) / Sensor] * 100**

Conductance Sensor Make/Model:					
Conductance standard	Temp (°C)	Sensor reading	Diff.	% Diff. (see eq.)	REMARKS
1)					Lot #: Exp. Date:
2)					Lot #: Exp. Date:
				Avg.	**= CALIBRATION Correction (%)**
3)					To reset sensor, use standard near 1,000 µS/cm **RESET SENSOR: NO ( ) YES ( ) Set to:**

Field Meter Make/Model:					
Conductance standard	Temp (°C)	Initial reading	Adjusted reading	Corr. factor	REMARKS See QW field form for field meter calibration ( )
1)					
2)					

Comments:

Figure 2. Example of U.S. Geological Survey Montana Water Science Center field inspection form for continuous-conductance monitors.

Table 9. Summary of calibration information for water-quality instruments used to measure selected water-quality properties in the U.S. Geological Survey Montana Water Science Center.

[Abbreviations: °C, Celsius; µS/cm, microsiemens per centimeter at 25°C; NIST, National Institute of Standards and Technology; USGS, U.S. Geological Survey]

Water-quality property	Calibration method used	Acceptance criteria and response if not acceptable	Calibration frequency and location	Responsible personnel	Reference for calibration and use
Temperature	NIST-certified thermometer	Within 0.25°C; replace thermometer	Semi-annually in laboratory	Field personnel, Water-Quality Lead Technician	USGS, variously dated (National Field Manual, chap. A6); see manufacturer's instructions.
	Field meters with internal temperature compensation	Within 0.2°C; verify with another thermometer, replace meter	Quarterly in laboratory	Field personnel, Water-Quality Lead Technician	USGS, variously dated (National Field Manual, chap. A6); see manufacturer's instructions.
Specific conductance	At least two standards, bracketing expected values	Within 3 percent over 100 µS/cm; within 5 percent under 100 µS/cm; verify with another standard, clean or replace probe	Prior to taking sample measurements in field	Field personnel	USGS, variously dated (National Field Manual, chap. A6); see manufacturer's instructions.
pH	Two-point calibration, bracketing expected values	Within acceptable slope range for instrument as indicated in manufacturer's instructions; verify with another standard; clean and replace probe	Prior to taking sample measurements in field	Field personnel	USGS, variously dated (National Field Manual, chap. A6); see manufacturer's instructions.
Dissolved oxygen	Air calibration in water	Within 5 percent of theoretical saturation at ambient temperature and barometric pressure; change membrane or replace probe	Prior to taking sample measurements in field; whenever membrane is changed	Field personnel	USGS, variously dated (National Field Manual, chap. A6); see manufacturer's instructions.
Barometric pressure	Mercury barometer	Within 5 millimeters mercury compared to local weather station; replace barometer	Annually in laboratory	Field personnel, Water-Quality Lead Technician	See manufacturer's instructions.

Table 10. Summary of references for water-quality instruments.

[Abbreviation: WRD, Water Resources Division]

Reference	Subject
USGS, variously dated (National Field Manual, chap. A6)	Calibration of water-quality instruments.
WRD Memorandum 95.35	Instrumentation plan for the WRD and the hydrologic field instrumentation and equipment policy and guidelines.
Wagner and others, 2006	Guidelines and standard procedures for continuous water-quality monitors.

all stages of flow to be monitored. If the water-quality station is located too close downstream from either the confluence of two or more streams or a point source of effluent, the collection of a representative sample may be difficult because of incomplete mixing. Under such conditions, the criteria for the minimum number of vertical transects sampled may need to be increased, and lateral mixing characteristics documented with cross-sectional surveys at various stages of flow. If possible, continuous water-quality monitors are installed where the water in the stream is vertically and horizontally well-mixed in the cross section and protected from physical damage.

7.1.2 Ground Water

The selection of wells for ground-water sampling is dependent on many variables, including location, depth and accessibility of the well, type of well completion, availability of geologic and water-use information, and sampling purpose(s). If suitable existing wells cannot be found, new wells will need to be installed.

7.1.3 Other Sites

Other types of sites used for hydrologic monitoring can include lakes and precipitation stations. These types of sites are less common than stream sites, but are occasionally operated as part of a special study or as part of a national network. Depending on their size, lakes would typically be sampled at multiple locations sufficiently distributed to provide a spatial characterization of conditions between the inflow and outflow reaches. In addition, samples would be collected at multiple depths in order to determine vertical variations in water quality associated with stratification and biological productivity. Precipitation stations are generally sampled as part of a national network to identify regional patterns of precipitation quality that potentially may be affected by sources of gaseous or particulate emissions to the atmosphere.

7.2 Site Documentation

The project chief or designated technical personnel constructs a site file containing descriptive information on location, conditions, purpose, and ancillary information for all new water-quality data-collection sites (Schroder and Shampine, 1995). Much of this information also is stored electronically in computerized site files maintained by the Data Management Unit. The project chief is responsible for assuring that the site file is complete and accurate, and that the file has been properly entered and stored in the records of the Data Management Unit. Archiving of this information is discussed in Section 10.4.

7.2.1 Surface Water

A station description is prepared for each water-quality station that is sampled on a regular or periodic basis. Sites established at existing surface-water gaging stations commonly will need only supplemental information to complete the description. Other surface-water sites, such as lakes, may require varying amounts of supplemental information to complete the station descriptions. The minimum information required for establishing electronic files in NWIS for surface-water stations is listed in table 1-1 in U.S. Geological Survey (variously dated, chap. A1). For continuous water-quality monitoring sites, station-description requirements are presented by Wagner and others (2006). The mandatory site information required by the Center includes: agency code, site identifier, project number, station name, latitude, longitude, latitude-longitude accuracy, horizontal datum, Center code, Country code, State code, county code, land-net location (township-range-section), location reference map, map scale, altitude, method of altitude measurement, accuracy of altitude, vertical datum, hydrologic unit code, topographic setting, agency use of site, date inventoried, site type, and data type.

7.2.2 Ground Water

A well file (analogous to a surface-water station description) is prepared for each well that is sampled on a regular or periodic basis. The minimum information required for establishing electronic files in NWIS is listed in table 1-4 in U.S. Geological Survey (variously dated, chap. A1). The mandatory Ground-Water Site Inventory information required by the Center includes: agency code, site identifier, project number, station name, latitude, longitude, latitude-longitude accuracy, horizontal datum, Center code, Country code, State code, county code, land-net location, location reference map, map

scale, altitude, method of altitude measurement, accuracy of altitude, vertical datum, hydrologic unit code, topographic setting, agency use of site, date inventoried, site type, data type, primary aquifer, well depth, source of well depth information, water level, source of water-level information, measurement-point height, measurement-point begin date, measurement-point description and remarks, well owner name, date of visit, and name of person visiting the site. The NWIS minimum requirements for site establishment need to be completed promptly upon the first visit to a site to allow the analytical results for the first sample shipped to the laboratory to be properly transmitted to the Center water-quality database. The project chief or designated technical personnel is responsible for ensuring the mandatory well file elements are promptly completed. Paper documents, such as agreements for use of the well between the well owner and the USGS, also must be stored in the appropriate file.

7.2.3 Other Sites

Similar types of site information described for surface-water and ground-water sites are required for other sites, such as lakes or precipitation stations. The project chief or designated technical personnel is required to ensure the completeness and accuracy of the site information. Site files are maintained by the Data Management Unit.

7.3 References for the Site-Selection and Documentation Section

Table 11 lists reports and/or memoranda referred to in Section 7.0. For a complete citation, refer to Section 13.0 of the report.

8.0 Sample Collection and Processing

Water-quality data collected by the USGS are used by Federal, State, Tribal, and local agencies and others to guide their decisions concerning the appropriate and efficient management of water resources for the Nation. Water-quality data are collected as part of such Federal programs as the National Stream-Quality Accounting Network (NASQAN) and the National Water-Quality Assessment (NAWQA) Program, as well as cooperative projects jointly funded by local, State, or Tribal governments, and are a vital component of water-resources activities performed by the USGS.

The primary objective in collecting a water-quality sample is to obtain environmental data that are representative of the system that is being studied. Sampling and processing techniques for specific constituents may vary according to the general class of compound, such as inorganic or organic chemicals. If incorrect sampling procedures produce a nonrepresentative sample, or if the sample is contaminated or degraded before analysis can be completed, the value of the sample is limited and the data are questionable. Therefore, compliance with documented and technically approved protocols for sample collection and processing is critical to ensuring the quality of water-quality data.

Center policy states that all personnel involved in collecting and processing water-quality data will be adequately informed and trained regarding sample collection and processing procedures established by the WRD. New and improved methods for sample collection and processing are continually being developed as the result of rapid changes in technology. All Center personnel who are involved in water-quality sampling must be aware of changing protocols and requirements for maintaining data quality. The Water-Quality Specialist, Water-Quality Lead Technician, and project chiefs are also responsible for providing current information to field personnel on the correct protocols to follow in collecting and processing water-quality samples and any changes in procedures as described in agency memoranda and reports. In addition to personal communication or in-house training, field personnel are responsible for checking existing technical references, including the National Field Manual (U.S. Geological Survey, variously dated, chap. A1-A9) and agency memoranda when technical questions arise.

The Water-Quality Specialist or project chiefs are responsible for seeing that field personnel ensure the quality and integrity of the Center's water-quality data. The following steps represent some fundamental aspects of maintaining data quality for both discrete samples and onsite measurements by continuous water-quality monitors:

1. Samples must be collected and processed according to prescribed USGS protocols, as described and referenced in the following sections.

2. All samples must be shipped to the laboratory from the field in an expedient manner, within the required holding times for each analysis.

3. All samples need to be logged into NWIS (usually within 7 days of sample collection) to establish a sample record in the database prior to the completion of analysis and transmittal of the results back to the Center. Analytical results transmitted by the lab are stored in the sample record, which uniquely links the data to the specific station, date, and time.

4. All analytical data for samples must be reviewed in a timely manner and within the required holding times for each analysis (to allow time for reanalysis), and documented in the station file.

5. Continuous monitors need to be operated and data processed as described by Wagner and others (2006).

6. All pertinent information necessary for computing records of continuous monitors, such as cross-sectional

Table 11. Summary of references for site selection and documentation for water-quality programs.

[Abbreviations: NWIS, National Water Information System; USGS, U.S. Geological Survey]

Reference	Subject
Schroder and Shampine, 1995	Guidelines for documenting new water-quality data-collection sites.
Wagner and others, 2006	Guidelines and standard procedures for continuous water-quality monitors.
USGS, variously dated (National Field Manual, chap. A1)	Establishing electronic NWIS files for surface- and ground-water data.

variability, equipment maintenance, and data shifts must be fully documented and included in the station analysis file.

7. Continuous monitors must be inspected and calibrated as frequently as required to obtain as complete a record as possible.

8.1 Water-Quality Samples

Most studies that are designed to evaluate the water quality of an aquatic system are based upon measurements of water-quality properties and analyses of constituent concentrations in the water. Water-quality properties generally are measured in the field, whereas most constituent concentrations require laboratory analysis. This section of the QA plan includes an overview of relevant Center and USGS policies, as well as references for specific procedures pertaining to the field measurement of water-quality properties and the collection and processing of samples for laboratory analysis of constituent concentrations. Information in this section is drawn primarily from the National Field Manual (U.S. Geological Survey, variously dated, chap. A1-A9), which represents the standard protocols for water-quality sample collection and processing in the USGS. Additional sources of information include manuals published by the NAWQA Program (Shelton, 1994; Koterba and others, 1995). The project proposal and workplan also are to be consulted by field personnel for specific guidance regarding any specialized procedures or departures from standard protocols.

8.1.1 Preparation for Sampling

Guidelines on preparations for sampling are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A1). Ensuring that field personnel have the correct equipment and supplies on hand to perform the necessary sampling activities saves time and labor costs associated with repeated sampling trips that result from inadequate planning. Therefore, before starting sampling activities, the Water-Quality Specialist, project chief, or designated technical personnel is responsible for ensuring that the following preparations have been completed:

- A site file has been established to allow storage of analytical results in the data base;
- Sampling instructions have been prepared for each site to document the sample types, bottles, and preservatives required for each sample;
- Bottles and labels have been prepared for all required sample sets;
- Sample bottles and capsule filters have been pre-rinsed with DI water, as appropriate;
- Field forms, notebooks, and Analytical Services Request (ASR) forms have been obtained;
- Necessary supplies, such as bottles, calibration standards, filters, preservatives, meter batteries, waterproof markers, shipping containers, etc. (see table 7 for list of supplies, equipment, and instruments) have been obtained and loaded in field vehicle;
- All sampling equipment, compositing vessels, and sample splitters have been thoroughly cleaned, and;
- Meters and sensors have been checked for proper performance.

8.1.2 Field Measurements

Field measurements are routinely made for various water-quality properties, including water and air temperature, dissolved-oxygen (D.O.) concentration, specific conductance, and pH. Other properties that are measured for some projects include alkalinity, acid-neutralizing capacity, oxidation-reduction potential (Eh), and turbidity. Procedures for making field measurements in surface- and ground-water systems are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A6). Field measurements need to represent, as closely as possible, the conditions of the system at the time of sampling; localized disturbances or other factors that could cause non-representative measurements are to be avoided. To verify accuracy of the meters used to make field measurements, a calibration check with standards that bracket

the range of ambient conditions at each site is required for most instruments.

Field-measured environmental data are recorded while onsite, along with a description of methods, equipment, and calibration information. Field measurements typically are repeated several times to ensure that a stable reading is obtained and the measurement value is repeatable. Data from field measurements can be recorded either electronically or on paper field forms, which may be national forms (fig. 3), or customized for a particular project. The project chief, Water-Quality Specialist, or designated field person is responsible for reviewing field records for completeness. To avoid the loss of data because of possible instrument malfunction, field personnel, in consultation with the project chief and Water-Quality Specialist, must ensure that backup sensors or instruments are readily available and in good working condition.

To assure the quality of field measurements, all Center personnel involved in the collection of water-quality data are required to participate in the National Field Quality Assurance (NFQA) Program (Stanley and others, 1992). Results of the NFQA Program are reviewed by the Regional Hydrologist, the Center Director, and the Water-Quality Specialist. Staff receiving an unsatisfactory rating are required to evaluate, in consultation with the Water-Quality Specialist or Water-Quality Lead Technician, possible deficiencies in the meter, calibration standards, or measurement procedures and are given an additional set of samples from the NFQA program to measure. Results of retesting must be satisfactory in order for the individual to continue making field measurements.

8.1.3 Cleaning of Sampling and Processing Equipment

Procedures for cleaning equipment used for water-quality sampling and processing are described in the National Field Manual (U.S. Geological Survey, variously dated, chap. A3). All new equipment acquired for water-quality sampling, as well as equipment that has been in long-term storage, must be cleaned in the office before being used in the field. Similarly, equipment must be cleaned as soon as possible after sample collection and before being used again to avoid cross-contamination between sampling sites (Horowitz and others, 1994). Field rinsing of equipment just prior to sample collection using only site water is not a substitute for proper cleaning.

To verify the adequacy of cleaning procedures used by the field personnel to remove contamination, equipment blanks are processed and submitted for laboratory analysis. These blanks ensure that the sampling equipment is not a source of detectable concentrations of constituents that potentially could be introduced into the environmental samples. Annual office equipment blanks, collected in the office laboratory, also are obtained for equipment used to collect water-quality samples (Horowitz and others, 1994; U.S. Geological Survey, variously dated, chap. A3). Equipment blanks that indicate persistent detectable concentrations of constituents require submission of additional blanks for individual components of the equipment to isolate the source of contamination. When the source of contamination has been determined, the necessary maintenance must be performed to eliminate contamination. The equipment must be retested and provide satisfactory results, or the equipment must be replaced. The Water-Quality Specialist or project chief monitors the results of annual equipment blanks to ensure acceptable quality.

8.1.4 Surface-Water Sampling

Surface-water sampling procedures are designed to ensure that the samples collected accurately represent the physical and chemical characteristics of the aquatic system. Obtaining representative samples requires the use of proper sampling equipment and appropriate sampling methods to quantitatively measure ambient conditions, describe environmental variability, and prevent contamination or bias in the sampling process. All Center personnel who are involved in water-quality activities must be well informed, through either formal training or working with experienced personnel, of the various factors that affect the collection of representative samples. The choice of sampling equipment and method of sample collection are based on established protocols and guidelines, depending upon the characteristics of the target constituents, study objectives, hydrologic conditions, and sampling logistics.

8.1.4.1 Equipment Selection

Guidelines for selecting appropriate equipment for sampling various surface-water environments are provided in Horowitz and others (1994) and in the National Field Manual (U.S. Geological Survey, variously dated, chap. A2). Review of equipment selection by the Water-Quality Specialist and project chief occurs during proposal and workplan development and during periodic project reviews.

8.1.4.2 Sample Collection

Guidelines for the collection of surface-water samples are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A4). Field personnel are responsible for examining the sampling site carefully and choosing the most appropriate sampling method to generate the best sample possible for the conditions at the time of sampling. The standard procedure for stream sampling is to collect the sample through the entire depth of the water column at multiple vertical transits by either the Equal-Discharge Increment (EDI) or Equal-Width Increment (EWI) method. These methods generate a representative cross-sectional sample that is both flow-weighted and depth- and width-integrated (Ward and Harr, 1990; Edwards and Glysson, 1999).

Occasionally, the use of non-flow-weighted methods may be appropriate because of hydrologic, climatic, or safety

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U. S. GEOLOGICAL SURVEY SURFACE-WATER QUALITY NOTES

FIELD ID _____

NWIS RECORD NO _____

Station No. _____ Station Name _____

Sample Date _____ Mean Sample Time (watch) _____ Tlime Datum _____ (eg. EST, EDT, UTC) End Date _____ End Time _____

Sample Medium _____ Sample Type _____ Sample Purpose (71999) _____ Purpose of Site Visit (50280) _____ QC Samples Collected? Y N

Project No. _____ Project Name_____ Project No. _____ Proj Name_____

Sampling Team ___ _____ Team Lead Signature _____ Date _____

START TIME _____ GAGE HT _____ TIME _____ GHT _____ TIME _____ GHT _____ TIME _____ GHT _____ END TIME _____ GHT _____

Sample Set ID _____

LABORATORY INFORMATION

SAMPLES COLLECTED: NUTRIENTS ___ MAJOR IONS ___ TRACE ELEMENTS: FILTERED ___ UNFILTERED ___ MERCURY: FILTERED ___ UNFILTERED ___ VOC ___

RADON ___ (Radon samp coll time:_____) TPC ___ (VOL FILTERED_____mL) PIC ___ (VOL FILTERED_____mL) TPC(QC) ___ (VOL FILTERED_____mL)

DOC ____ ORGANICS: FILTERED ___ UNFILTERED ___ RADIOCHEMICALS: FILTERED ___ UNFILTERED ___ ISOTOPES ___ MICROBIOLOGY ____

CHLOROPHYLL ____ BOD ____ COD ____ ALGAE ____ INVERTEBRATES ____ FISH ____ BED SED. ____ SUSP. SED. ____ CONC. S/F SIZE

WASTEWATER ___ ___ OTHER _____ OTHER _____ OTHER _____ OTHER _____

LABORATORY SCHEDULES: _____ _____ _____ _____ _____ _____

LAB CODES: _____ ADD/DELETE _____ ADD/DELETE _____ ADD/DELETE _____ ADD/DELETE _____ ADD/DELETE _____ ADD/DELETE

COMMENTS: _____ DATE SHIPPED _____

****Notify the NWQL in advance of shipment of potentially hazardous samples—phone 1-866-ASK-NWQL or email LabLogin@usgs.gov**

FIELD MEASUREMENTS

Temp, Water (00010) _____ °C	Q, inst. (00061) _____ cfs meas. rating est	ANC ( ) _____ mg/L
pH (00400) ____ _____ units	Gage ht (00065) _____ ft	Alkalinity ( ) _____ mg/L
Sp. Cond (00095) _____ µS/cm@25 °C	Temp, Air (00020) _____ °C	Carbonate (00452) _____ mg/L
Dis. Oxygen (00300) _____mg/L	Turbidity ( ) _____ Method Code ____ units: FNU NTRU FNMU FBU _____	Bicarbonate (00453) _____ mg/L
DO Sat. (00301) _____ %	Other: _____ _____	Hydroxide (71834) _____ mg/L
Barometric Pres. (00025) _____ mm Hg	Other: _____ _____	Eh (00090) _____ mvolts

SAMPLING INFORMATION

Sampler Type (84164) _____ Sampler ID _____ Sample Splitter Type (84171) _____ Splitter ID_____ Filter Type(s): capsule disc 142mm 25mm GFF membrane

Sampler Bottle/Bag Material: plastic teflon other _____ Nozzle Material: plastic teflon other _____ Nozzle Size: 3/16" 1/4" 5/16"

Stream Width: _____ ft mi Left Bank _____ Right Bank _____ Mean Depth: _____ft Ice Cover _____% Ave. Ice Thickness _____ in.

Sampling Points: _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Sampling Location: wading cableway boat bridge upstream downstream side of bridge _____ ft mi above below gage _____

Sampling Site: pool riffle open channel braided backwater Bottom: bedrock rock cobble gravel sand silt concrete other _____

Stream Color: brown green blue gray clear other _____ Stream Mixing: well-mixed stratified poorly-mixed unknown other_____

Weather: ***sky-*** clear partly cloudy cloudy ***precipitation-*** none light medium heavy snow sleet rain mist _____

wind- calm light breeze gusty windy est. wind speed_____ mph ***temperature-*** very cold cool warm hot _____

Sampling Method (82398): EWI[10] EDI [20] single vertical [30] mult vertical [40] other _____ Stream Velocity (81904) _____ ft/sec

Transit Rate, minimum (50014) _____ ft/sec Transit Rate (50015) _____ ft/sec Transit Rate, maximum (50016) _____ ft/sec

Hydro.Condition: Not determined [A]; Stable, low stage [4]; Falling stage [5]; Stable, high stage [6]; Peak stage [7]; Rising stage [8]; Stable, normal stage [9]

No. days since last significant rainfall _____

Comments:

Observations [Codes: 0=none; 1=mild; 2=moderate; 3=serious; 4=extreme]
Floating debris (01345) ___ Floating algae mats (01325) ___ Detergent suds (01305) ___ Atm. Odor (01330) ___
Floating garbage (01320) ___ Fish kill (01340) ___ Turbidity (01350) ___ Oil-grease (01300) ___

COMPILED BY: _____ **DATE** _____ **CHECKED BY:** _____ **DATE:** _____ **LOGGED INTO NWIS BY:** _____ **DATE** _____

1

SW form ver. 7.1

Figure 3. Example first page of a national field form for recording field-measurement data.

conditions, or specific project objectives. For example, dip samples are acceptable when the stream is very shallow (less than about 1 ft deep) or velocities are very low (less than about 1.5 ft/s) and the depth-integrating features of the sampling equipment and method are rendered ineffective. Additionally, point samples collected from a specific depth may be warranted using equipment such as a pumping sampler for high-frequency sample collection in special studies or for obtaining samples in remote areas that cannot be reached by field crews during critical or short-lived hydrologic events.

Thorough documentation of the type of sampling equipment and method used to collect the sample is required in field records for water-quality samples. The project chief, Water-Quality Specialist, or designated technical personnel is responsible for timely review of field records.

Two-person sampling teams with specific, designated roles in sample collection and handling (commonly referred to as "clean hands-dirty hands") typically are required when sampling for trace inorganic constituents with ambient concentrations less than about 10 parts per billion (ppb), as described in Horowitz and others (1994). The two-person sampling protocol (commonly referred to as "parts-per-billion" protocol) may be modified as appropriate for studies in which low-level trace elements are not measured. Also, the Center has developed a policy and procedures whereby one person may sample in a manner equivalent to parts-per-billion protocol during low-flow, wadable conditions by using specialized equipment and materials for collecting and handling the sampler, sample-collection bottle, and compositing vessel. Departures from the standard two-person sampling team require adequate QC samples to document the absence of contamination introduced by the modified protocol. In all cases of sampling from bridges or cableways, or during potentially hazardous weather conditions (extreme cold, storms, etc.), two-person sampling teams are to be employed.

Surface-water sampling procedures for water-quality projects are routinely overseen during work onsite by the Water-Quality Specialist, project chief, or experienced technical personnel to ensure that proper protocols are followed. An independent formal review of field methods for at least one or more selected projects is conducted once every 3 years during the OWQ technical review of Center water-quality activities.

8.1.5 Ground-Water Sampling

Ground-water sampling procedures are designed to ensure that the samples collected are representative of water in the aquifer. Because of potential changes in water quality that can occur when ground water is exposed to the atmosphere, it is important that the chemical or physical properties of the samples are not altered by the sampling process. Field personnel need to be aware of the various factors that can affect ground-water samples to protect sample integrity. The choice of sampling equipment and method of sample collection are based on established protocols and guidelines, depending upon the characteristics of target constituents, study objectives, geohydrologic conditions, and well-construction materials.

8.1.5.1 Equipment Selection

Guidelines for selecting appropriate equipment for ground-water sampling are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A2). All project personnel involved in ground-water sampling for water-quality studies must understand the advantages and disadvantages of available equipment with respect to study objectives. Because of the wide range of well-construction factors, the ideal equipment for sample collection under some circumstances may not exist. When decisions regarding compromise solutions are required, the field team must thoroughly document with field notes the compromises that are made. Review of equipment selection occurs during proposal and workplan development and during periodic project reviews.

8.1.5.2 Sample Collection

Guidelines for collecting representative ground-water samples are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A4). The standard procedure for ground-water sampling is to purge the well to remove at least three well volumes of standing water while monitoring field measurements for stabilization. However, exceptions to the three-well-volume rule can be made under some circumstances, depending upon project objectives or site characteristics.

Thorough documentation of the type of sampling equipment and method used to collect the sample is required in the field records for water-quality samples. The project chief or designated technical personnel is responsible for timely review of field records.

As a general rule, field personnel are required to follow a prescribed order of sample collection, described in the National Field Manual (U.S. Geological Survey, variously dated, chap. A4), to help ensure the quality of the data collected. In addition, two-person sampling teams are required to implement coordinated clean-handling techniques when collecting samples for trace elements with ambient concentrations less than about 10 ppb, as described in Horowitz and others (1994).

Ground-water sampling procedures for water-quality projects are routinely overseen during work onsite by the project chief or experienced technical personnel to ensure that protocols are properly followed. An independent formal review of field methods for at least one or more projects is conducted once every 3 years during the OWQ technical review of Center water-quality activities.

8.1.6 Precipitation Sampling

Specific procedures for collecting precipitation samples are based primarily on the study objectives and written guid-

ance provided by national program managers for the National Atmospheric Deposition Program (NADP). Major factors that must be considered when sampling for precipitation quality include the location of the sampling station relative to human influences, the choice of sampling equipment, and special sample-handling procedures that may be necessary. Precipitation-quality sampling equipment must be composed of inert, nonabsorbent material that will not affect the typically low concentrations of ions in solution.

Guidelines regarding the collection of precipitation samples are provided in the following references:

1. Dossett and Bowersox (1999) for guidance in field and laboratory procedures in the WRD;
2. Peden and others (1986) for procedures for collecting precipitation samples recommended by the USEPA; and
3. Willoughby (1995) for a case study discussing methods of precipitation sampling and analysis.

The project proposal and workplan are to be consulted for specific guidelines regarding the factors that must be considered in choosing the sample location, the sampling equipment and frequency, and the special sample handling procedures that may be necessary based upon the study objectives. Questions related to analysis of precipitation samples that are not addressed by these references can be addressed to the chief of the Inorganics Activities Section of the NWQL.

8.1.7 Sample Processing

All samples collected for water-quality analysis are processed onsite or as soon as possible following collection according to procedures in the National Field Manual (U.S. Geological Survey, variously dated, chap. A5). The constituents of interest and study objectives, which are described in the project workplan, determine the specific processing procedures that are necessary.

Water-quality studies that include the analysis of inorganic trace constituents that occur in concentrations less than 10 µg/L use the rigorous protocols for clean sample processing as described in Horowitz and others (1994) and the National Field Manual (U.S. Geological Survey, variously dated, chap. A5). These "parts per billion" protocols use processing and preservation chambers to reduce the potential for contamination from the surrounding environment during sample splitting, filtration, and preservation. If studies do not require analyses of trace constituents at concentrations less than 10 µg/L, less rigorous processing procedures can be used, but samples must be processed and preserved in a protected environment, such as a clean mobile laboratory or work surface that is isolated from airborne sources of contamination. Under such conditions, additional field blanks are recommended to ensure that the sample integrity was not compromised during processing. If clean processing areas are not available, then processing chambers must be used.

Research projects developing analytical or specialized sampling methods may deviate from the standard protocols, provided that the sampling methods are documented in project work plans and published reports. The data from these research projects are stored in the NWIS database if the laboratories have been approved by the USGS Branch of Quality Systems; however, not all research data are stored in the NWIS database. Data stored outside of NWIS need to be made publicly accessible through publications or Web pages.

Regardless of the magnitude of constituent concentrations, most components of the parts-per-billion protocols are recommended for all sample collection and processing. The use of clean protocols that protect sample integrity by using gloves, bags, chambers, clean work areas, clean equipment, and careful handling procedures enhances the quality of the data. Although the two-person (clean hands-dirty hands) team approach for sampling can be modified for one person in certain circumstances, two-person teams are required if there are any field safety issues, such as high water, remote and difficult access, extreme weather conditions, or individual health issues.

8.1.7.1 Sample Compositing and Splitting

Guidelines for using sample compositors and splitters are in the National Field Manual (U.S. Geological Survey, variously dated, chap. A2). Two types of sample splitters presently in use in the WRD are the churn splitter, which also serves as a compositing device, and the cone splitter, which requires a separate compositing vessel. Each splitter has specific advantages and disadvantages, as described in OWQ Technical Memorandum 97.06. Either splitting method can be applied to inorganic and organic constituents within the technical design limits of the device and as long as the equipment is constructed of appropriate materials.

8.1.7.2 Sample Filtration

Filtration is required for many water-quality samples in order to separate particulate material from the dissolved constituents in the water. Selection of the appropriate filter unit and filter characteristics to be used depends on the constituent group of interest and is based on guidance provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A2). Guidelines for filtration procedures for specific constituent groups also are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A5). For inorganic analyses of surface water, the most common filtration system consists of a reversible, variable-speed, battery-operated, peristaltic pump with silicon tubing and an in-line 0.45-micron pore size disposable capsule filter. For organic analyses, teflon tubing and stainless steel plate filter units are used. For ground water, the sample is generally pumped directly from the well through a 0.45-micron pore size disposable capsule filter. Samples that will be analyzed for dissolved trace elements that typically occur at ambient concentrations of less than 10 ppb generally are filtered in a

processing chamber that encloses the filtering unit and sample bottles in a protected environment (U.S. Geological Survey, variously dated, chap. A5).

8.1.7.3 Sample Preservation

Sample preservation techniques are required for some constituent groups to prevent reduction or loss of target analytes and to stabilize analyte concentrations until the sample can be analyzed. Guidelines for sample preservation are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A5). Because some samples have a very limited holding time, even when preserved, field personnel must ensure that all water-quality samples are shipped to the laboratory as quickly as possible and that time-sensitive samples are received in good condition within the appropriate holding times. Samples that are required to be chilled are tested upon arrival at the NWQL for temperature of the surrounding ice (or ice water as the ice melts) to ensure that the samples are received at the necessary temperature to meet the criteria for proper preservation and subsequent analysis. Chilled samples are immediately placed in a refrigerated holding area at the NWQL as soon as they are logged in and the sample identity is recorded in the lab sample-tracking system. For details on sample shipping requirements, refer to Section 9.3 of this QA plan.

8.2 Other Types of Samples Related to Water Quality

Many water-quality studies in the USGS are beginning to employ a multidisciplinary approach that relies on data from a range of environmental media. Biological and sediment samples may be incorporated into a water-quality project in order to provide multiple lines of evidence with which to evaluate a particular aquatic system. This section of the QA plan includes an overview of Center QA procedures and references for detailed instructions that describe the collection of biological and sediment samples.

8.2.1 Biological Samples

A limited number of Center water-quality activities include the collection of biological samples. At times, various programs require the collection and analysis of bacteria samples or 5-day biochemical oxygen demand (U.S. Geological Survey, variously dated, chap. A7). Biological sampling has recently been implemented for characterizing the abundance and composition of algae, invertebrate, and fish communities (Moulton and others, 2002). Characterization of stream habitat (Meador and others, 1993) typically is done in conjunction with biological sampling. In addition to population characteristics, the trace-element content of aquatic insect tissue has been analyzed (Crawford and Luoma, 1993) by the USGS National Research Program in Menlo Park, Calif.

8.2.2 Sediment Samples

Water-quality activities in the Center routinely include the collection and analysis of suspended-sediment samples and occasionally bottom-sediment samples. Guidelines for the collection and analysis of sediment samples are described by Guy (1969), Matthes and others (1992), Knott and others (1993), Shelton and Capel (1994), Edwards and Glysson (1999), Dodge and Lambing (2006), U.S. Geological Survey (variously dated, chap. A8), and Office of Surface Water Memorandum 93.01. Suspended-sediment samples typically are analyzed for concentration and sand-silt size distribution (percent finer than 0.062-millimeter diameter) by the USGS Montana Sediment Laboratory in Helena, Mont. Suspended-sediment samples collected for the NASQAN program and bottom-sediment samples collected for the U.S. Army Corps of Engineers are analyzed for concentration and complete particle-size distribution by the USGS Iowa Sediment Laboratory in Iowa City, Iowa. Bottom-sediment samples in selected studies are analyzed for trace-element concentrations by the NWQL or USGS National Research Program laboratories to assess exposure levels to biological organisms that inhabit streambed or lake-bottom environments.

Field personnel need to be familiar with the factors involved in the selection of sediment-sampling equipment (Davis and Federal Interagency Sedimentation Project, 2005) so that the equipment is appropriate for both the particular hydraulic conditions at the sampling site and the type of analyses to be performed. The Water-Quality Specialist needs to be consulted for selection of sediment sampling equipment. Knowledge of specific cleaning procedures for the sampling equipment also is required when collecting sediment for chemical analysis. The project workplan is to be consulted for specific guidelines for sediment sampling, as determined by project objectives. Individuals who have questions regarding the collection and handling of sediment samples need to contact either the Water-Quality Specialist or project chief.

8.3 Quality-Control Samples

QC samples are collected as integral components of all Center water-quality studies to determine whether the data-collection process is producing data of acceptable quality. QC data provide a basis for evaluating the adequacy of specific procedures that were used to obtain and analyze samples and are crucial for identifying deficiencies in need of corrective action. Guidelines for the collection of specific types of QC samples and the use of QC data are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A4). Specific guidelines for the collection and processing of QC samples are included in project workplans,

as discussed in section 3.2. The project chief or Water-Quality Specialist is responsible for reviewing QC data in a timely manner and implementing additional testing or modifications to sampling and processing techniques if deficiencies in data quality are indicated. The Water-Quality Specialist has the responsibility for advising Center personnel regarding the collection and interpretation of analytical results for QC samples.

8.4 Safety Issues

Because the collection of water-quality data in the field can be hazardous at times, the safety of field personnel is a primary concern to avoid accidents and injuries. Field teams often work in high-traffic areas, remote locations, or extreme environmental conditions. Field work involves the transportation and use of equipment and chemicals and sometimes requires working with heavy machinery. Additionally, field personnel may come in contact with waterborne and airborne chemicals and pathogens while sampling. Beyond the obvious concerns regarding safety, the quality of the data can be compromised when sampling teams are exposed to dangerous conditions.

Information and directives related to safety are communicated to all personnel to enhance awareness and advise staff regarding established procedures and protocols that promote all aspects of safety. Information about safety is communicated through agency memoranda, electronic mail, videotapes, and training courses. Several types of critical training, such as first aid and defensive driving are mandatory to attend every 3-5 years. Specific policies and procedures related to safety are available to USGS employees through USGS internal Web links.

A Safety Officer is designated by the Center Director. The duties of the Safety Officer include distributing safety information, working with technical specialists to implement the inspection and testing of cableways and stilling wells, coordinating boat safety training, and assisting field offices in developing bridge safety plans, JHAs, and site hazard analyses (SHAs). JHAs identify potential hazards for various USGS activities and provide recommended procedures to maintain safe working conditions. SHAs identify potential hazards for a particular USGS site. The Safety Officer also serves as the Chemical Hygiene Officer and works closely with the Water-Quality Lead Technician and Water-Quality Specialist to maintain an inventory of chemicals used for water-quality work in the Center and their associated MSD sheets. Appropriate response actions to potentially unsafe conditions are implemented using guidance from the Regional Safety Officer. Personnel who have questions or concerns pertaining to safety, or who have suggestions for improving some aspect of safety, can direct those questions, concerns, and/or suggestions to the Safety Officer and their supervisor. Safety-related suggestions are then compiled for consideration by Center management and discipline specialists. If a new or revised safety procedure is adopted, guidance and policy regarding implementation are provided by Center management. Guidelines pertaining to safety in general field activities are provided in the National Field Manual (U.S. Geological Survey, variously dated, chap. A9). Guidelines pertaining to safety for specific projects or sites are documented in JHAs for each project or activity.

8.5 References for the Sample Collection and Processing Section

Table 12 lists reports and/or memoranda referred to in section 8.0. For a complete citation, refer to Section 13.0 of the report.

9.0 Water-Quality Sample Handling and Tracking

All water-quality samples must be uniquely identified, documented, handled, shipped, and tracked appropriately. Following proper protocols for sample handling, shipping, and tracking ensures that samples are processed correctly and expeditiously to preserve sample integrity between the time of collection and the time of analysis. This section describes the procedures used by the Center for handling, shipping, and tracking samples from collection in the field through transfer of the samples to an analytical facility. Receipt of analytical data from laboratories is covered in Section 10.0 (Water-Quality Data Management).

9.1 Onsite Sample Handling and Documentation

During a sampling trip, it is imperative that accurate notes be taken and that sample bottles be labeled and handled appropriately for the intended analysis. Otherwise, bottle mix-ups or other errors may occur, and the sample information may be lost or useless. Field personnel are responsible for ensuring that all of the sampling requirements are implemented according to USGS and Center procedures. Guidance on sample processing and container types is provided in National Field Manual (U.S. Geological Survey, variously dated, chap. A5). All samples must be in the required container type and clearly labeled with the station identifier, sample date, sample time, and bottle type designation (which indicates sample treatment and preservation). The required sample treatment (filtered or unfiltered) and preservation (acidified, unacidified, chilled) is indicated for individual sample bottles on the sampling instructions prepared for each site that is sampled in the Center, along with the analyses to be requested on the NWQL's ASR form. An example of a sampling-instruction form used in the Center is shown in figure 4.

Table 12. Summary of references for collecting and processing samples.

[Abbreviations: NAWQA, National Water-Quality Assessment Program; ppb, parts per billion; OSW, Office of Surface Water; OWQ, Office of Water Quality; USEPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey]

Reference	Subject
Crawford and Luoma, 1993	Collecting samples for analysis of contaminants in tissue (NAWQA).
Davis and Federal Interagency Sedimentation Project, 2005	Selection of sediment and water-quality samplers.
Dossett and Bowersox, 1999	Field and laboratory procedures for precipitation stations.
Edwards and Glysson, 1999	Representative sampling techniques for surface water.
Guy, 1969	Laboratory theory and methods for sediment analysis.
Horowitz and others, 1994	Protocol for collecting and processing inorganic constituents at ppb concentrations.
Knott and others, 1993	Quality assurance plan for collecting and processing sediment data.
Koterba and others, 1995	Collecting and processing ground-water samples (NAWQA).
Dodge and Lambing, 2006	Sediment laboratory procedures and quality assurance.
Matthes and others, 1992	Sediment laboratory procedures and quality assurance.
Meador and others, 1993	Characterization of streambed habitat (NAWQA).
Moulton and others, 2002	Revised protocols for collecting algae, invertebrate, and fish samples (NAWQA).
OSW Memorandum 93.01	Instrumentation and field methods for collecting suspended-sediment data.
OWQ Memorandum 97.06	Comparison of splitting capabilities of the churn and cone splitters.
Peden and others, 1986	Procedures for collecting precipitation samples, recommended by USEPA.
Shelton, 1994	Collecting and processing stream-water samples (NAWQA).
Shelton and Capel, 1994	Collecting and processing streambed-sediment samples (NAWQA).
Stanley and others, 1992	National field quality-assurance program.
USGS variously dated (National Field Manual, chap. A1)	Preparations for water sampling.
USGS variously dated (National Field Manual, chap. A2)	Selection of equipment used to collect and process water-quality samples.
USGS variously dated (National Field Manual, chap. A3)	Cleaning equipment used to collect and process water-quality samples.
USGS variously dated (National Field Manual, chap. A4)	Collecting water-quality samples from surface and ground water.
USGS variously dated (National Field Manual, chap. A5)	Processing water-quality samples.
USGS variously dated (National Field Manual, chap. A6)	Well-purging procedures.
USGS variously dated (National Field Manual, chap. A7)	Collecting and measuring bacteria samples; 5-day biochemical oxygen demand test.
USGS variously dated (National Field Manual, chap. A8)	Collecting and processing bottom-sediment samples.
USGS variously dated (National Field Manual, chap. A9)	Safety in field activities.
Wagner and others, 2006	Guidelines for operation of continuous water-quality monitors.
Ward and Harr, 1990	Representative sampling techniques for surface water.
Willoughby, 1995	Case study discussing methods of precipitation sampling and analysis.

9.2 Sample Shipment and Documentation

Upon completion of a sampling trip, samples are to be packaged and shipped to the laboratory for analysis as soon as possible. Generally, the shorter the time between sample collection, onsite processing, and laboratory analysis, the more reliable the analytical results will be. After collecting and processing the samples, the field personnel need to complete the following:

1. Cross-check the sample sets with the sampling instructions for the site to ensure that all necessary bottles for that particular visit have been collected and that all sample bottles are labeled correctly, with all required information (see Section 9.1).

2. Complete the ASRs for all samples being sent to the NWQL. If samples are being sent to a different, approved laboratory, information similar to that required on the ASRs is to be provided to the laboratory in accordance with the laboratory's protocol for sample delivery.

3. Pack samples carefully in shipping containers to avoid bottle breakage, shipping container leakage, and sample degradation. Check that bottle caps are securely sealed. Follow the packing and shipping protocols established by the USGS and the receiving laboratory. Additional information is contained in the NWQL Technical Memorandum 02.04 and the National Field Manual (U.S. Geological Survey, variously dated, chap. A5).

4. Samples collected from water sources suspected or known to be contaminated, or samples that contain hazardous materials, are to be securely packed and accompanied by special identification on the shipping container and shipping form to alert shipping and laboratory personnel of the potential hazardous nature of the contents. Additional information on submitting samples of contaminated water is contained in OWQ Water-Quality Information Note 2004.13.

5. Ship samples as promptly as possible after sample collection, preferably the same day whenever possible.

9.3 Sample Tracking Procedures

The Data Management Unit maintains a record of all samples collected and shipped to the NWQL to ensure the complete and timely receipt of analytical results. In addition to the shipping receipts that document the date that samples were shipped to the laboratory, the NWQL uses an automated electronic acknowledgment system that generates an email during sample login that is transmitted to the sample collector, Water-Quality Database Manager, and Water-Quality Specialist informing them of receipt of the sample and sample condition. Samples that may have been damaged in transit or do not meet temperature criteria are noted in the email so that a decision on whether or not to proceed with the analysis can be made by the Science Center. The Water-Quality Database Manager compiles a log for each station of the dates that samples were collected, the analytical schedules or lab codes requested, the date that analytical results are received, requests for reruns of particular analytes, dates that rerun results were received, and updates made to the database.

The tracking log is updated as analytical results are received and is reviewed to confirm completion of sample analysis or to determine if analyses are missing. In addition, the NWQL has an internal Web page that personnel can query to determine the status of analytical progress and dates of completion. If results are not received for submitted samples within a reasonable time period, the tracking information is used to identify the specific station, date, and time so that the NWQL can be informed of the missing data. At that point, the NWQL will initiate a search for the sample bottles or will review the laboratory database to evaluate whether or not the data were successfully transmitted.

9.4 Chain-of-Custody Procedures for Samples

Chain-of-custody procedures generally are not used in routine water-quality programs that are intended for basic characterization of environmental conditions. The high cost of chain-of-custody, as well as the substantial burden placed upon laboratory staff, typically restricts use of this rigorous process to special situations. When chain-of-custody procedures are appropriate or required (for example, when data will likely be used in legal proceedings), the project chief needs to establish, maintain, and document a chain-of-custody system for field samples that is commensurate with the intended use of the data. The NWQL maintains a protocol for specific actions required to implement chain-of-custody within the laboratory premises. A sample is in custody if it is in actual physical possession or in a secured area that is restricted to authorized personnel. Every exchange of a sample between people or places from the field to the laboratory, and within the laboratory, that involves a transfer of custody must be recorded on appropriate forms that document the release and receipt of the sample. Each person involved in the release or receipt of a sample needs to keep a copy of the transfer paperwork. The project chief and designated NWQL officer are responsible for ensuring that transfers of sample custody are performed and documented in their respective areas of operation according to the requirements listed below:

- The means for identifying custody are clearly understood (use of forms, stickers, etc.);

- Instructions for documenting the transfer of samples and the person responsible for this documentation within the Science Center and within the NWQL must be clearly defined; and

- A plan must be in place for maintaining records in a specific location for a specific period of time (for example, in the site folder).

WATER-QUALITY SAMPLING INSTRUCTIONS, 2006 WY 09-29-05

STATION: 06326500 POWDER RIVER NEAR LOCATE

OFFICE: Billings
ACCOUNT: 8620-00300
COUNTY: Custer, 017
COOPERATOR: Montana Department of Environmental Quality (MDEQ)
SAMPLING PURPOSE: To characterize water quality in area of coal-bed methane development

TYPE AND FREQUENCY OF SAMPLES

GROUP A: 12/yr - Major ions, dissolved
Schedule No: 1158
Add lab code: 70
Bottles: FA (250 ml - add nitric acid), FU (500 ml), RU (250 ml)

GROUP B: 12/yr - Nutrients, dissolved and total
Schedule No: 1698
Bottles: FCC (125 ml brown), WCA (125 ml plain - add sulfuric acid), chill both and ship within 3 days.

GROUP C: 12/yr - Metals, total recoverable
Schedule No: 1681
Bottles: RA (250 ml - add nitric acid)

GROUP D: 1/Year - Mercury, high flow
Lab Code: 2708
Bottles: RAM (250 ml glass - add hydrochloric acid)

QA GROUP: 1/Year, field replicate (R) split from churn. Use regular station ID, offset time by 5 minutes from routine sample (medium code=9 for routine sample, R for replicate). Add parameter codes and values on both samples: 99111=30, 99105=30.
Schedule No: 1158, 1698, 1681
Add Lab Code: 70
Bottles: RU (250 ml), FU (500 ml), FA (250 ml), WCA (125 ml), FCC (125ml)

SEDIMENT: 12/yr
Analysis: Concentration and sand-silt break
Samples: One multi-bottle sample set collected either by EWI (wading) or EDI (bridge) methods. Collect second sediment sample on day that chemical replicate is collected.

FIELD DETERMINATIONS: 12/yr
Streamflow (rating), water temperature, air temperature, conductance, and pH.

TOTAL SAMPLING VISITS REQUIRED = 12 **CROSS OFF AS SAMPLES ARE COLLECTED**

GROUP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A	X	X	X	X	X	X	X	X	X	X	X	X
B	X	X	X	X	X	X	X	X	X	X	X	X
C	X	X	X	X	X	X	X	X	X	X	X	X
D									X*			
QA		R										
SED	X	X	X	X	X	X	X	X	X	X	X	X

*Use field judgment on when to collect high-flow mercury sample.

Figure 4. Example of U.S. Geological Survey Montana Water Science Center sampling-instruction form.

9.5 References for the Water-Quality Sample Handling and Tracking Section

Table 13 lists reports and/or memoranda referred to in Section 9.0. For a complete citation, refer to Section 13.0 of the report.

10.0 Water-Quality Data Management

Water-quality data are recorded on paper and electronically in computer files. Data that are recorded on paper include chemical, physical, biological, and ancillary data measured in the field. This information is documented on standard USGS field forms (fig. 3) and stored in station files. Data that are recorded electronically include field measurements entered on computer forms, analytical results from the NWQL, and continuous-monitor data transmitted over the computer network or stored by electronic-data logger. Paper copies of electronically recorded data are printed and stored in station files as backup.

The national NWIS database is the long-term storage medium for water-quality, streamflow, and ground-water information collected by the USGS. Data that are recorded on paper forms or electronically initially are entered and stored in the local NWIS database of the USGS State Water Science Centers. Analytical results for water-quality samples reside in a subsystem of NWIS (Water Quality System), where the data are accessed through the QWDATA program (Gellenbeck, 2005). Unit values recorded by continuous monitors at selected time intervals (15-minute, 30-minute, hourly), as well as daily values (24-hour mean, minimum, maximum) computed from continuous monitors or daily sampling programs, reside in the NWIS subsystem (Automatic Data Processing System), where the data are accessed through the ADAPS program (Bartholoma, 2005). Data that cannot be stored in the NWIS database may be stored in other databases, such as project databases.

The data stored in the national NWIS database are publicly accessible for either viewing or retrieval at the USGS Web page *http://waterdata.usgs.gov/nwis*. Water-quality data are currently (2006) uploaded from the local NWIS databases in the national database one time during the year, after all data for the previous water year have been reviewed and approved. Prior to final approval, the water-quality data in the local NWIS databases are considered provisional. Recently collected provisional data that have not yet been approved or uploaded to the national NWIS database may be requested from the Center for inspection after a preliminary review has been done to examine the data for any obvious errors. Data that are of uncertain quality and that may require additional examination are withheld from provisional release until the uncertainty in data quality can be resolved. Provisional data that are released are qualified as being for inspection only and are not to be formally cited, as they are subject to further review and possible revision.

10.1 Processing Data

Sampling information, field determinations, and ancillary data are recorded on water-quality field notes that are considered original record. These data are combined with analytical data from the laboratory in computer data files and stored with other paper documents in the station folders maintained by the Data Management Unit. In addition, electronically recorded data from continuous monitors are loaded into Center computer files for subsequent processing and computation of daily records.

10.1.1 Analytical Data

Analytical data are results of field or laboratory physical, chemical, or biological determinations. Most water-quality samples are analyzed in the field, at the NWQL, or at the Center Sediment Laboratory. In some instances, samples may be analyzed by USGS research laboratories or by laboratories outside of the USGS (see Section 4.1).

In order to enter analytical data into the Center NWIS database, a site identification number must first be assigned and entered into the Center site file (see Section 7.2). Field measurements are entered into the NWIS database as soon as possible after returning from the sampling trip by either the Water-Quality Database Manager or by personnel trained in using QWDATA. An NWIS record number unique to each

Table 13. Summary of references for handling and tracking water-quality samples.

[Abbreviations: ASR, Analytical Services Request; NWQL, National Water Quality Laboratory; OWQ, Office of Water Quality; USGS, U.S. Geological Survey]

Reference	Subject
NWQL Memorandum 02.04	Shipping samples to the NWQL and instructions for filling out ASR forms.
OWQ Water-Quality Information Note 2004.13	Working in contaminated waters and submission of samples.
USGS, variously dated (National Field Manual, chap. A5)	Processing water samples.

sample is assigned by the system and is recorded on the field sheet and on a sample-collection log book (fig. 5) to track the collection of samples. Similarly, the NWQL also assigns a laboratory (ID) number that is cross-matched to the Center NWIS record number to uniquely track the sample through the analytical process and for storage of results in the NWQL database. Accurate sample log-in is required so that analytical results from the NWQL are successfully cross-matched to the proper sample and electronically transferred to the Center NWIS database. Environmental sample data are stored in the Center NWIS environmental database (Database 1); QA data for blanks, replicates, and spikes are entered into the Center NWIS QA database (Database 2). Data can be retrieved using site identifiers (station number) or sample identifiers (record numbers) for any variety of dates or parameters. The data can be retrieved from each database separately or can be merged to allow data from both databases to be compiled into a single output file.

Analytical results from the NWQL are electronically transferred to the appropriate Center NWIS database by a retrieval program run by the Water-Quality Database Manager at least once per week. Hard copies for each water analysis list (WATLIST) are forwarded to the Water-Quality Specialist or project chief for data review. Anomalous values are identified during initial review and requests for analytical reruns are submitted to the NWQL for the specific analyte(s) in question. After initial review by the Water-Quality Specialist or project chief, the data are stored in site files maintained by the Data Management Unit. Copies of the data also may be stored in project files. A record of rerun requests and receipt of results is maintained in the sample-collection log book (fig. 5). The Center NWIS database receives a full backup every working day.

Data for samples analyzed by USGS-approved laboratories other than the NWQL also are entered into NWIS, if possible (Hubbard, 1992), and identified according to the analyzing laboratory. Entry of data from outside laboratories into NWIS is the responsibility of the project chief or designated technical personnel. Data are entered and stored according to procedures already described for processing NWIS analytical data. Appropriate codes are used to identify the data as originating from non-NWQL sources.

10.1.2 Continuous-Monitor Data

Continuous-monitor data are water-quality records collected onsite at frequent intervals by electronic sensors and data loggers. Two methods for electronically recording data on medium, such as magnetic tape, disc, or solid-state memory device, are (1) transmitting data from a remote location by land line or radio telemetry to a central location, and (2) recording data directly onto a medium at the remote location. Initial data processing in the office is for the purpose of obtaining a copy of the original data for archiving (see Section 10.4). Recorded data are not manipulated by the field instrument or a computer except to convert recorded values into commonly used units or to display data in a convenient format. The transfer of data from the electronic storage medium to the NWIS database requires thorough checking to ensure that the data have transferred successfully or that as much data as possible have been recovered and errors identified (WRD Memorandum 87.085).

Recorded data are reviewed for completeness and compared to field measurements to determine their accuracy. The field measurements used to assess the level of error in the monitor readings include a comparison of the stream value (measured with a separate, calibrated meter) to the reading displayed by the monitor, and a test of sensor readings against known values of at least two calibration standards. Results of these quality-assurance checks are documented on field forms and are used to evaluate the representativeness of the recorded data and whether or not adjustments to the recorded data need to be made to achieve the required accuracy.

Recorded data may be adjusted by applying data corrections to account for errors owing to environmental effects (such as fouling of the probe by sediment or biofilm, or physical damage caused by impact of debris or ice) or instrument sensitivity (electronic drift due to voltage irregularities, response to temperature changes, or freezing). Data corrections are quantified based on field comparisons and calibration checks and commonly are applied as a percentage adjustment that is prorated back to the previous inspection, or to the point where the error initially began, if that can be determined. After the corrections are applied, a new ADAPS primary computation of unit values is prepared and reviewed to verify that the changes have corrected the error. Guidelines and standard pro-

Station number	Date/time	Analytical schedules requested	NWIS record number	Lab ID number	Reruns requested	Reruns received
12352500	Apr. 23, 2003/0930	1247	00300243	1190056		
"	"	2631	"	"		
12344000	Apr. 23, 2003/1500	1247	00300246	1190052		
"	"	2631	"	"		

Figure 5. Example page from a U.S. Geological Survey Montana Water Science Center sample-collection log book.

cedures for processing data from water-quality monitors are documented in Wagner and others (2006). Additional guidance and WRD policy pertaining to electronically recorded data is contained in WRD Memorandum 87.085.

10.1.3 Non-National Water Information System Databases

Sometimes data collected by project personnel cannot be entered into the Center NWIS database because the data are proprietary (such as data collected for some military projects) or because NWIS cannot accommodate the type or format of data that are generated by the project (for example, taxonomic data). In these cases, project databases may be established to store the data. Project databases that are the sole repository for project data need to have a written procedure for data entry, storage, backup, and long-term archiving. The project chief or designated technical personnel has the responsibility for developing and implementing management of project databases. Data that are not stored in the NWIS database are to be made publicly available through either publication in reports or journals, or through Web page access.

10.2 Data Review

Data review is the process whereby provisional water-quality and associated data are checked for completeness and accuracy, using a variety of criteria and technical evaluations. After preliminary review, corrective actions (if necessary), and final review, the water-quality data for discrete samples and daily records from continuous monitors or daily sediment stations are approved by the Water-Quality Specialist or project chief and finalized in the Center NWIS database.

10.2.1 Analytical Data

All field notes and field measurements are reviewed for completeness and accuracy as soon as possible after returning from the field trip by a designated water-quality technician, field office supervisor, or project chief. Analytical results from the laboratory are reviewed by the Water-Quality Specialist or project chief for completeness and accuracy within the context of chemical principles, hydrologic conditions, season, comparison to previous results, and comparison to other values at nearby sites. Questionable values are noted by the Water-Quality Specialist or project chief for further evaluation. When possible, analytical data are reviewed within 5 days after receipt from the laboratory. Prompt review is necessary to allow sample reanalysis to be performed before sample holding times have been exceeded, which is especially important for time-critical analyses such as nutrients or unstable constituents (such as organic compounds and pesticides). Every entry of analytical data into the NWIS database results in a WATLIST report that includes the analytical results and results of general validation checks (Gellenbeck, 2005). WATLIST reports include various chemical logic checks and comparisons to water-quality standards such as:

- Comparison of measured and calculated values for dissolved-solids concentration,
- Comparison of dissolved and total recoverable concentrations,
- Comparison of specific conductance with dissolved-solids concentration,
- Comparison of constituent concentrations relative to Federal drinking-water standards, and
- Verification of ionic balance by comparing the sum of cations with the sum of anions, in milliequivalent units.

Failure of analytical results to meet chemical logic checks within the limits of method precision can form the basis for requesting a reanalysis of a particular constituent. Several water-quality properties, such as pH, specific conductance, and alkalinity, are commonly measured in both the field and the laboratory to confirm agreement of independent measurements. If previous samples are available for a site, the current analysis is compared with previous data to assess the nature of water-quality variations relative to varying streamflow conditions, season, or suspended-sediment concentrations. Unusual variations in values, anomalies such as extreme values, obvious errors (such as decimal errors), and possible sample mix-ups between stations can warrant requests for laboratory reanalysis of the sample or verification of sample identity. If other sites were sampled closely in time within the same or nearby areas, those results also are compared to evaluate if similar variations occurred elsewhere. Observations of questionable values requiring further verification or reanalysis are noted on the WATLIST report, and a copy of correspondence with the laboratory regarding the anomalous value is kept in the station folder. If necessary, updates to the provisional data stored in the Center NWIS database may be necessary if analytical reruns do not support initial results. Acceptance or rejection of updates to the database are determined by the Water-Quality Specialist or project chief.

After the need for reanalysis has been determined, requests to the NWQL for reanalysis typically are sent by the Water-Quality Database Manager to the NWQL through USGS internal Web links. Reanalysis requests for other laboratories may be made in writing, as stipulated in the laboratory contract. Reanalysis requests are logged and tracked by the Water-Quality Database Manager, the original and rerun values are listed for comparison, and the action taken upon receipt of the rerun results is recorded on a reanalysis tracking form (fig. 6).

Updates to sample values stored in the Center NWIS database resulting from sample reanalysis by the NWQL also must be made to the NWQL database to ensure that both repositories of data store the same values. Updates to the Cen-

ter database are made by the Water-Quality Database Manager, who also emails the NWQL (*GS-W-COden NWQL LabHelp@USGS.gov*) to inform the NWQL of the updated value that needs to be updated in the NWQL database. Similarly, if the NWQL discovers a systematic bias for a particular constituent resulting from ongoing internal QA testing, those adjustments to constituent concentrations are applied to the NWQL database. The Centers are alerted to the parameter, period of time when sample values were affected, and the magnitude of correction. The updated values are then loaded from the NWQL database to the Center NWIS database to ensure conformity between databases.

QA data, such as blanks, replicates, standard reference samples, and matrix spikes, periodically are tabulated or graphed by the project chief to facilitate identification of inaccuracies or systematic bias that may not be discernible when reviewing an individual analysis. Similarly, analytical method performance at the NWQL is documented by quality-control charts derived from analyses of standard reference samples to assess potential bias in results for environmental samples. The Water-Quality Specialist periodically reviews the entire QA database to examine patterns that might indicate inaccuracies or systematic bias that may be occurring across Center projects or basic data programs. Systematic problems that are identified will trigger the collection of additional QA samples to attempt to isolate the source of any problem and develop a strategy to correct the problem. Corrective actions could include replacement of equipment or supplies, modifying procedures to more effectively ensure sample integrity, or additional training for staff.

At the end of the water year, all water-quality data for a site are compiled and reviewed for a final time to ensure that the data are complete and accurate. When all data for a year are viewed collectively, subtle anomalies in data patterns may become obvious that were not readily apparent earlier in the year. If holding times have not expired, additional reruns may be requested. Other checks and comparisons may be made to confirm the data validity. Decisions to delete values typically are made at the end of the water year, when the maximum amount of information is available to evaluate anomalous values. The deletion of values is avoided unless there is compelling evidence that the data are probably or certainly in error. If a value is deleted, Data-Quality Indicator (DQI) codes are used to describe the reason. After all data for a site have been reviewed relative to streamflow variations and seasonality, after all reanalysis results have been received, and after any corrective actions have been implemented, the data are approved by the Water-Quality Specialist and prepared for publication.

10.2.2 Continuous-Monitor Data

Continuous-monitor data are recorded electronically and downloaded into the ADAPS subsystem of the NWIS database. Tabulations and graphs of raw data are reviewed by the field office technical personnel for anomalous values, missing record, and accuracy relative to comparisons with field measurements, sensor-cleaning effects, and calibration checks. Records are initially edited by deleting obviously bad values resulting from electronic or physical disruptions. Where recorded data fall outside of an excellent accuracy rating (Wagner and others, 2006), but are within acceptable limits, the data are adjusted by applying data corrections to remove instrument drift. After the data are updated, all field inspections and calibrations are compiled into an annual summary table. A table of daily values (mean, minimum, maximum) is retrieved and a station analysis is written. The daily record is then submitted to a designated technician for checking. Following the computation and checking of the record by field-office staff, the entire records-computation folder of raw data and computed daily record is submitted to the Water-Quality Specialist or project chief for final review, revisions to the record, and approval. After approval, the data are considered to be final and are prepared for publication.

Date requested	Lab ID number	Station number	Date	Time	Parameter number	Parameter name	Old value	New value	Update/No update/ Delete

Figure 6. Example of reanalysis tracking form.

10.3 Data Storage

In accordance with WRD policy, all water data collected as part of routine data collection by the WRD are stored in the national NWIS computer database and publicly accessible at the USGS Web page at *http://waterdata.usgs.gov/nwis/*. Data collected by others, such as cooperators, universities, or consultants, which are used to support published USGS documents and are not published or archived elsewhere, also can be entered into the NWIS database; however, these data must be flagged with the appropriate DQI code, and the source agency for sample collection and analysis identified (OWQ Technical Memorandum 02.15). Other outside data, such as field measurements by a trained observer, may be entered into the database at the discretion of the Water-Quality Specialist if data-collection methods and quality have been reviewed and found acceptable. Electronically stored data that cannot be entered into the NWIS database due to incompatible formats or other features are stored in project databases.

The Center Information Technology Specialist has responsibility for maintaining backups of data stored electronically in NWIS or online. Data stored electronically offline are maintained by the project chief or designated technical personnel. In addition to electronically stored data, other project data and information, including field notes, ASRs, WATLISTs, and other data sheets, are retained in station folders and maintained by the project chief or designated technical personnel in the project office while the project is active.

10.4 Records Archival

According to WRD policy, all original data that are published or support published scientific analyses shall be placed in archives (WRD Memorandum 92.059; Hubbard, 1992). Original data—from automated data-collection sites, laboratories, outside sources, and non-automated field observations—are unmodified data as collected or received and in conventional units (engineering units, generally with a decimal). Original data need to be preserved in this form, no matter how they may be modified later (Hubbard, 1992). Original data on paper include field notes, field measurements, calibration notes, ASRs, WATLISTs, continuous water-quality monitor records, and graphical analog charts. For projects, these data are archived when the project is completed; for monitoring-data programs, the data are archived when they are more than 5 years old. It is the responsibility of the project chief and Data Management Unit personnel to ensure that project and data program files entered into the Center archive are organized and complete. The archive for monitoring data is located in the Center office in Helena, Mont., and is maintained by the Data Management Unit Chief. Data from the Center archives may be transferred for permanent storage to the U.S. National Archives and Records Administration in Denver, Colo., after project data are published and routine access to original data and notes is no longer required.

10.5 References for the Water-Quality Data Management Section

Table 14 lists reports and/or memoranda referred to in Section 10.0. For a complete citation, refer to Section 13.0 of the report.

11.0 Publication of Water-Quality Data

Water-quality data are published in either data reports or interpretive reports. The selection of the appropriate publication outlet for water-quality data is determined by the project chief, Hydrologic Investigations Section Chief, and Reports Specialist and is based upon the objectives established in the project proposal or data program agreement. A summary of USGS and WRD policies pertaining to the publication of data and interpretive reports is contained in WRD publications guides (Alt and Iseri, 1986, p. 382-384; U.S. Geological Survey, 1995). Other references that can be consulted when writing reports include “Suggestions to Authors of Reports

Table 14. Summary of references for managing water-quality data and records.

[Abbreviations: ADAPS, Automated Data Processing System; NWIS, National Water Information System; QWDATA, Quality-of-Water Database; WRD, Water Resources Division]

Reference	Subject
Bartholoma, 2005	NWIS ADAPS user’s guide, Open-File Report 05-1160.
Hubbard, 1992	Policy recommendations for managing and storing hydrologic data.
Gellenbeck, 2005	NWIS QWDATA user’s guide, Open-File Report 05-1081
OWQ Memorandum 02.15	Data-Quality Indicator codes in NWIS.
Wagner and others, 2006	Guidelines and standard procedures for continuous water-quality monitors.
WRD Memorandum 87.085	Policy for collecting and archiving electronically recorded data.
WRD Memorandum 92.059	Policy for the management and retention of hydrologic data.

of the U.S. Geological Survey" (Hansen, 1991) and the U.S. Government Printing Office Style Manual (U.S. Government Printing Office, 2000). Bureau (USGS) approval is required for all reports and typically is obtained at the Regional level, although approval authority is delegated to USGS Water Science Centers for selected USGS report products.

11.1 Data Reports

The term "data" refers to uninterpreted observations or quantitative measurements resulting from field determinations or laboratory analyses of water, sediment, or biological samples. Non-proprietary water-quality data collected during the water year are published in the WRD annual data report, "Water Resources Data, Montana, Water Year XXXX," or in individual project data reports. Data reports make final, approved water-quality data available to users, but do not include interpretations or conclusions. Peer review and approval of data reports is in accordance with applicable USGS policy (U.S. Geological Survey, 2006). In the USGS Montana Water Science Center, data reports must be reviewed by at least two technical peer reviewers, one of whom can be from the Center. The report is subsequently reviewed by the appropriate discipline specialists, including the Water-Quality Specialist and the Hydrologic Investigations Section Chief. After all review comments have been addressed, the Center Director then provides a final review and Bureau approval (U.S. Geological Survey, 2006); the report is then prepared for publication.

11.2 Interpretive Reports

Interpretive reports are publications that describe the analysis of data and interpretations of environmental conditions or processes. Interpretive reports require two peer reviews and Bureau (USGS) approval (U.S. Geological Survey, 2006). Release of preliminary interpretations prior to peer review and Bureau approval is prohibited to avoid disseminating incomplete and/or incorrect conclusions, which are subject to change as a result of subsequent technical and policy reviews. The complexity of interpretive reports can vary greatly, depending on the study objectives and quantity and quality of available data on which conclusions are based. The effort to prepare an interpretive report can be extensive, and must be well-planned and budgeted in the project workplan. Examples of types of interpretive reports include USGS Circulars, Professional Papers, Fact Sheets, Scientific Investigations Reports, Scientific Map Reports, and Open-File Reports, as well as non-USGS outlets, such as scientific journals, books, and proceedings of technical conferences. The Water-Quality Specialist, project chief, Reports Specialist, Hydrologic Investigations Section Chief, and discipline specialists provide guidance and technical reviews to ensure that the conclusions are supported by the data and that the report meets the highest technical standards.

Approval of interpretive reports is in accordance with applicable Bureau, WRD, Region, and Center policy and is more technically rigorous than the approval process for non-interpretive data reports. Technical peer review must be provided by at least two reviewers, one of which must be from outside the Center. Reviewers are selected that have the appropriate technical expertise to evaluate the study design, methods of data collection, quality of data, and correctness of data analysis and interpretations. Following peer review, the report is then reviewed by appropriate Center discipline specialists and the Hydrologic Investigations Section Chief. The Center Director conducts a final Center review of the report, and approves it for routing to the Regional Office in Denver, Colo., for Bureau approval. After all reviewer comments have been addressed and revisions have been incorporated, the report is prepared for publication.

11.3 Other Data Outlets

Data and information typically are released through publications; however, publication is not limited to paper media. Electronic outlets include the NWIS Web page (*http://waterdata.usgs.gov/nwis/*), other USGS Web pages as appropriate, and various computer storage media.

Provisional data can be released to the public after preliminary review for accuracy by appropriate WRD personnel (WRD Memorandum 90.030). Constituent concentrations that exceed USEPA drinking water maximum contaminant levels (MCLs), as specified in the National Primary Drinking Water Regulations, are automatically flagged by the NWQL on a laboratory alert report. If the water body from which the samples were collected is a potential drinking water source, the results are promptly reported by the project chief or designated technical personnel to appropriate agencies that have a need to know (WRD Memorandum 90.038).

11.4 References for the Publication of Water-Quality Data Section

Table 15 lists reports and/or memoranda referred to in Section 11.0. For a complete citation, refer to Section 13.0 of the report.

12.0 Water-Quality Training and Reviews

Periodic reviews of data-collection procedures are used to evaluate the effectiveness of training programs and to determine if technical work is being conducted correctly and efficiently. Such reviews also are used to identify and resolve problems before they become widespread and potentially compromise the quality of the data.

Table 15. Summary of references for publishing data.

[Abbreviations: USGS, U.S. Geological Survey; WRD, Water Resources Division]

Reference	Subject
Hansen, 1991	Suggestions to authors of USGS reports.
U.S. Geological Survey, 1995	Guidelines on writing hydrologic reports.
U.S. Geological Survey, 2006	Authority to approve information products.
U.S. Government Printing Office, 2000	Style manual for printed government documents.
WRD Memorandum 90.030	Policy for release of digital data.
WRD Memorandum 90.038	Policy for reporting maximum contaminant level exceedances.

12.1 Training

Employee training is an integral part of water-quality activities that allows current employees to maintain and enhance their technical knowledge and new employees to gain the specific skills needed to adequately perform their job. Personnel who are involved in water-quality sampling attend formal USGS training courses to obtain intensive instruction on procedures, equipment, data recording, and basic water-quality concepts. A thorough training program not only ensures that samples are collected correctly by technically competent personnel, but also lends legal credibility to data and interpretations. Training is accomplished according to the following policies and protocols.

Individual training plans are developed by the supervisor and employee at least annually as part of the performance evaluation process. The Center Training Officer is responsible for informing staff about the availability of training opportunities. The Water-Quality Specialist provides recommendations and advice to supervisors and their staff as needed. The Center Director has authority and responsibility for approving attendance at training courses, which is subject to the availability of funds. In addition, staff are responsible for successfully completing required elements of the training provided.

Primary sources of water-quality training are formal USGS courses, typically taught at the National Training Center at the Denver Federal Center; Regional training; cyber-seminars; and Center seminars or in-house training courses. The Water-Quality Specialist plays an important role in providing training by either conducting or coordinating training sessions, with assistance from technical personnel or discipline specialists. Much of the expertise in water-quality sampling that is achieved over time comes through routinely participating in field trips with experienced personnel and acquiring the skills to independently collect and process samples. This continual acquisition of skills is similar to an apprenticeship and requires a period of time ranging from months to years to become fully proficient in all aspects of sample collection, processing, and records computation. Training documents are maintained in personnel files administered by the Center Training Officer and by the USGS Central Region Human Resources Office in Denver, Colo.

12.2 Reviews

Informal and formal reviews of water-quality data-collection activities are conducted throughout the duration of both basic-data programs and projects. Field reviews are conducted by the Water-Quality Specialist, Water-Quality Lead Technician, or project chief to evaluate sample collection and processing techniques, compliance with WRD, OWQ, and Center policies, the condition of sampling equipment and water-quality vehicles, safety conditions in both the field and service-unit laboratories, and any other activities or situations related to data quality. If deficiencies are noted, the reviewer, in consultation with the Water-Quality Specialist or Center management, is responsible for identifying corrective actions. The immediate supervisor is responsible for ensuring that any necessary corrective actions are implemented and completed in a timely manner. All personnel collecting water-quality samples participate in the annual NFQA program to test proficiency in making field water-quality measurements. A formal technical review of field methods, for at least one or more Center projects, is conducted once every 3 years by the OWQ and Regional discipline specialists. Reviews are completed in a timely manner, and comments are documented by the reviewer in a memorandum or email correspondence to create a record of the quality of performance, actions taken to address identified deficiencies, and remaining issues that require additional assessment or corrective action.

13.0 Bibliography

This section presents the publications and publicly accessible memoranda (internal documents) cited in the report. U.S. Geological Survey memoranda can be accessed at the Web page *http://water.usgs.gov/public/admin/memo/*

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