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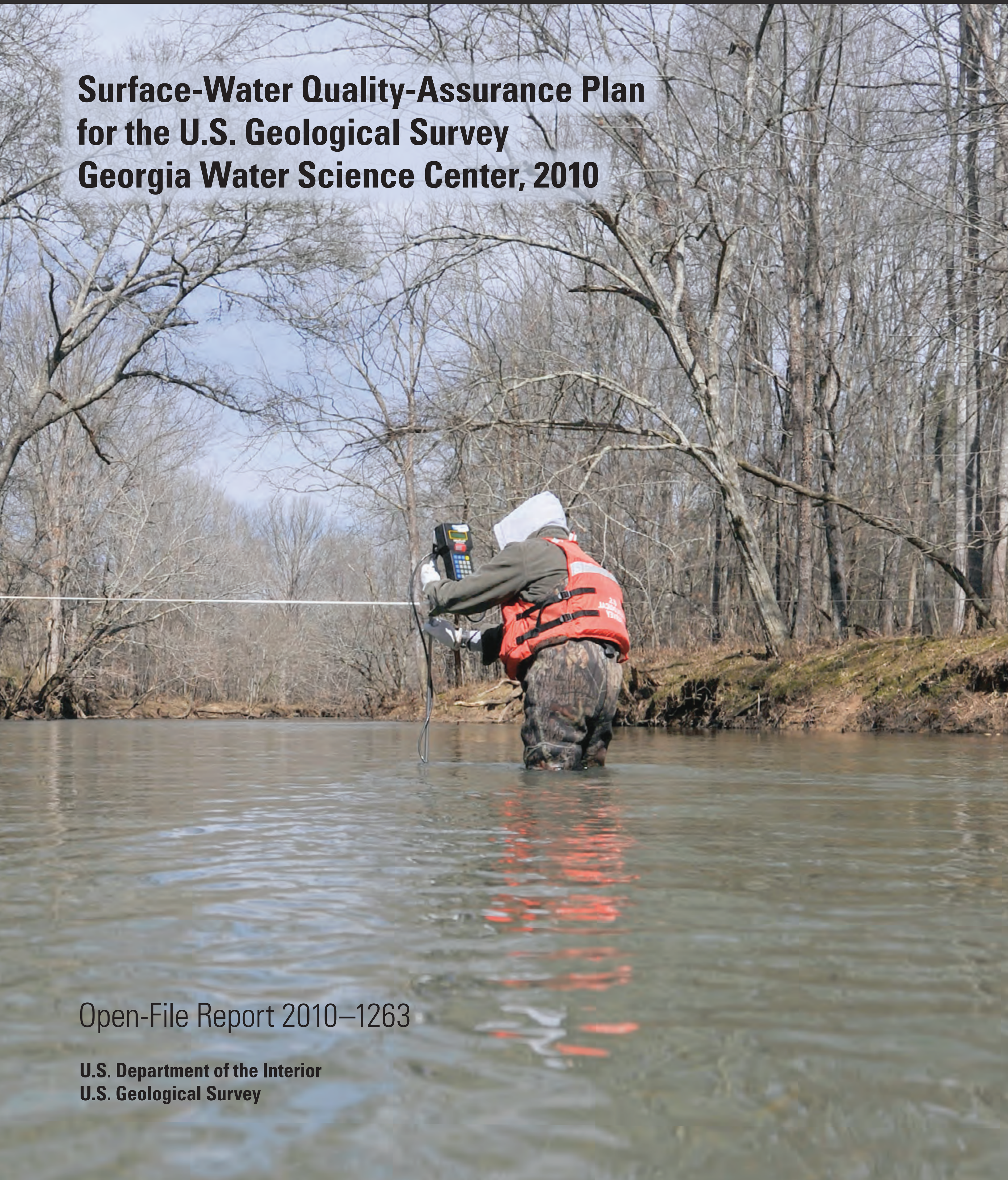

Surface-Water Quality-Assurance Plan for the U.S. Geological Survey Georgia Water Science Center, 2010

Open-File Report 2010–1263

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

Cover photographs.

Front and back: USGS hydrographer making a measurement of streamflow on the Armuchee Creek near Armuchee, Georgia (USGS streamgage 02388010). Photograph by Thear K. Fraley.

Back lower left: USGS hydrographer making a measurement of streamflow on the New River at Georgia State Highway 100, near Corinth, Georgia (USGS streamgage 02338660). Photograph by Thear K. Fraley.

Back lower right: USGS hydrographer making a measurement of streamflow on the Upatoi Creek near Columbus, Georgia (USGS streamgage 02341800). Photograph by Jonathan B. Evans.

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

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2010

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Acronyms Used in This Report

ADAPS	Automated Data Processing System
ADCP	acoustic Doppler current profiler
ADR	annual data report
ADV	acoustic Doppler velocimeter
ADVM	acoustic Doppler velocity meter
CAP	culvert-analysis program
CSG	crest-stage gage
Data Chief	Chief of the Hydrologic Monitoring and Analysis Section
DCP	data-collection platform
DD	data descriptor
DECODES	Device Conversion and Delivery System
DS-CI	Discontinued Station Maintenance-Capital Improvement
DOI Learn	Department of Interior's Learning Management System
EDI	equal-discharge increment
EWI	equal-width increment
FISP	Federal Interagency Sedimentation Program
FRC	Federal Record Center
GaWSC	Georgia Water Science Center
GZF	gage-height of zero flow
IDA	Instantaneous Data Archive
MEWI	multiple equal-width increment
NWIS	National Water Information System
NWISWEB	National Water Information System Web
OSW	Office of Surface Water
OWQ	Office of Water Quality
PC	personal computer
QA	quality assurance
QA Plan	Surface-Water Quality-Assurance Plan
QWDATA	NWIS Water-Quality subsystem
REX	regional executive
RMS	Records Management System
RP	reference point
SAC	slope-area computation
SEWI	single equal-width increment
SIMS	Site Information Management System
SSC	suspended-sediment concentration
SWAMI	Surface-Water Measurement and Inspection
SWS	Surface-Water Specialist
SWUC	Surface-Water Unit Chief
TSS	total suspended solids
TWRI	Techniques of Water-Resources Investigations
USGS	U.S. Geological Survey
UWI	unequal-width increment
WDR	Water Data Report
WRD	Water Resources Discipline
WSPRO	Water-Surface Profile Computation

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Abstract

The U.S. Geological Survey requires that each Water Science Center prepare a surface-water quality-assurance plan to describe policies and procedures that ensure high quality surface-water data collection, processing, analysis, computer storage, and publication. The Georgia Water Science Center's standards, policies, and procedures for activities related to the collection, processing, analysis, computer storage, and publication of surface-water data are documented in this Surface-Water Quality-Assurance Plan for 2010.

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 the public lands, and examination of the geologic structure, mineral resources, and products of the national domain." Surface-water activities in the Georgia Water Science Center (GaWSC) are part of the overall mission of the USGS to appraise the Nation's water resources. Surface-water information—including streamflow, stage, precipitation, and sediment data—is used by Federal, State, and local agencies for resources planning and management. The GaWSC conducts surface-water data-collection activities throughout Georgia from offices in Atlanta, Albany, Savannah, and Tifton. A field office Chief Technician, under the supervision of the Chief of the Hydrologic Monitoring and Analysis Section (Data Chief), supervises operations in each office.

This Surface-Water Quality-Assurance Plan (QA Plan) documents the standards, policies, responsibilities, and procedures used by the GaWSC for activities related to the collection, processing, analysis, computer storage, and publication of surface-water data. The QA Plan identifies individual responsibilities for ensuring that stated National policies and procedures are followed. The plan also serves as a guide for all GaWSC personnel involved in surface-water activities and as a resource for identifying memorandums, publications, and other literature that describe associated techniques and requirements in more detail.

The scope of this report includes discussions of policies and procedures that are followed by the GaWSC for all surface-water data-collection activities. Specific types of surface-water data include stage, streamflow, precipitation, sediment, and basin characteristics. In addition, issues related to management of the computer database and employee safety and training are addressed. Although the procedures and products of interpretive projects are subject to the criteria presented in this report, specific interpretive projects are required to have separate and complete QA Plans.

This QA Plan is reviewed and revised at least once every 3 years to ensure that responsibilities and methodologies are current and that ongoing procedural and instrumentation improvements are documented effectively.

Responsibilities

Quality assurance (QA) is an ongoing process. Achieving and maintaining high-quality standards for surface-water data are accomplished by specific actions carried out by specific persons. Errors and deficiencies can result when individuals do not carry out their responsibilities. Clear and specific statements of responsibilities promote an understanding of each person's duties in the overall process of assuring surface-water data quality. The responsibility for implementation of the QA Plan is distributed throughout the GaWSC. Much of the responsibility rests with field offices and the Hydrologic Monitoring and Analysis Section; however, the GaWSC Director ultimately is responsible for quality assurance. The following list summarizes responsibilities of GaWSC personnel involved in the collection, processing, analysis, computer storage, and publication of surface-water data.

Responsibilities of the Georgia Water Science Center Director include the following:

1. Generally overseeing the GaWSC program, including all surface-water activities;
2. Ensuring that surface-water activities in the GaWSC meet the needs of the Federal Government, the GaWSC, State and local agencies, other cooperating agencies, and the general public;
3. Ensuring that all aspects of this QA Plan are understood and followed by GaWSC personnel, either through direct involvement or through clearly stated delegation of this responsibility to other personnel in the GaWSC;
4. Briefing subordinates on procedural and technical communications from Regional Offices and Headquarters;
5. Ensuring that all publications and other technical communications released by the GaWSC are accurate and in accordance with USGS policies; and
6. Implementing USGS and GaWSC safety policies.

Responsibilities of the Chief of the Hydrologic Monitoring and Analysis Section (Data Chief) include the following:

1. Managing the data-collection program by serving as the principal contact between cooperators and the GaWSC;
2. Managing the budget to ensure that the data-collection program operates in a fiscally responsible manner;
3. Ensuring that surface-water data-collection and analysis activities associated with the Georgia streamgaging network conform to the goals and policies of the USGS, Office of Surface Water (OSW), and GaWSC;
4. Ensuring that any identified deficiencies associated with the collection, analysis, or publication of surface-water data are corrected and that improved methods are instituted;
5. Developing work plans designed to accomplish the work of collecting, processing, analyzing, storing, and publishing Georgia surface-water data and communicating the contents of those work plans to personnel in the Hydrologic Monitoring and Analysis Section;
6. Ensuring that all personnel in the GaWSC involved in the collection, analysis, and publication of surface-water data receive a copy of the Surface-Water Quality-Assurance Plan and that personnel are familiar with the plan's contents;
7. Overseeing the production of the GaWSC annual data report;
8. Serving as or assigning a Flood and Drought Coordinator;
9. Ensuring that supervised personnel receive appropriate training;
10. Ensuring that supervised personnel are current in safety training and operate in accordance with safety policies established by the USGS and GaWSC as implemented by the GaWSC Director;
11. Ensuring that surface-water databases are current and properly maintained; and
12. Coordinating activities with the OSW Storm Surge Center in Atlanta.

Responsibilities of the Surface-Water Specialist (SWS) include the following:

1. Assuring appropriate methods are used by GaWSC personnel in collecting all types of surface-water data;
2. Performing inspections of individual personnel for appropriate field and data-collection procedures;
3. Assuring GaWSC surface-water programs and projects are planned to efficiently and effectively provide information required to address high-priority local or national water problems;
4. Collaborating with the Data Chief to evaluate the surface-water data-collection and analysis methods applied in the GaWSC and determine any needed improvements in those methods; and
5. Reviewing all indirect streamflow measurements performed by the GaWSC and annually reviewing a portion of the surface-water records.

Responsibilities of the Surface-Water Unit Chief (SWUC) include the following:

1. Examining data collected by field personnel for completeness, accuracy, and adherence to prescribed collection techniques;
2. 2. Providing training in data collection, analysis procedures, and instrumentation to individuals assigned to the field office;
3. Ensuring that field visitations are scheduled at frequencies to allow adequate measurements to facilitate accurate computation of streamflow records;
4. Ensuring that supervised personnel are aware of and operate in accordance with safety policies established by the USGS and GaWSC as implemented by the GaWSC Director;
5. Ensuring that data collected by the unit are computed, reviewed, and checked in a timely manner so that data are available in final form before the GaWSC annual data-report publication target date;
6. Performing thorough examinations of each employee's data-collection and field procedures to ensure that employees possess adequate knowledge of technical concepts and demonstrate acceptable practical skills;
7. 7. Ensuring that streamgages are installed in accordance with USGS and GaWSC policy;
8. 8. Providing help in troubleshooting malfunctioning equipment in the field; and
9. Overseeing the implementation of new equipment deployed in the field.

Responsibilities of the Hydroacoustic Specialist include the following:

1. Advising the Data Chief, SWUC, and SWS on all aspects of the use of hydroacoustic instrumentation;
2. Updating GaWSC users of hydroacoustic instruments on new policies and recommended procedures pertaining to the use of those instruments;
3. Updating GaWSC users of hydroacoustic instruments on software and hardware upgrades related to the installation and use of the instruments;
4. Updating GaWSC hydroacoustic quality-assurance documents;
5. Advising the Data Chief on hydroacoustic training for personnel;
6. Helping users of hydroacoustic instruments troubleshoot malfunctions and take corrective actions;
7. Reviewing data, procedures, methods, and documentation regarding hydroacoustics; and
8. Designating specific GaWSC personnel as qualified users of hydroacoustic instruments.

Responsibilities of the hydrographers include the following:

1. Ensuring that streamgaging stations operate in a manner that minimizes loss of record;
2. Making discharge measurements of various types correctly and accurately;
3. Installing, servicing, and repairing instruments at streamgaging stations;
4. Storing all data retrieved into the Automated Data Processing System (ADAPS) database;
5. Developing ratings, computing records, and writing station descriptions and analyses in a timely manner;
6. Helping in constructing streamgaging stations;
7. Surveying station levels, establishing and periodically confirming elevations of appropriate reference marks in accordance with USGS surveying procedures; and
8. Reviewing real-time data from field stations that are accessible on the Web on a daily basis when in the office.

Responsibilities of the Safety Officer include the following:

1. Assisting the GaWSC Director in implementing USGS and GaWSC safety policies; and
2. Serving as a resource for GaWSC personnel seeking current information pertaining to safety.

Overall responsibilities of personnel in Hydrologic Monitoring and Analysis Section include the following:

1. Understanding and following the policies and procedures presented in this report; and
2. Collecting, processing, analyzing, storing, and preparing surface-water data for publication in accordance with the policies and procedures presented in this report.

Collection of Stage and Streamflow Data

Many of society's daily activities—including industry, agriculture, energy production, waste disposal, and recreation—are closely linked to streamflow and water availability; therefore, reliable surface-water data are necessary for planning and resource management. The collection of streamflow data is a primary component in the ongoing operation of streamgaging stations (referred to hereafter as gaging stations) and other water-resources studies conducted by the USGS and the GaWSC.

The objective of operating a gaging station is to obtain a continuous record of stage and discharge at the site (Carter and Davidian, 1968, p. 1). A continuous record of stage, or gage height, is obtained by installing instruments that sense and record the stream-surface elevation. Discharge measurements are made at periodic intervals to define or verify the stage–discharge relation and to define the time and magnitude of variations in the relation.

It is the GaWSC policy that all data-collection activities conform with the USGS Water Resources Discipline (WRD) guidelines pertaining to the collection of stage and streamflow data. All employees involved in surface-water data-collection activities are informed of and follow the surface-water data-collection policies and procedures established by the WRD. The highest priority in collecting streamflow data, however, is employee safety.

Gaging Station Installation and Maintenance

Proper installation and maintenance of gaging stations are critical activities for ensuring the quality of streamflow-data collection and analysis. Effective site selection, correct design and construction, and regular maintenance of a gaging station can make the difference between efficient, accurate determinations of drainage-basin discharge and time-consuming, poor estimations of flow.

Site selections for installing gaging stations are determined to meet the intended purpose of each gaging station. Additionally, sites are selected with the intent of achieving, to the greatest extent possible, ideal hydraulic conditions. Rantz and others (1982, p. 5) listed criteria that describe the ideal gaging station. These criteria include unchanging natural controls that promote a stable stage–discharge relation, a satisfactory reach for measuring discharge throughout the range of stage, and efficient access to the gaging station and measuring location. Other criteria considered by GaWSC personnel when planning gaging-station installations include those discussed in Kennedy (1984, p. 2).

The individuals responsible for selecting sites for new gaging stations are the Data Chief, SWS, and (or) SWUC. The process of site selection includes discussions with the cooperator(s) on the purpose of the gaging station, analysis of the terrain that includes using topographic maps combined with field reconnaissance, evaluation of types of installation and equipment options, and a file search to determine if discontinued stations or partial-record stations previously were located in the area. The Data Chief is responsible for ensuring proper documentation of agreements with property owners. The Data Chief and (or) the SWUC are responsible for approval of site design, construction of gaging stations, and inspection and approval of the completed installation.

A program of careful inspection and maintenance of gaging stations and gage houses promotes the collection of reliable and accurate data. Allowing equipment and structures to fall into disrepair can result in unreliable data and safety problems. Unsightly gaging stations also reflect poorly on the public’s perception of the USGS. It is GaWSC policy that a visual inspection is performed at sites by field personnel during each site visit by comparing inside, outside, and recorder stage readings. In addition, all equipment is inspected to ensure operational reliability. The inspection of equipment includes battery condition, structural stability, locking mechanisms, and the general operating condition of the gaging station. Inspection of data-collection equipment at a gaging station is an important means of ensuring accurate stage-data records.

To prevent the buildup of mud or clogging of the intakes of stilling wells or the orifice of bubbler systems, intakes are flushed and orifices are purged at least annually. Stilling wells equipped with intakes and flushing devices are flushed during each site visit. The goal of the GaWSC is to collect a continuous, complete, and accurate record of stage at each gaging station. It is critical that problems resulting in the loss of stage record be dealt with immediately.

It is the responsibility of field personnel to correct gaging station deficiencies immediately. If conditions cannot be corrected at the site, the immediate supervisor should be notified, and that person is responsible for initiating a plan of action to restore the stage record at the earliest possible time.

At times, gaging stations are deactivated because of loss of funding, a project ending, or gage relocation. Deactivated gaging stations that are still important to National, State, or local data-collection network goals and potentially still usable for data-collection activities are considered inactive gaging stations. The GaWSC takes actions necessary to protect, secure, and minimize safety hazards at inactive gaging stations pending their eventual return to service. Deactivated gaging stations that are no longer part of any data-collection network or in such state of disrepair that they can no longer be activated are considered discontinued gaging stations. The GaWSC dismantles discontinued gaging stations and restores the land, as much as possible, to previous conditions. The GaWSC documents the status of deactivated gaging stations in the National Water Information System (NWIS) database. The GaWSC also documents deactivated gaging station liabilities and cost estimates for remediation in the Discontinued Station Maintenance-Capital Improvement (DS-CI) database, which can be accessed at *http://1stop.usgs.gov/discontinued* (WRD Technical Memorandum 2009.02). All technical memorandums mentioned in this QA plan are cited in Appendix 1.

Measurement of Stage

Many types of instruments are available, and advances in technology continually improve the ability to accurately measure water level or stage at gaging stations. Gages can be nonrecording or recording gages (Rantz and others, 1982, p. 24 and 32, respectively). Because the ways in which stage data will be used cannot always be predicted, it is OSW policy that surface-water stage records be collected at stream sites having instrumentation and procedures to provide sufficient accuracy to support the computation of discharge from a stage–discharge relation unless greater accuracy is required (OSW Technical Memorandum 93.07). The OSW technical memorandums from 1969 to present are available online at *http://water.usgs.gov/osw/*.

In general, the operation of gaging stations for the purpose of determining daily discharge includes the goal of collecting stage data at the accuracy of plus or minus (±) 0.02 foot. In cases where lower accuracy is acceptable, the project proposal or station description and analysis will state why a lower accuracy is being used. An explanation of WRD policy on stage-measurement accuracy as it relates to instrumentation is provided in OSW Technical Memorandum 93.07.

The type of instrumentation installed at any specific gage house operated by the GaWSC is dependent on the physical site conditions as well as the needs of the cooperator, the availability of utility lines for landline data access, types of terrain, expected range of stage, and other factors that can influence the data-collection process. Types of data-collection platforms (DCPs) currently operated by personnel in the GaWSC include Vaisala 555 and Design Analysis H-522. The water-level recorders used are Design Analysis H-350, H-350XL, and H-510. The devices used to sense stage at Georgia stations are H-350/H355 and H-350XL/H-355 bubbler systems; Vaisala 436B and 436BD shaft encoders; Design Analysis H-510, H-334, and H-3341 shaft encoders; and Design Analysis H-3611 and H-3612 radar sensors.

The Data Chief or SWUC is responsible for determining the types of water-level recorders and the data-collection intervals (typically 15 minute) for operation at each gaging station.

The Data Chief or SWUC also is responsible for ensuring that new equipment has been installed correctly. Field personnel who service the gaging station are responsible for maintenance or replacement, if appropriate, of gage instrumentation.

Accurate stage measurement requires not only accurate instrumentation but also proper installation and continual monitoring of all system components to ensure consistent accuracy over time (OSW Technical Memorandum 93.07). To ensure that instruments located within the gage house record water levels that accurately represent the water level of the body of water being investigated, “recorder” water-level readings are compared to the designated reference gage, as described in the station description and(or) station analysis.

At stilling-well sites, the float-tape pointer serves as the reference gage. Readings from the float-tape pointer and shaft encoder should always be equal. If these values are not equal, the shaft encoder should be reset to the float-tape pointer reading. The float-tape pointer should never be reset unless levels are run at the site and levels indicate that the float-tape indicator is reading incorrectly. At stilling-well sites, other gages are installed outside the gage house to indicate whether the intakes are operating properly (Rantz and others, 1982, p. 53 and 64). Gages installed outside the gage house include a wire-weight gage, a staff plate, or a reference point (RP).

At bubbler-system sites, the outside gage serves as the reference gage and is used to calibrate the reading of the bubbler system. The readings from the bubbler system do not always equal outside readings, especially if the gages are not in the same pool at all ranges of stage. Whereas bubbler-system and outside gage readings do not have to be the same in all cases, the relation between the two for a given stage should be consistent. Relations between the two gages across a range of stages can be checked for consistency by examining form 9-207. Inconsistent readings usually indicate a failure of the system, and the system should be investigated. The outside gage should not be reset unless levels that are run at the site indicate that the outside gage reading is correct.

Personnel servicing the gaging station are responsible for comparing inside and outside gage readings at the beginning and end of each site visit to determine if the outside water level is represented correctly by the gages. If a deficiency is identified, personnel servicing the gaging station are responsible for thoroughly documenting the problem in the field notes and either correcting the problem immediately or contacting the SWUC so that corrective actions can be taken at the earliest opportunity.

Field personnel assigned to the site are responsible for ensuring that instrumentation installed at gaging stations is properly serviced and calibrated. The SWUC is responsible for ensuring that personnel correctly carry out this duty. This is accomplished by inspecting gages at the time of installation or soon thereafter, discussing field trips and reviewing field notes with the less-experienced personnel, and reviewing computed records to identify errors or inconsistencies. When deficiencies are identified, field personnel correct the deficiency by their own initiative or receive specific instruction from the SWUC. Questions related to the calibration and maintenance of water-level recorders should be directed to the Data Chief, SWUC, and (or) SWS. Standard procedures for documenting corrections to stage data are covered in OSW Technical Memorandum 91.09.

Field personnel are advised to carry spare equipment in their field vehicles for most repairs. In the event that repairs cannot be made with equipment on hand, field personnel should contact the office and advise the SWUC of equipment needs for the repairs. Questions related to the calibration and maintenance of water-level recorders should be directed to the SWUC or Data Chief. When gages are inspected, any recording gage or telemetry gage that differs from the reference gage by more than 0.02 foot is reset to agree with the reference gage unless a lower accuracy standard has been set and documented for that site. Gages should not be reset in adverse conditions, such as surging wells, high-flow stages, or ice in the stilling well. It is important that bubbler systems not be reset during high flow in order to avoid reset errors that may be caused by drawdown.

At stilling wells where data recorders are driven by floats with steel tapes, peak-stage indicator clips are attached to steel tapes to identify or confirm maximum stages. It is the responsibility of field personnel to inspect gages and ensure peak-stage indicator clips are read and reset during each site visit and to document clip readings in the field notes. At bubbler-system sites, a crest-stage gage (CSG) should be installed to verify peak stage. It is the responsibility of field personnel to check the CSG intakes and ground-cork level during each gage inspection to ensure that all peaks are recorded.

Most of the basic concepts and procedures used in surface-water data-collection activities are presented in three chapters of the “Techniques of Water-Resources Investigations of the U.S. Geological Survey” (TWRI) series; the chapters are entitled “General Procedure for Gaging Streams” (Carter and Davidian, 1968), “Stage Measurement at Gaging Stations” (Buchanan and Somers, 1968), and “Discharge Measurements at Gaging Stations” (Buchanan and Somers, 1969). A number of important aspects contained in these references are enumerated and reinforced here. Generally, all surface-water data-collection activities are in accordance with procedures outlined in the TWRIs (Hubbard and Barker, 1995). For data-collection activities that are not adequately covered by written guidance, supervisors assign personnel who have unique experience and (or) special training to be fully capable.

Gage Documents

It is GaWSC policy to have certain documents placed in each gage house for the purpose of keeping an on-site record of observations, equipment maintenance, structural maintenance, and other information readily available to field personnel. Documents maintained at each gage house include (1) the most recent rating table; (2) a graph of the rating on which each new measurement is plotted; (3) the most recent station description, including all gages and reference marks at the site and associated elevations, locations of measurement cross sections, information related to extreme events, including the potential for channel storage between the gage and measuring section during flood conditions, and other information (see the section "Site Documentation, Station Descriptions" in this report); (4) a table containing previous discharge-measurement information; (5) important telephone numbers; (6) a bridge-safety plan; and (7) a job-hazards analysis. Each gaging station is representative of the USGS and, therefore, should be kept clean and orderly. Field personnel should clean and sweep the gage house during each site visit and keep the gage-house exterior and surrounding area neat in appearance. During a gage inspection, all gage readings are documented.

Field personnel who run the field trip are responsible for exchanging outdated material with updated gage documents, as needed. When a field person visits a gage house and identifies a need to update one or more of the documents, that individual makes note of the needed document in the field notes and uses this note as a reminder to bring the documents on the next field trip. Questions related to which documents should be kept in a gage house, when the documents should be replaced with newer documents, or appropriate methods of appending logs or plotting measurements should be directed to the Data Chief or SWUC.

Levels

Various instruments at a gaging station are set to register the altitude of the water surface above a selected reference level called the gage datum. The gaging station's supporting structures—stilling wells, backings, shelters, bridges, and other types of structures—tend to settle or rise as a result of earth movement, static or dynamic loads, vibrations, or battering by floodwaters and flood-borne debris. Vertical movement of the structure can cause the attached gages to read too high or too low and, if errors go undetected, can lead to increased uncertainties in streamflow records. Leveling, a procedure by which surveying instruments are used to determine the differences in altitude between points, is used to set gages and check them from time to time for vertical movement (Kennedy, 1990, p. 1). Levels are run periodically to all benchmarks, reference marks, reference points, and gages at each station to determine if datum changes have occurred (Rantz and others, 1982, p. 545).

It is GaWSC policy to run levels at newly installed gaging stations either at the time of construction or within 6 weeks of the beginning date of data collection. Levels are run at established gaging stations once every year for the first 3 years. After the first three sets of levels are acquired, a level frequency of once every 3 years is used. A level frequency of at least every 5 years is used if stability is shown to exist (Kenney, 2010). Gages are reset to agree with levels when the levels indicate at least a 0.015-foot vertical change. Level notes are checked before the reset is made. When gages are reset, field personnel document the reset by including pertinent information in the level field notes. The Data Chief or SWUC is notified of the reset as soon as field personnel return to the office.

Field notes identify procedures, specifications, and regulations to be followed, describe the unmeasured variables that can affect the accuracy and (or) reliability of determinations, indicate any uncertainties or deviations from common practice, and report information that could affect the analyses, interpretation, or use of the data. For less-structured field activities, such as indirect discharge measurements or gage-datum checks, available forms provide only recording space; and special effort is required to assure that notes are appropriate, complete, and accurate.

Level notes need to include a sketch that shows the location of reference marks, reference points, outside gage, and gage house. Level notes also should contain a clear and detailed description of the location of reference marks and points. All information is recorded as collected and never from memory.

Levels are run by use of field and documentation methods described in Kenney (2010). Level procedures followed by GaWSC personnel pertaining to circuit closure, instrument reset, and repeated use of turning points are also described in Kenney (2010). Level instruments are kept in proper adjustment by appropriate care and handling of equipment. Frequent peg tests are performed and documented, and any corrections made are noted on the peg-test form using the procedures documented in Kenney (2010). A log of peg tests for each instrument is kept in each field office, and a copy of the latest peg test is kept with the instrument.

Field personnel and the SWUC are responsible for ensuring that level field notes are checked. Field personnel involved in running levels enter the information in the level-summary form; this information is checked during station analysis procedures for the year. Field personnel and the SWUC are responsible for ensuring that levels are run correctly and that all level field notes are complete. The SWUC is responsible for ensuring that levels are run at the appropriate frequency.

Site Documentation

Thorough documentation of qualitative and quantitative information describing each gaging station is required. This documentation, in the forms of station descriptions and photographs, provides a permanent record of site characteristics, structures, equipment, instrumentation, altitudes, location, and changes in conditions at each site. Information pertaining to where these forms of documentation are maintained is discussed in the section of this report entitled "Office Setting."

Station Descriptions

A station description is prepared for each gaging station and becomes part of the permanent record for each station. One station description is used to detail all data-collection activities at that location. It is GaWSC policy that the station description is complete by the time the first year's record is computed and analyzed. The field person, SWUC, or Data Chief is responsible for ensuring that station descriptions are prepared correctly and in a timely manner. The SWUC is responsible for ensuring that station descriptions are updated as needed and reviewed each year during the annual station analysis report process.

Station descriptions are written to include specific types of information in a consistent format (Kennedy, 1983, p. 2). Types of information included in the station description are location, access routes, drainage area, establishment history, cooperator identification, reason for cooperation, descriptions of equipment and gaging-station structure, descriptions of control, statements on measurement cross sections, information on stage extremes, gage datum, elevations of reference marks, and a photocopy of an area map. Additional information includes information about observers, flow regulation or diversion, and anything that will assist in data collection under various conditions and ranges of flow. A digital copy of the most recent station description for each site is kept in the Site Information Management System (SIMS) on the GaWSC server.

Photographs

Gaging stations and control sections are documented in photographs made by field personnel. Additional photographs in the field are taken to document gage-house construction; damage to gaging station structures or equipment resulting from storms, floods, droughts, or vandalism; significant changes in control conditions; or to supplement written descriptions. Field personnel carry digital cameras in their vehicles as part of their regular field equipment to photograph the items mentioned and to document inundated areas, high-water marks, or any other items that may assist the GaWSC in data-collection activities.

Historical photographs are filed in the historic-site files. Photographs taken with a digital camera are kept on the GaWSC server. A site folder for each station is stored in the Archive Station Photos folder. Only photographs that are important to the gage record are filed.

Direct Measurements

Direct measurements of discharge are made using WRD-approved methods. The GaWSC uses both hydroacoustic and conventional current meter methods.

The hydroacoustic methods used by the GaWSC include acoustic Doppler current profilers (ADCPs). The ADCPs are used to make discharge measurements at sites that are appropriate for the use of ADCPs. The ADCP methods used are in accordance with USGS standard procedures and are documented by Mueller and Wagner (2009) and in OSW Technical Memorandums 2009.05. Personnel in the GaWSC who collect and review ADCP data for discharge measurements must have completed the USGS training class "*Measurement of Streamflow using ADCPs.*" The GaWSC has implemented a separate QA Plan for hydroacoustics, which includes the use of ADCPs for measuring discharge. Appendix C of this report contains the GaWSC QA Plan for hydroacoustics.

The GaWSC also uses acoustic Doppler velocimeters (ADVs) to make discharge measurements at sites that are appropriate for the use of ADVs, and ADV measurements are made in accordance with OSW Technical Memorandum 2004.04 and 2007.01. The use of ADVs also is included in the GaWSC hydroacoustics QA Plan, which is contained in Appendix C. Personnel using ADCPs and ADVs must read and become familiar with the GaWSC hydroacoustics QA Plan.

The GaWSC still uses conventional current meters at sites that are not appropriate for the use of hydroacoustic methods and to verify discharge measurements made using hydroacoustic methods. A conventional current-meter measurement is the summation of the subsection areas of the stream cross section and their respective average velocities, and procedures for making current-meter measurements are described in Carter and Davidian (1968, p. 7), Buchanan and Somers (1969, p. 1) and Rantz and others (1982, p. 80, 139). When personnel make measurements of stream discharge, attempts are made to minimize errors. Sauer and Meyer (1992) identified sources of errors, including random errors such as depth errors associated with soft, uneven, or mobile streambeds, or uncertainties in mean velocity associated with vertical-velocity distribution errors and pulsation errors. Errors also include systematic errors, or bias, associated with improperly calibrated equipment or the improper use of such equipment. In order to minimize systematic errors, field trips are rotated to different personnel every 3 years.

To ensure and document the accurate performance of meters used to make streamflow discharge measurements, the GaWSC uses care and maintenance procedures and spin-test documentation as recommended in OSW Technical Memorandums 89.07 and 99.06. Individual responsibilities are well documented by the memorandum and all persons who make current meter streamflow measurements are expected to follow the procedures as outlined. The prescribed spin-test logs are maintained in the GaWSC field offices.

- *Depth criteria for meter selection.* GaWSC hydrographers select the type of current meter to be used for each discharge measurement on the basis of criteria provided by the OSW Technical Memorandum 85.14. Meters are used with caution when a measurement must be made in conditions outside of the ranges of the method provided by OSW. Any deviation from the criteria is noted, and the measurement accuracy is downgraded accordingly.

Field personnel should carry a pygmy current meter and a Price AA current meter for wading and(or) bridge measurements, and these meters are to be maintained and spin tested according to policies described in the “Acceptable Equipment” section of this QA Plan. For a conventional current meter, the following criteria should be followed. A Price AA current meter may be used to make direct streamflow measurements when depths average 1.5 feet and greater. When depths are less than 2.5 feet, a single velocity measurement is made at 0.6-foot total depth. When depths are greater than 2.5 feet, velocity measurements are made at 0.2- and 0.8-foot total depth.

If bottom velocities are equal to or greater than the top velocity, a standard profile does not exist. In the case of a nonstandard profile, velocity measurements must be made at all three depths—0.2, 0.6, and 0.8 foot. When average depths are less than 1.5 feet, the pygmy current meter is used. The GaWSC field personnel make meter selections for specific measurement conditions based on guidance provided in OSW Technical Memorandum 85.14, Buchanan and Somers (1969), and Rantz and others (1982).

In shallow-depth and low-velocity situations, an ADV or standard Price AA current meter can be used where velocities are too slow to be recorded by the pygmy. These situations are to be avoided by looking for cross sections where higher velocity occurs. It is recognized, however, that at some sites during low-flow periods, sections suitable for the pygmy meter cannot be found. A measurement made by using a Price AA meter in these slow-velocity conditions must be downgraded accordingly.

- *Number of measurement subsections*. The spacing of observation verticals in the measurement section can affect the accuracy of the measurement (Rantz and others, 1982, p. 179). GaWSC criteria require observations of depth and velocity be made at a minimum of 25–30 verticals, which are normally necessary so that no more than 5 percent of the total flow is measured in any one vertical. Even under the worst conditions, discharge computed for each vertical should not exceed 10 percent of the total discharge, and ideally should not exceed more than 5 percent (Rantz and others, 1982, p. 140). Exceptions to this policy are allowed in circumstances where accuracy would be sacrificed if this number of verticals were used, such as for measurements during rapidly changing stage (Rantz and others, 1982, p. 174). Fewer verticals sometimes are used for very narrow streams. Measurement of discharge is essentially a sampling process, and the accuracy of sampling results typically decreases markedly when the number of verticals is less than 25.

- *Other direct methods of measuring discharge*. It is GaWSC policy that WRD and OSW techniques and guidelines are followed when discharge measurements are made with any selected method.

- *Computation of mean gage height*. The GaWSC personnel use the procedures for the computation of mean gage height during a discharge measurement presented in Rantz and others (1982, p. 170). Mean gage height is one of the coordinates used in describing the stage–discharge relation at a streamflow-gaging site.

- *Check measurements*. A second discharge measurement is often made for the purpose of checking an initial discharge measurement. If the measurement exceeds normal tolerance, a check measurement is made, computed, and also checked against the rating curve. Normal tolerance is generally within 8 percent. However, many streams in Georgia have loose sand channel controls and are subject to considerable shifting. Normal tolerance for these streams is within 10 percent. For extreme flood events, normal tolerance is increased to 15 percent. Measurements that are exempt from the check-measurement policy are measurements made on highly regulated streams where the previous measurement conditions no longer exist, are changing rapidly, or are expected to change immediately due to regulation patterns. Also exempt from the check-measurement policy are measurements made where changes in the control or obvious changes in the channel are observed. When a discharge measurement is made above or below the rating, a check measurement is made to verify the rating extension.

  When check measurements are made, the potential for systematic errors is minimized by using methods described in Rantz and others (1982, p. 346). These methods include using a different cross-section location for wading measurements, using a different meter, using verticals offset from the locations of the original verticals used for a bridge measurement, using spin-tested meters, and using other similar procedures. If the initial measurement is made using an ADCP or ADV, then the check measurement is made using a conventional current meter when possible.

- *Corrections for storage*. Corrections for storage applied to measured discharges for the purpose of defining stage–discharge relations are those discussed in Rantz and others (1982, p. 177) and in OSW Technical Memorandum 92.09.

- *Questions*. Questions concerning the appropriate procedures for making stage and discharge measurements should be directed to the GaWSC Data Chief, SWUC, and(or) SWS.

Field Notes

Thorough documentation of field observations and data-collection activities performed by field personnel are a necessary component of surface-water data collection and analysis. To ensure that clear, thorough, and systematic notations are made during field observations, field personnel are to use Surface-Water Measurement and Inspection (SWAMI) electronic forms to record discharge measurements.

It is GaWSC policy that all discharge measurements are to be calculated in their entirety before field personnel leave the field site, with the only exception being emergency evacuation for reasons of safety. Information required on the measurement note sheet includes, at minimum, initials and last names of all field-party members; station name; station number; date; times of gage readings and other pertinent observations; gage readings; extreme indicator-clip readings; all items describing the type, location, and quality of the measurement; control conditions; spin-test comments; cross-section width and area; mean velocity; mean gage height; total discharge; site identification; and all observed depth and velocity data.

Notations associated with miscellaneous surface-water data-collection activities are to be documented on SWAMI electronic forms. All miscellaneous notes are required to include, at minimum, initials and last names of field-party members, station name, station number, date, time of observations, purpose of the site visit, and any descriptive comments that field personnel consider applicable and appropriate.

A review of field notes is required annually when station records are computed for each station by both the record worker and checker. Deficiencies in the content, accuracy, clarity, or thoroughness of field notes are identified and orally communicated by the reviewer to the individual who collected the field data or to the SWUC. Deficiencies are remedied by the SWUC providing specific instructions to the individual(s) who failed to record field notations that meet USGS and GaWSC standards.

Acceptable Equipment

Equipment used by the GaWSC to measure surface-water discharge meets WRD standards through use and testing. An array of standard equipment for measuring discharge includes current meters, timers, wading rods, bridge cranes, tag lines, and others (Smoot and Novak, 1968; Rantz and others, 1982, p. 82). Although an official list of standard equipment is not available, Carter and Davidian (1968), Buchanan and Somers (1969), and Edwards and Glysson (1988) discuss the equipment typically used by the USGS.

The meters most commonly used by GaWSC personnel for measuring surface-water discharge are the Price AA current meter, pygmy current meter, ADCP, and ADV. Methods followed by GaWSC personnel for inspecting, repairing, and cleaning these meters are described in Smoot and Novak (1968, p. 9), Buchanan and Somers (1969, p. 7), and Rantz and others (1982, p. 93). The GaWSC has implemented a separate and specific hydroacoustics QA Plan, included as Appendix C in the GaWSC surface-water QA Plan. The hydroacoustic QA Plan describes the use of ADCPs, ADVs, and index acoustic velocity meters.

Field personnel who use the equipment are ultimately responsible for the condition and accuracy of the current meters (OSW Technical Memorandums 89.07 and 99.06). A timed spin test made a few minutes before a measurement does not ensure that the meter will not become damaged or fouled during the measurement. Field personnel must assess apparent changes in velocity or visually inspect the meter periodically during the measurement to ensure that the meter continues to remain in proper operating condition. The GaWSC follows the care and maintenance procedures of vertical-axis current meters as described in OSW Technical Memorandum 99.06. After a day of use in the field, the pivot and contact-chamber cap are removed to clean and lightly oil the upper and lower bearing surfaces. Bearing surfaces, especially the pivot point, are examined for wear and damage. After cleaning, meter cups are spun to ensure that the rotation motion does not have a "wobble" and that cups do not come to an abrupt stop. General condition of the meter is examined to ensure that cups, tail fins, or other parts are not bent or damaged. Any needed repairs are made and significant problems are documented in the spin log book. After each field trip, meters that were used during the trip are put through a timed spin test to document each meter's condition, and then disassembled, inspected, cleaned, and repaired to prepare each meter for the next use.

- *Spin tests.* It is GaWSC policy that timed spin tests are required in the office prior to each field trip or at least once a quarter. Spin-test results are documented in a log that is maintained for each instrument, and all spin tests for all current meters are listed in chronological order. The log is located in each field office. This log is part of the archived data of WRD (OSW Technical Memorandum 89.07). Repairs are made to meters when deficiencies are identified during the spin test or inspection. The SWUC is required to review this log annually. If deficiencies are observed during the review of the log, the field person is informed through oral or written communication, and the problem is corrected immediately. The SWUC performs an overall review of the log during annual program review, and field personnel promptly correct any deficiencies.

  In addition to office-timed spin tests, field personnel are required to perform a field-timed spin test and inspect the meter before and after each measurement to ensure that the meter is in good condition and that cups spin freely and do not come to an abrupt stop. The time of the spin test is noted in the appropriate location on the electronic (SWAMI) measurement form. Descriptive notations also are made in the appropriate location on the SWAMI form concerning meter condition, such as "OK" or "free" or other such comments. To ensure that field personnel carry out their responsibilities in maintaining the equipment they use, the SWUC or SWS inspects the equipment during annual review, and field personnel promptly correct any deficiencies.

Alternative Equipment

New or unusual conditions and the development of new technology may, at times, involve the collection of surface-water data with alternative equipment that has not been fully accepted by the USGS. To demonstrate the quality of surface-water data collected with alternative equipment, thorough documentation of procedures and observations must be maintained.

Indirect Measurements

In many situations, especially during flooding, it is impossible or impractical to measure peak discharges by using a current meter. Personnel may not receive sufficient warning to get to the site to make a direct measurement, or physical access to the site during the event may not be feasible. In these cases, discharge can be determined by using indirect measurements. The GaWSC Flood Coordinator, assisted by other qualified personnel of the Hydrologic Monitoring and Analysis Section, oversees indirect measurements of discharge. The Flood Coordinator is responsible for seeing that indirect measurement computations are made according to appropriate TWRI procedures or to recommend alternative procedures when established methods are not possible because of unusual physical conditions. The GaWSC SWS reviews all indirect measurements; and the Regional SWS reviews those made by methods that substantially depart from established procedures.

A peak discharge determined by indirect methods is, in many situations, the best available means of defining the upper portion of the stage–discharge relation at a site. Because extrapolation of a stage–discharge relation, or rating, beyond twice the measured discharge at a gaging station is undesirable and may be unreliable, discharge measurements made by indirect methods during periods of high flows are important forms of data (Rantz and others, 1982, p. 334).

The GaWSC follows data-collection and computation procedures presented in Benson and Dalrymple (1967), which includes policies and procedures related to site selection, field survey, identification of high-water marks, selection of roughness coefficients, computations, and the written summary. The GaWSC also follows procedures for measurement of peak discharge by indirect methods presented in Rantz and others (1982, p. 273).

In addition to the general procedures presented in Benson and Dalrymple (1967), the GaWSC follows guidelines presented in other reports describing specific types of indirect measurements suited to particular types of flow conditions. The slope-area method is described in Barnes (1967) and Dalrymple and Benson (1967). The USGS applies the Manning equation in the application of the slope-area method (Barnes, 1967). Procedures for selecting the roughness coefficient are described in Barnes (1967) and in Arcement and Schneider (1989). The computer-based tool, slope-area computation (SAC) program, as described in Fulford (1994), is available to assist in computations of peak discharge with the slope-area method, which is discussed in OSW Technical Memorandum 97.01. Procedures for the determination of peak discharge through culverts, based on a classification system that delineates six types of flow, are described in Bodhaine (1982). The computer-based tool, culvert-analysis program (CAP), as described in Fulford (1995), is available to assist in computations of peak discharge at culverts and is discussed in OSW Technical Memorandums 96.04 and 97.01. At sites where open-channel width contractions occur, such as flow through a bridge structure, peak discharge can be measured by using methods described in Matthai (1967) and the Water-Surface Profile Computation (WSPRO) model (Shearman, 1990). Debris-flow conditions, which are most common in small mountainous basins, are discussed in OSW Technical Memorandum 92.11.

Determinations of water-surface profiles along a stream channel in association with selected discharges are made when studies involve delineations of floodplains or when extensions are made to stage–discharge relations at streamflow sites. GaWSC personnel are required to follow the procedures associated with step-backwater methods described in Davidian (1984). The computer-based tool, WSPRO, used for assisting in the computations of water-surface profiles with step-backwater methods is discussed in OSW Technical Memorandum 87.05.

General guidelines followed by the GaWSC when making indirect measurements include those discussed in OSW Technical Memorandum 92.10 and in Shearman (1990). Violation of more than one of the general guidelines does not necessarily invalidate an indirect measurement (OSW Technical Memorandum 92.10). The decision to invalidate an indirect measurement is based on the application, knowledge, and experience of the SWS in reviewing or in computing the measurement.

The SWS is responsible for ensuring that indirect measurements are performed correctly. The SWS or Regional SWS is required to review GaWSC procedures and documentation for each indirect measurement before finalizing the discharges in any publication or peak-flow files. If deficiencies are found during the review, the SWS communicates proposed solutions to the person who computed the measurement, and that person is responsible for ensuring that corrective actions are taken to correct the deficiencies. Specialists outside the GaWSC review measurements that are questionable and difficult to assess, and the SWS is responsible for ensuring that deficiencies identified by the outside party are corrected.

The SWS is responsible for determining when and where indirect measurements are made. For the GaWSC, it is a general rule that indirect measurements are made at sites where the peak flow is estimated to be at least 1.5 times the discharge of the greatest measured flow, or when it is essential that a peak discharge be determined. Because selection of a suitable reach of channel is an extremely important element in making an indirect measurement, at some gaging stations the stream reach for indirect measurements at specified ranges of stage has been preselected, and this information is included in the station description.

Trained personnel are responsible for identifying and flagging high-water marks. Because the quality and clarity of high-water marks are best soon after a flood, personnel traveling in the field are required to have flagging equipment, such as nails and plastic markers, spray paint, paint sticks, survey flagging, survey stakes, and other items as needed available in the field vehicles. After each indirect measurement is computed, the SWS checks the graphs, field notes and data, plotted profiles, maps, calculations or computer output, and written analysis associated with the measurement. The information is organized into a folder labeled with all pertinent data and filed in the station or historical indirect-measurement files.

Peak-Flow Files

The GaWSC is responsible for maintaining the accuracy of the peak-flow data files, including computer database files (OSW Technical Memorandums 92.10 and 2009.01). The SWS is responsible for ensuring that appropriate indirect-measurement results are entered into the peak-flow files. The SWS and the Data Chief are responsible for ensuring that peak-flow files are correct. For further discussion on the update and review of the peak-flow files, refer to the “Database Management” section of this report.

Crest-Stage Gages

Crest-stage gages are used as tools throughout the WRD for determining peak stages at otherwise ungaged sites, confirming peak stages at selected sites where recording gages are located, confirming peak stages where pressure transducers and radar sensors are used, and determining peak stages along selected stream reaches or other locations, such as upstream and downstream from bridges and culverts. The OSW requires QA procedures comparable to those used at continuous-record stations for the operation of CSGs and for the computation of annual peaks at CSGs (OSW Technical Memorandum 88.07). Because of this, the GaWSC has a CSG coordinator to ensure continuity of CSG data activities statewide.

The operation of CSGs is part of the GaWSC’s surface-water program. Procedures followed by the GaWSC in the operation of CSGs are presented in Rantz and others (1982, p. 9, 77, 78). One or more gages are maintained at each selected site where peak water-surface elevations are required. Upstream and downstream gages are maintained at culverts or other structures where water-surface elevations are required to compute flow through the structure and to establish the resulting type of flow. CSGs are required at all sites with bubbler systems in order to confirm peaks recorded by the bubbler systems.

Except at sites where CSGs are used only to confirm or determine peak stages, stage–discharge relations are developed in association with the gage based on direct or indirect high-water measurements. Direct or indirect measurements are made as site conditions warrant to verify or adjust the rating. Levels are run to the gage using the procedures documented in Kenney (2010). When extremely high peaks occur, an outside high-water mark to confirm the gage reading is obtained when possible, described in the field notes, and flagged by a durable marker so that the elevation of the high-water mark can be determined the next time levels are run.

Field observations are written on CSG forms or miscellaneous field sheets. All field notes are required to include, at minimum, initials and last names of field personnel, the station name and number, date, time of observation, current stage, CSG reading, and outside high-water mark, if obtained.

The CSG coordinator, SWUC, Data Chief, and SWS are responsible for ensuring that correct data-collection procedures are used by personnel. Review of data-collection procedures and data processing is carried out by each responsible field person and the SWUC at least once a year as part of the station analysis. When a deficiency in data-collection activities is identified, the problem is remedied by proposed solutions communicated by the SWUC to the responsible field person, and that person is responsible for ensuring that corrective actions are taken to correct the deficiencies. A corrected CSG analysis form is kept in the station folder and reviewed by the SWUC prior to publication in the annual Water Data Report (WDR).

Policies and procedures for the computation of peak discharges at CSGs and associated documentation are presented in the section entitled, “Processing and Analysis of Stage and Streamflow Data.”

Artificial Controls

Artificial controls, including broad-crested weirs, thin-plate weirs, and flumes, are built in stream channels for the purpose of simplifying the procedure of obtaining accurate records of discharge (Rantz and others, 1982, p. 12). Such structures serve to stabilize and constrict the channel at a section, reducing the variability of the stage–discharge relation.

Artificial controls are used at a few gaging stations maintained by the GaWSC. In situations where artificial controls are installed as permanent structures, it is GaWSC policy that stage–discharge relations are determined by making current-meter measurements throughout the range of stage at the site if such measurements are practicable and possible. If direct methods cannot be used, theoretical methods are used and verified by some type of direct measurement, if possible. Portable weir plates and flumes are not used currently by GaWSC personnel. These portable devices, if used, would be applied in accordance with the methods described in Buchanan and Somers (1969, p. 57) and Rantz and others (1982, p. 263).

The Data Chief and SWS are responsible for ensuring the correct design and installation of artificial controls for the GaWSC. When installing an artificial control, the GaWSC personnel must take into account the criteria for selecting the various types of controls, principles governing their design, and attributes considered to be desirable in such structures (Carter and Davidian, 1968, p. 3; Rantz and others, 1982, p. 15, 348; Kilpatrick and Schneider, 1983, p. 2, 44).

When field inspections of artificial controls are performed, specific information pertaining to control conditions is noted on the SWAMI forms to assist in the analysis of the surface-water data. These notes include comments concerning scour or fill of the streambed immediately upstream from the control, leakage, or other pertinent information that could affect the accuracy of the artificial control structure. When field personnel encounter problems pertaining to artificial controls, the SWUC, Data Chief, or SWS should be contacted to assist in solving a non-routine problem.

Flood Conditions

Flood conditions present problems that otherwise do not occur on a regular basis. Such problems can include difficulties in gaining access to a gaging station or measuring site because roads and bridges are flooded, closed, or destroyed. Debris in the streamflow can damage equipment and present dangers to personnel during data collection. Rapidly changing stage or conditions that necessitate making measurements at locations some distance away from the gage can create problems in associating the gage height to a measured discharge.

The GaWSC maintains a Flood Plan to ensure that high-priority surface-water data associated with flooding conditions are collected correctly and in a timely manner. The Flood Plan describes responsibilities before, during, and after a flood, information-reporting procedures, and field-activity priorities. The Flood Plan serves as a central reference for emergency communications, telephone numbers for key GaWSC personnel, and codes for accessing gaging stations equipped with telemetry.

The Flood Coordinator is responsible for ensuring that the Flood Plan includes all appropriate current information. Currently, the Data Chief is the designated GaWSC Flood Coordinator. The Data Chief and SWS review the Flood Plan every 3 years or after a major flooding event. A copy of the Flood Plan is provided to all personnel in the Hydrologic Monitoring and Analysis Section, as wells as other individuals in the GaWSC who assist in surface-water activities. Individuals who receive a copy of the plan keep separate copies in their office and in their assigned field vehicle. The Data Chief is responsible for ensuring that individuals who receive a copy of the plan are fully versed on the content of the Flood Plan.

During a flood, the Flood Coordinator oversees related activities for the GaWSC. A primary responsibility for personnel who are not already in the field during flood conditions is to arrive at the office with the intent of going into the field for an extended period of time. The Flood Coordinator makes field assignments. A primary responsibility for personnel who are already in the field during flood conditions is to proceed to make a measurement at the previously selected streamflow site and then call the Flood Coordinator to report related flood information. Personnel who arrive at a gaging station to find that a flood has already peaked are responsible for calling the Flood Coordinator to report information about flood stage and making a discharge measurement before proceeding to find and document high-water marks. GaWSC personnel apply methods discussed in Rantz and others (1982, p. 60) for determining peak stage at gaging stations.

GaWSC personnel follow policies and procedures stated in a number of publications and memorandums when collecting surface-water data during floods. Techniques for current-meter measurements of flood flow are presented in Rantz and others (1982, p. 159–170). Procedures for identifying high-water marks for indirect discharge measurements are presented in Benson and Dalrymple (1967, p. 11). Adjustments applied to make measured flow hydraulically comparable with recorded gage height when discharge measurements are made a distance from the gaging station are presented in OSW Technical Memorandum 92.09 and in Buchanan and Somers (1969, p. 54). All questions about particular policies or procedures related to flood activities should be directed to the Flood Coordinator and SWUC, and personnel who recognize their need for further training in any aspect of flood-data collection should consult with the Data Chief and SWUC.

The Data Chief and SWS are responsible for reviewing GaWSC activities related to floods. This review includes ensuring that guidelines and priorities spelled out in the Flood Plan are followed and that the guidelines appropriately address GaWSC requirements for obtaining flood data in a safe and thorough manner. When deficiencies are identified, the Data Chief and SWS will remedy them.

Low-Flow Conditions

Streamflow conditions in Georgia during periods of low flow are typically quite different from streamflow conditions during periods of medium and high flow. Low-flow discharge measurements are made to define or confirm the lower portions of stage–discharge relations for gaging stations, as part of seepage runs to identify channel gains or losses, and to help in the interpretation of other associated data. Additionally, low-flow measurements are made to define the relation between low-flow characteristics in a basin and those of a nearby basin for which more data are available (OSW Technical Memorandum 85.17).

In many situations, low flows are associated with factors that reduce the accuracy of discharge measurements. These factors include algae growth, which impedes the free movement of current-meter buckets, and larger percentages of the flow moving in unmeasured zones, such as between vegetation, at channel edges, and through narrow spaces between cobbles. When natural conditions are considered by the field personnel to be undependable, the cross section is physically improved for measurement by removal of debris or large cobbles, construction of dikes to reduce the amount of nonflowing water, or other such efforts (Buchanan and Somers, 1969, p. 39). If possible, however, channel modification should not be made where it could affect the recorded stage at the gage. After modification of the cross section, flow should be allowed to stabilize before the discharge measurement is initiated.

Gage-height of zero flow (GZF) is the gage-height reading at the gaging station when the discharge past the gaged location is zero. It is GaWSC policy that GZF measurements are made by field personnel during periods of low flow at all gages where the low-flow control is recognizable in order to make the GZF determinations. A channel control is an example of where a GZF measurement generally is not made.

During extreme drought conditions, stage may fall below the recording range of the stage equipment and (or) below the stage–discharge relation. The SWUC is responsible for ensuring that GaWSC personnel modify equipment in use or install new equipment to measure the extremely low stage. Also, the SWUC is responsible for ensuring that discharge measurements are made at gaging stations where the stage is below the stage–discharge relation.

The Data Chief and SWS are responsible for ensuring that GaWSC personnel use appropriate equipment and procedures during periods of low flow. Determination by the Data Chief, SWUC, or SWS that appropriate procedures are being used for data-collection activities during low-flow conditions is accomplished by reviewing the low-flow measurements and other field activities. The Data Chief and SWUC are responsible answering questions from GaWSC personnel pertaining to data collection during periods of low flow.

Cold-Weather Conditions

Surface-water activities occasionally include making streamflow-discharge measurements during cold weather conditions. Cold temperatures, wind, snow, and ice can create difficulties in collecting data. These factors also can create dangers for field personnel. The highest priority in collecting streamflow data during any season is employee safety.

At gaging stations where the stream is subject to freezing during winter months, discharge measurements under ice cover and during periods of partial ice cover are useful for analysis and determination of flow throughout the winter period. GaWSC personnel are required to follow the procedures for discharge measurements under ice cover presented in Buchanan and Somers (1969, p. 42). This same publication includes procedures for discharge measurements made by wading or discharge measurements from cableways and bridges when debris and ice are in the streamflow. GaWSC personnel also follow procedures to collect winter streamflow data as presented in Rantz and others (1982, p. 124). Additionally, guidelines on equipment used for measuring flow under ice are provided in OSW Technical Memorandum 84.05.

Presently, OSW views the preferred metering equipment for making discharge measurements in slush-free conditions under ice cover to be a Price AA current meter modified with a Water Survey of Canada winter-style yoke and a conventional metal-cup rotor. For conditions where ice slush is present, the OSW views the preferred metering equipment to be the Water Survey of Canada winter-style yoke with a polymer rotor (OSW Technical Memorandum 88.18). Although polymer rotors are not allowed (OSW Technical Memorandum 90.01) during all other conditions, the superior ability of the polymer rotor to shed ice slush and retard freezing in ice-covered streams is considered to be more important than the turbulent-flow-related inaccuracies associated with the metal rotor (OSW Technical Memorandum 92.04). The OSW also views the regular AA meters with conventional metal-cup rotors to be acceptable for use in slush-free conditions if cutting the required larger holes through the ice is feasible (OSW Technical Memorandum 92.04).

The Data Chief or SWS is responsible for ensuring the correct use of equipment and procedures for surface-water data-collection activities during winter conditions. This is accomplished by ensuring that appropriate equipment and procedures are used and by reviewing all field notes immediately following winter field trips, or reviewing field notes when station records are reviewed annually.

Storm-Surge Sensor Network

The USGS developed a mobile storm-surge sensor network to capture information about the timing, extent, and magnitude of storm tides. This mobile network consists of 40–70 water-level and barometric-pressure monitoring devices that are deployed in the days and hours just prior to hurricane landfall. The GaWSC Atlanta office serves as one of the USGS's storm-surge centers, all of which coordinate the deployment and recovery of storm-surge sensors and the processing and dissemination of the surge data. The Data Chief is responsible for coordinating the efforts of the storm-surge center in Atlanta.

Processing and Analyzing Stage and Streamflow Data

The computation of streamflow records involves analyzing field observations and field measurements, determining stage–discharge relations, adjusting and applying those relations, and systematically documenting the methods and decisions applied. Streamflow records are computed and published for each gaging station annually (Rantz and others, 1982, p. 544).

This section of the QA Plan includes descriptions of procedures and policies pertaining to the processing and analysis of data associated with the computation of streamflow records. Procedures followed by the GaWSC coincide with those described in Rantz and others (1982) and in Kennedy (1983).

Real-Time Streamflow Data

A necessary and critical element in maintaining accurate streamflow records on a real-time basis is the need for rating analysis and shift application as soon as practicable after a discharge measurement has been made. It is GaWSC's policy that rating analyses and shift applications be performed using the following procedures for data to be disseminated on the GaWSC's public Web site *http://ga.water.usgs.gov/*.

Real-time data presented on the GaWSC Web site are considered to be provisional and subject to revision. Web-site users are warned of the inherent limitations of provisional data by prominent clickable headings that link to a page that explains, in detail, the meaning of the term "provisional data." It is a goal of the GaWSC to process, check, and finalize all surface-water records by April 1 of the following water year. Additionally, records for the Georgia surface-water network (including the provisional application of shifts, gage-height corrections, and datum corrections) are up-to-date within 2 weeks of the most recent field measurement. Recent field measurements may indicate the need to correct gage-height data or shift the stage–discharge relation, which could lead to changes in the provisional data displayed on the Web.

During times of flooding, the use of real-time data is an integral part of improving and maintaining stage–discharge relations for use in computing streamflow records. The GaWSC Flood Plan specifies procedures and responsibilities during floods. The Data Chief serves as the Flood Coordinator. It is the responsibility of the Flood Coordinator to declare a flood emergency based on the criteria spelled out in the Flood Plan. The plan includes a list of high priority stations and medium priority stations for which high-water measurements are needed to define the upper portion of station ratings. The list specifies the gage height above which measurements are needed for each site. The real-time data on the Web and projected crest estimates provided by the National Weather Service are used to help determine to which stations and the appropriate time to deploy field personnel. It is the responsibility of the Flood Coordinator to direct the deployment of field personnel for the purpose of obtaining field measurements and for the repair of failed equipment. It is the responsibility of the field personnel to call in and report measurement data to the Flood Coordinator and to provide other pertinent field information. Flood measurements are used to update station ratings, shifts, and other aspects of real-time discharge computations. Every attempt is made to update this information the same day that the measurement information is called into the office.

Web-Site Presentation

Georgia real-time data can be accessed by computers from servers located and maintained in the GaWSC Atlanta office. The National Water Information System Web (NWISWeb) software is used to conform the data to national USGS standards. Links to real-time streamflow data are displayed prominently on the GaWSC Web site *http://ga.water.usgs.gov/*. By clicking on the phrase "Map of current streamflow conditions," the user can access a map of Georgia showing color-coded dots that identify the locations of gaging stations equipped with telemetry that provide the current streamflow conditions at each site. The user also can access a list of Georgia real-time gaging stations grouped by river basins by clicking on "Streamflow" at this Web site. The GaWSC Web site also contains a direct link to a national map that contains color-coded dots that indicate the locations of gaging stations across the Country that provide current streamflow conditions. The GaWSC Webmaster approves and executes any modifications to the GaWSC Web site, whether it is the addition or deletion of Web links, the posting of USGS publications, or the addition of new Web pages. The Webmaster also is responsible for ensuring that the GaWSC Web site conforms with all USGS Web and publication policies. The GaWSC Director ultimately is responsible for approval of all content posted on the GaWSC Web site.

Handling Errors

Two general types of errors are associated with streamflow data that are delivered in real-time and disseminated on the Web. The first type of error is the persistent-type problem that usually is associated with equipment failure, whether in data collection, satellite transmission, or computer systems, but this type of problem also could be related to weather, such as ice effects. Because of the nature of these problems, they generally occur on a continuing basis and affect more than a single recording interval. The second type of error is the intermittent-type problem that usually results in a data-transmission error that shows up either as a zero or an unreasonably large value. It is GaWSC policy that intermittent-type errors, such as the transmittal of extremely large gage-height data, be identified as soon as is reasonably possible and the erroneous data either deleted or corrected as soon as is reasonably possible. For example, if the SWUC identifies a data-transmission error during a daily visual check of the real-time data, that individual takes immediate actions to delete or correct the value and update the real-time Web site to display the corrected data. In regard to persistent-type problems, it is GaWSC policy not to estimate corrected discharges on an ongoing basis during periods of backwater caused by the effects of ice. Web users, however, are warned about the provisional nature of discharges during winter periods. When real-time data on the Web are clearly in error for a particular station, possibly because of malfunctioning equipment, vandalism at the site, major control damage caused by beaver-dam construction, or other similar problems, the Data Chief is responsible for deciding when to remove data for that particular site from the Web. After repairs have been made at the site and the data are determined to be accurate, the Data Chief is responsible for deciding when to resume posting the real-time data on the Web.

Data-Qualification Statements

The USGS policy regarding the posting of streamflow data on the Web is summarized in WRD Technical Memorandum 95.19, which states that streamflow data made available on the Web should be considered provisional until the formal review process has been completed. To ensure that the public who access data from the Web are aware of this, data-qualification statements are included at key locations on all real-time data Web pages stating Provisional Data Subject to Revision. It is GaWSC policy that all GaWSC Web pages that contain real-time data, or data that have not been formally approved as final, contain a prominent clickable heading that links to the following explanations:

Recent data provided by the USGS in Georgia—including stream discharge, water levels, precipitation, and components from water-quality monitors—are preliminary and have not received final approval.

Most data relayed in real-time by satellite or other telemetry have received little or no review. Inaccuracies in the data may be present because of instrument malfunctions or physical changes at the measurement site. Subsequent review may result in significant revisions to the data.

Data users are cautioned to consider carefully the provisional nature of the information before using it for decisions that concern personal or public safety or the conduct of business that involves substantial monetary or operational consequences.

Information concerning the accuracy and appropriate uses of these data or concerning other hydrologic data may be obtained from the state manager whose name is shown on the single station data summary pages, or from the USGS SWS in Georgia care of the Webmaster e–mail alias Georgia NWISWeb Maintainer.

Measurement and Field Notes

Gage-height and discharge information, control conditions, and other field observations in the electronic SWAMI files form the basis for records computation for each gaging station. Measurements and field notes containing original data are required to be stored indefinitely (Hubbard, 1992). All SWAMI files are archived. The archival structure for SWAMI files are documented in Appendix B.

Measurements and other field notes that are currently being computed for the water year are filed in the primary station folder or in the current water year measurement file drawer in the office. Measurements and notes for previous water years are filed in the office historical files.

It is GaWSC policy that all measurements are checked. For conventional measurements, this includes a check of computations and procedures, such as stationing, number of sections, use of appropriate equipment, correct gage height, and proper transcription of numbers. For measurements computed by using an automated discharge-measurement calculator, only the procedural check is made. The procedural check may be done by any Hydrologic Monitoring and Analysis Section member other than the field person who made the measurement. Measurement information is entered and stored in the USGS NWIS database. A printout of the measurement list (Kennedy, 1983, p. 12), grouped by year, is included in the office technical file in the station-records filing cabinet.

The person who processes the records for each station is responsible for ensuring that the measurement notes are correct, the information stored in the computer files agrees with the measurement notes, and an updated printout of the measurement list is contained in the technical folder.

Continuous Record

Surface-water gage-height data are collected as continuous record (generally at 15-minute intervals) and transmitted electronically by satellite or stored in electronic data recorders at the site. Streamflow records are computed by converting gage-height record to discharge record through the application of stage–discharge relations. Ensuring the accuracy of gage-height record is, therefore, a necessary component of ensuring the accuracy of computed discharges.

Gage-height record is assembled as completely as possible for the period of analysis. Periods of inaccurate gage-height data are identified and corrected (see the section “Datum corrections, gage-height corrections, and shifts”) or deleted as appropriate and as determined by the Data Chief, SWUC, or SWS. Items included in the assembly of gage-height record and the procedures for processing the data are discussed in Rantz and others (1982, p. 560, 587) and Kennedy (1983, p. 6).

Immediately following a data-collection field trip, all surface-water data loaded onto a computer in the field are transferred into ADAPS by using Device Conversion and Delivery System (DECODES). Data that are transmitted by satellite are automatically entered into the ADAPS database using DECODES. Raw data are maintained unaltered for future reference in a file on the data-entry personal computer (PC) and on backup tapes as part of a backup system created by the GaWSC system administrator. Stage data from the primary recorder known to be erroneous can be overwritten by correct data obtained from a backup recorder if a backup recorder is maintained at the site.

The person inserting backup record into the primary data-descriptor (DD) record is responsible for ensuring that correct data are inserted. Any such modification of data should be quality controlled, using graphical methods, and noted in the station analysis. Stage data stored in the computer files are used for computing surface-water records and are compared closely with field observations, including observer readings. Observer readings are maintained in the designated file drawer and are grouped by station. All stage data are to be reviewed by the person entering the data, using database graphics routines, immediately after entering the data into ADAPS. Any problems with the gages should be reported to the SWUC and corrected without delay.

Records and Computation

Computation of streamflow data for each station normally is computed each year by the field person who is responsible for the data-collection activities at the site. Other field personnel check all records for each station by using a records computation checklist. Similar procedures are used in each field office, and each field office is responsible for setting up the necessary office files for storing collected data.

Records-Management System

The status of progress on records computation for each gaging station in the State is monitored by using the Records Management System (RMS). RMS is a database with an internal Web interface that facilitates the documentation and tracking of records computation on a sub-water-year basis. It stores the comments exchanged among the record processor, checker, and reviewer during the record-computation process for the period.

Procedures for Processing and Checking Records

Procedures for ensuring the thoroughness, consistency, and accuracy of streamflow records are described in this section of the QA Plan. Goals, procedures, and policies presented in this section are grouped in association with the separate components that are included in the records-computation process.

Gage Height

The accuracy of surface-water discharge records depends on the accuracy of the discharge measurement, accuracy of the rating definition, and completeness and accuracy of the gage-height record (OSW Technical Memorandum 93.07). Computation of streamflow records includes ensuring the accuracy of gage-height record by comparisons of gage-height readings made by use of independent reference gages, comparison of inside and outside gages, examination of high-water marks, comparisons of the redundant recordings of peaks and troughs by use of maximum and minimum indicators, examination of data obtained at CSGs, and confirmation or updating of gage datum by levels.

Records computation includes examination of the gage-height record to determine if the record accurately represents the water level of the body of water being monitored. Additionally, it includes identifying periods of time during which inaccuracies have occurred and determining the cause of the inaccuracies. When possible and appropriate, inaccurate gage-height data are corrected. When corrections are not possible, erroneous gage-height data are documented in writing (station analysis) and removed from the set of data being used for streamflow records computation. All missing gage-height periods are documented. Specifically, the period and the reason for the missing record should be listed in the station analysis. It is GaWSC policy to not estimate missing gage-height data.

In general, data that accurately reflect stream level should be kept. Examples may include backwater from leaves, ice, or beaver dams. Stage record that does not reflect stream level, such as a float that is stuck, plugged intakes, or a buried orifice, should be removed. Periods of mildly lagging intakes may be retained in the unit-value record. Also, periods of gage-height data when zero flow occurred but the gage pool was not dry are retained in the unit-value record.

The person processing the record is responsible for clearly identifying periods of erroneous gage-height record and deleting erroneous gage-height record from the computer file. When data from the primary recorder are replaced by data from a backup recorder, the affected periods are to be thoroughly documented in the station analysis.

Levels

Errors in gage-height data caused by vertical changes in the gage or gage-supporting structure can be measured by running levels. Gages can be reset or gage readings can be adjusted by applying corrections based on levels (Kenney, 2010).

Procedures for computing records and completing level information for each gaging station include ensuring that level notes are completed for each set of levels, checking level notes, ensuring that all shots are balanced correctly, ensuring that the level information is listed in the historical levels summary, and ensuring that information was applied appropriately as datum corrections, or other. The individual computing the record is required to check field notes for indications that the gages were reset correctly by field personnel. The individual computing the records makes appropriate adjustments to the gage-height record by applying datum corrections.

Rating

The development of the stage–discharge relation, also called the rating, is one of the principal tasks in computing discharge record. The rating is usually the relation between gage height and discharge (simple rating). Ratings for some special sites involve additional factors, such as rate of change in stage, fall in slope reach, or index velocity (complex ratings; Kennedy, 1983, p. 14).

GaWSC personnel follow procedures for the development, modification, and application of ratings that are described in Kennedy (1984). GaWSC personnel also follow guidelines pertaining to rating and records computation that are presented in Rantz and others (1982, chap. 10–14, p. 549) and Kennedy (1983, p. 14).

For each gaging station, the most recent digital rating table can be obtained from a printout from the electronic file stored in ADAPS, the standard USGS software. In addition, a paper copy of the current digital rating is kept in the technical folder maintained in the office filing cabinet with the station files. A graphical plot of the most recent rating can be obtained by generating the graph by using the plotter with standard USGS software. When new rating plots are generated to be used as the work plots, the previous work plots are discarded. Graphical master ratings of all previous numbered ratings are retained in the backfile.

The SWUC and other experienced GaWSC personnel check and review each rating as part of the annual station analysis to ensure accuracy in the development, documentation, and application of each rating. Standard procedures, as described in Buchanan and Somers (1969) and Kennedy (1984) that pertain to rating development and applications are followed in data computations. All measurements are plotted on the current rating plot as standard procedure for data analysis. When personnel have questions pertaining to ratings, the Data Chief, SWUC, or SWS is responsible for providing answers. It is GaWSC policy that new ratings are checked before copies of the ratings are sent outside the office. Significant changes on the upper end of the rating must be approved by the Data Chief, SWUC, or SWS.

Rating Numbering System

Ratings are stored with sequential identification numbers, and any modification to rating-input points, including a change-of-scale offset, results in a new whole-number rating (such as from 12.0 to 13.0). If a rating is extended to a new gage height either above or below the current rating, then it should be sequenced by a tenth of a whole number (such as from 12.0 to 12.1).

The goal of policies and procedures pertaining to ratings is to promote efficiency and accuracy in the development and documentation of ratings. The person processing the station records is responsible for ensuring that all measurements for the current year and all high-water measurements for the station are plotted on the current work plot of the rating.

In general, changes in the stage–discharge relation that tend to be temporary changes are addressed through the use of variable-stage shifts. It is, however, left to the discretion of the person working the station records to determine if changes in the relation are addressed with shifts or if conditions warrant the introduction of a new rating.

In general, changes in the stage–discharge relation that are deemed to be relatively stable warrant the introduction of new ratings, and well-defined trends also warrant new ratings. It is the responsibility of the person processing the records to fully develop the new rating; enter all input values and offsets into the computer, using standard USGS software; and plot the new rating along with the measurement data.

The person checking the station records is responsible for ensuring that the rating-input points and offsets agree with available measurement data. The checker has the latitude to disagree with the scope and shape of the new rating and with the original decision to introduce a new rating. The checker also can choose to develop a new rating for the station, if appropriate. The checker, however, is responsible for discussing disagreements with the original records processor. The two must come to a consensus on the appropriate rating to be used. If a consensus is not reached, they are responsible for presenting the matter to the Data Chief, SWUC, or SWS for a final determination.

Datum and Gage-Height Corrections and Shifts

A correction applied to gage-height readings to compensate for the effect of settlement or uplift of the gage is usually measured by levels and is called a *datum correction* (Kennedy, 1983, p. 9). Datum corrections are applied to gage-height record in terms of magnitude (in feet) and when the datum change occurred. In the absence of evidence indicating exactly when the change occurred, the change is assumed to have occurred gradually from the time the previous levels were run, and the correction is prorated with time (Rantz and others, 1982, p. 545). Datum corrections are applied when the magnitude of the vertical change is greater than 0.015 foot.

A correction applied to gage-height readings to compensate for differences between the recording gage and the base (reference) gage is called a *gage-height correction* (Rantz and others, 1982, p. 563). These corrections are applied in the same manner as datum corrections by use of the same computer software. Gage-height corrections are applied so the recorded data agree with reference gage data. These corrections are applied when the difference between the recording gage and the reference gage is equal to or greater than 0.02 foot.

A correction applied to the stage-discharge relation, or rating, to compensate for variations in the rating is called a *shift*. Shifts reflect the fact that stage–discharge relations are not permanent but vary with time, either gradually or abruptly, because of changes in the physical features that form the control at the gaging station (Rantz and others, 1982, p. 344). Shifts can be applied to vary in magnitude with time and (or) with stage (Kennedy, 1983, p. 35). Most shifts are applied as variable-stage adjustments in GaWSC database applications software. Generally shifts are applied if discharge measurements plot more than their rated accuracy from the rating. Certain factors, however, can affect when and how the application is determined, such as stream conditions under which the measurement was made. Judgment and experience of field personnel are used in shift applications. The SWUC or SWS check and review the rating development, application, and documentation. Review of each shift application by the SWUC or SWS ensures that stage shifts perform as expected.

The person who processes the station records documents the shifts by describing shift magnitude and time of application in the station analysis and by including the shift-analysis printout and shift bar-diagram plot with the station analysis. Station records also should contain a description of why the shift was needed. The shift-diagram points should be plotted on a copy of the work rating so that the hydraulic logic of the shift curve can be seen. The checker is responsible for ensuring that the logic and procedures used in developing and applying the shifts are correct and the shifts are documented fully.

Datum corrections, gage-height corrections, and shifts for each station are entered in the standard NWIS database and are stored as finalized data upon completion of the GaWSC's records-processing work. The person who processes the station record ensures that recorded gage heights and computed discharges represent a logical and smooth transition between water years. The checker also ensures the quality of the transition between water years. Datum corrections, gage-height corrections, and shifts are documented in the station analysis, and associated graphs and computer printouts are attached to the station analysis as part of the permanent record. This documentation is maintained indefinitely for future reference.

Hydrographs

A discharge hydrograph is a plot of daily mean discharge in relation to time. The date is aligned with the horizontal axis, and the discharge is aligned with the logarithmic vertical axis. In the process of computing station records, this hydrograph is a useful tool in identifying periods of erroneous information, such as incorrect shifts or datum corrections. Additionally, hydrographs are helpful when estimating discharges for periods of undefined stage–discharge relation, such as during backwater or ice conditions, and in estimating discharges for periods of missing record.

Information placed on the hydrograph for each gaging station includes, at minimum, the station name and number, water year, date the hydrograph was plotted, drainage area, plot of daily mean discharge data, plots of measurements, indications of datum corrections and shifts, names of the gaging stations used for comparison with the hydrograph, periods of missing record, estimated discharges for days of missing record, periods of ice effect, estimates of discharge during periods of ice effect, and the maximum instantaneous discharge for the water year. All hydrographs are plotted on a standard form with standard log cycles so that the dimensions of the graphs are uniform for all gaging stations.

The person who processes the gaging-station record is responsible for completing the hydrograph. The checker ensures that the hydrograph is complete and correct. Plots typically are printed on the GaWSC's large-format plotter.

Hydrograph comparisons assist GaWSC personnel in identifying potential problems that may have been overlooked in the normal computation procedures (Rantz and others, 1982). The hydrograph is used in downstream analysis of gaging stations in the same or adjacent basin as a tool for ensuring the quality of computed discharge record. Hydrographs are filed in the station folder during the computation process and are stored in the historical station file when computations for the water year are completed. The Data Chief, the SWUC, or the SWS provides guidance when questions are raised concerning hydrographs.

Station Analysis

A complete analysis of the data collected, procedures used in processing the data, and the logic used in the computations is documented for each year of record for each gaging station, which provides a basis for review and serves as a reference if questions arise about the records at some future date (Rantz and others, 1982, p. 580). In essence, the station analysis tells the "story" of the gage for the year. The use of digital photographs is strongly encouraged to help tell the "story." Topics discussed in detail in the station analysis include, but are not limited to, equipment, hydrologic conditions, gage-height record (including when and why record is missing), datum corrections, rating, discharge, special computations, hydrographic comparison, and remarks concerning the quality of records. The person who processes the record writes the station analysis.

The person writing the station analysis must use SIMS to construct the analysis. Completed hard copies of the station analysis for previous years are grouped in a separate folder in the station backfile. Also, an electronic copy of the station analysis generated in SIMS is stored on the GaWSC server. Included with the hard copy of the station analysis are all graphs of variable stage-shift diagrams, a printout of the shift analysis, a printout of the year-end summary, and printouts of the datum and shift applications.

The person who processes the station record is responsible for ensuring that the computation is comprehensive and complete and that all aspects of the process are documented fully in the station analysis and associated material. Likewise, the checker is responsible for ensuring that all aspects of the records-computation process for the station were carried out correctly and completely and that the documentation is clear, complete, and accurate.

In the event that the checker disagrees with any of the methods or interpretations used, it is the checker's responsibility to discuss any potential changes with the person who processed the station records. It is the responsibility of the person who processes the record to make any recommended changes proposed by the checker. If a consensus cannot be reached between the two parties, it is their responsibility to present the issue to the Data Chief or SWUC who will make the final determination.

Winter Records

The GaWSC rarely has ice-affected streamflow data. However, on the few occasions when ice forms in stream channels or on section controls and causes backwater, the stage–discharge relation is affected; the effect varies with the quantity and nature of the ice, as well as with the discharge (Rantz and others, 1982, p. 360). During some conditions, the recorded gage-height data may be accurate, although the actual stage-discharge relation may be undeterminable and unstable. An example of this condition would be when surface ice forms on the stream, but the stilling well remains unfrozen and the water level in the stilling well represents the backwater caused by the ice in the channel. During other conditions, the recorded gage-height data are inaccurate, resulting in periods of missing gage-height record. An example of the latter would be when a stilling well or the intakes to the stilling well are frozen.

The individual computing the station record is responsible for identifying ice-affected periods and estimating the daily discharges during the ice-affected period. The same procedures are followed as described in the previous section under gage-height corrections and shifts.

Furnished Record

The GaWSC periodically receives surface-water data collected under the supervision of other agencies, organizations, or institutions. When received, these data are published in the WDR and may be used in comparison of computed streamflow data for specific stations.

If the GaWSC receives furnished data from other organizations, agencies, or institutions, the data are checked and compared with other station data, if possible. The Data Chief, SWUC, or SWS is responsible for checking data and assuring that data are in conformance with WRD standards. If errors in the data are suspected, the furnishing agency is contacted to determine if an error was made. The Data Chief, SWUC, or SWS is responsible for contacting the furnishing agency. Published data from another agency are not normally retained as permanent record in the GaWSC database.

Daily-Values Table

With few exceptions, a daily discharge value is determined for each gaging station operated by the WRD and stored for each day. The daily-values table generated in NWIS represents the discharge values that are stored for each day of the water year.

Daily mean discharge is one of the major products of the records-computation process. The person who processes the record is responsible for determining that calculated daily mean discharges accurately represent actual streamflow conditions. That person is responsible for ensuring that the daily-values table, which includes the daily values stored electronically, contains the correct data. In addition, it is that individual's responsibility to ensure that the correct values stored in the daily-values table also are contained in the hydrograph, working primary computations, and the publication-ready manuscript. In turn, the checker confirms the accuracy of this information. A hard copy of the daily-values table is included in the station primary folder. The finalized daily values are stored in the NWIS database for future retrieval and analysis. The person who processes the record updates the progress of the record upon completion of the station record. The checker then updates the record progress accordingly when the checking process has been completed.

Manuscript and Annual Report

When records computation for the water year has been completed, and the data collected and analyzed by GaWSC personnel have been determined to be correct and finalized, the surface-water data for that water year are published with other data in the GaWSC's WDR. The WDR is part of the series entitled "U.S. Geological Survey Water-Data Reports," which can be accessed at *http://wdr.water.usgs.gov/*. Information presented in the WDR includes daily discharge values for the year, extremes for the year and period of record, and various statistics. Additionally, manuscript station descriptions are presented in the WDR. Information contained in the manuscript includes physical descriptions of the gage and basin, history of the gaging station and data, and statements of cooperation.

In preparing the WDR for publication, the GaWSC follows the relevant guidelines presented in Novak (1985) and OSW Technical Memorandum 92.07 (summary statistics memo). Someone other than the person who computed the record and wrote the station analysis checks each station. The SWUC or SWS does the final review of the data and publication. The Data Chief or SWS checks the proof copy of the report.

Manuscripts for publication in the WDR are produced in SIMS. Tables and graphs of daily values and streamflow statistics presented in the report are compiled with the station manuscript file using automated computer scripts. Each compiled station file is reviewed. The final compiled file for each station is then submitted to the server at USGS Headquarters for publication.

Instantaneous Data Archive

Instantaneous (unit-value) discharge data are an additional product of the records-computation process. In recent years, and particularly since the USGS began making real-time instantaneous data available on NWISWeb in 1994, more attention has been given to historical instantaneous discharge data, and USGS offices have received increasing requests for these data. The Instantaneous Data Archive (IDA), accessible at *http://ida.water.usgs.gov/*, was developed by the USGS to provide a means for the public to retrieve instantaneous discharge data from the Web. Following completion of the WDR each year, the SWS loads the unit-value discharge data for the water year into IDA.

Review of Records

After streamflow records for each gaging station have been computed and checked, senior personnel who are chosen by the Data Chief review records for all of the GaWSC's gaging stations. The SWS reviews 10 percent of the gaging stations, which include complex or nontraditional sites. The goals of the review are to ensure that proper methods were applied throughout the process of collecting surface-water data and computing the record, and to identify areas where further training is needed.

If deficiencies are identified during the record review, the individuals responsible for compiling the station analysis data are notified in writing or verbally. The individuals are responsible for correcting identified deficiencies and re-documenting the station data, as necessary. If questions arise concerning the validity of the identified deficiencies, the Data Chief or SWS resolves the questions.

The Data Chief is responsible for ensuring that any deficiencies identified in the review are corrected and that actions are taken to prevent recurrence of the deficiencies. The Data Chief also is responsible for ensuring that positive aspects of the review are communicated to GaWSC personnel to recognize good work and reinforce the continued use of correct methods and procedures.

Crest-Stage Gages

Records for CSGs are computed with goals and procedures similar to those for other gaging stations. Field notes are examined for correctness and accuracy. Peak stages recorded by CSGs are cross referenced with other available information; dates of the peaks are determined by analyzing available precipitation data and peak data from recording gages within the same basin or from nearby basins.

A discussion on the policies and procedures used in the field for collecting data at CSGs is included early in this report in the section, "Collection of Stage and Streamflow Data." The discussion in this section describes the analysis and office documentation of crest-stage data. This section does not pertain to data collected at CSGs installed solely for the purpose of confirming peak stages at sites where pressure transducers or radar sensors are used.

At sites where CSGs are used to compute peak discharges, an initial stage–discharge relation, or rating, is developed for the site by direct or indirect high-water measurements. The rating is verified or adjusted on the basis of subsequent direct measurements that are made at least every 3 years. Also, a direct measurement is made whenever water is on the pipe during a site visit.

For each gaging station, a list of all measurements is maintained and each measurement is assigned a chronological number. For each station, a graphical plot and table of the current rating along with each recent and notably high stage-discharge measurement are contained in each station folder and made readily available to those who check and review the station record. These data are all stored in the GaWSC database. Current station descriptions and a summary of levels are maintained in the station folders and in electronic files. A brief station analysis is written each year describing the computation of the annual peak; identifying the rating number, type of rating, and type of flow condition; and describing how the dates of the peaks were determined.

The CSG coordinator, Data Chief, SWUC, or SWS is responsible for ensuring the correct computation of annual peaks at CSGs. Senior personnel, who are chosen by the Data Chief, review CSG computations. When incorrect actions or procedures are identified during the review, the reviewer informs the person who maintains the site that corrective action is needed.

The CSG coordinator is responsible for updating the peak-flow file promptly after peak data have been finalized. A current listing of annual peaks is maintained in the station folder and (or) electronically for review purposes (OSW Technical Memorandum 88.07).

Office Setting

Maintaining surface-water data and related information in a systematic and organized manner increases the efficiency and effectiveness of data analysis and dissemination. Good organization of files reduces the likelihood of misplaced information; misplaced data and field notes can lead to analyses based on inadequate information, with a possible decrease in the quality of analytical results.

This section of the QA Plan includes descriptions of how station folders, reference maps, levels documentation, and other information related to surface-water data are organized and maintained. Additionally, this section provides an overview of how work activities are designed to be carried out within the office setting.

Work Plan

The SWUC and chief of each field office, with assistance and approval from the Data Chief, assign and schedule routine field activities. Trips are run at a frequency that reflects the need to define or verify station ratings but are conducted at a minimum frequency of every 8 weeks. The workload is based on experience and the knowledge of field personnel but is distributed as equally as possible. Beyond normal data-collection activities, it is very important that plans be formulated to cover extreme hydrologic events. The GaWSC Flood Plan provides basic guidance for data-collection activities during flooding events.

The Data Chief, assisted by the SWS, supervises the Flood Plan implementation. Low-flow events, by their very nature, have lengthy response times and appropriate personnel have ample time to plan field activities tailored to the anticipated significance of the event. The exception is a special low-flow synoptic run, which requires careful planning and logistics. The chief for each field office, with assistance from the Data Chief or SWS, almost exclusively directs low-flow field activities for relatively minor events. The Data Chief, with support from Section personnel, directs low-flow field activities for highly significant events.

File Folders for Surface-Water Stations

This section describes the location and content of hard-copy files associated with surface-water data. Information pertaining to files maintained electronically can be found in the “Database Management” section of this report.

For each gaging station, a separate set of file folders is maintained for current and historical data. Current files are organized by station number in downstream order, and historical files are organized by station number in downstream order. Current files are filed in the data section filing area of the GaWSC, and historical files are kept in the record section filing area of each field office. The set of current files for each gaging station contains primary-computation printouts, graphed data of stage and discharge, recent measurements, current rating, shift and gage-height application sheets, and other pertinent data. The set of historical file folders contains all previous water data and analyses data for the period of record and station description. Extraneous items are removed from the current files after the Data Chief determines that records are to be finalized for the year. Historical file folders from the past 3 years for sites assigned to field offices are filed in downstream-order number in those offices and are annually transferred to the GaWSC historical files.

Field-Trip Folders

The GaWSC maintains separate folders for each gaging station by field trip or project. The primary purpose of these folders is to compile maps, station descriptions, station lists, and other pertinent information to allow field personnel to run the trips effectively at a moment’s notice and with minimum time spent on last-minute preparations. Field personnel are responsible for maintaining current information in each gaging station folder.

Level Notes

Recent or current level notes are included in current gaging station office folders. When new levels are run, the old level notes are moved to the historical measurement and field-note files. Level summaries are filed in the current station office folder. A copy of the most recent level notes is included in the station field folder. All level notes are checked for accuracy and proper leveling procedures. Individual field personnel, as determined by the SWUC or Data Chief, remedy any deficiencies.

Station Descriptions

Surface-water station descriptions are maintained for each gaging station in the current and historical office folders. Electronic files of station descriptions are maintained in SIMS on the GaWSC server by station and water year. Field personnel are responsible for updating and maintaining the station descriptions for their assigned areas. The SWUC or Data Chief is responsible for ensuring that folders or files are updated.

Discontinued Stations

File folders for discontinued stations are maintained in the historical files by downstream-order number. These station folders contain station descriptions, station analyses, ratings, daily discharge data, and other pertinent information for each water year.

Map Files

The GaWSC maintains separate map files for official use, which include drainage areas and general topographic maps of the State. All maps are organized in alphabetical order. Topographic maps are available in scales of 1:24,000, and 1:100,000; county maps are available at various scales. All maps must remain in the office since these are original informational (official) maps used in our operations. Other topographic maps are available for general or field use. These maps are filed separately from the official maps. The Data Chief is responsible for updating information regarding the official office maps.

Archiving

All WRD personnel are required to safeguard all original field records containing geologic and hydrogeologic measurements and observations. Selected materials that are not maintained in field offices are placed in archival storage. Detailed information on what records have been moved to archival centers should be retained in the GaWSC (WRD Technical Memorandum 77.83). The types of original data that should be archived include, but are not limited to, recorder charts and tapes, original and edited data, observer's notes and readings, station descriptions, analyses, and other supporting information (WRD Technical Memorandum 92.59; Hubbard, 1992, p. 12). Electronic data are archived following the policies and guidance in OSW Technical Memorandum 2005.08. Appendix B contains the electronic archiving structure used by the GaWSC.

Surface-water information is sent to the National Archives and Records Administration's regional Federal Record Center (FRC) from the GaWSC as needed and in accordance with USGS Records Disposition Schedules, which can be accessed at *http://www.usgs.gov/usgs-manual/schedule/index.html*. The Data Chief is responsible for deciding what information is sent to the FRC, ensuring that the information is properly packaged and logged, and verifying that the information has been received by the FRC. The Data Chief maintains records in the surface-water section of exactly what has been archived. Questions concerning archiving procedures should be directed to the Data Chief. Personnel who receive requests for information that require accessing archived records should contact the Data Chief for assistance.

Revision of Records

When the WDR was published in printed form, revisions to discharge records were formalized and documented by publishing a revision in the WDR. According to Novak (1985, p. 103), these revisions were limited to

> "…only those published records of discharge that are substantially in error—and only when the revisions are reliable. Revisions may result from additional data, re-examination and reinterpretation of data, or from the discovery of errors in computation. If revisions are published, an analysis should be prepared explaining the basis for making the revisions and the reasons why other periods perhaps do not need revision. This analysis should be completed and filed for reference."

The basic principles guiding revisions described by Novak (1985) are still sound and are applied by the GaWSC when using electronic databases and publishing formats. The GaWSC also uses additional guidance provided in OSW Technical Memorandum 2006.05 when revisions of discharge, stage, and elevation data are made.

Communication of New Methods and Current Procedures

Personnel who receive training or learn new methods or procedures are required to share the information with all persons directly involved in tasks that can make use of the information. Sometimes the Data Chief, SWUC, or SWS will conduct informal training to exchange information to help improve the collection and analysis of streamflow data. Any new procedure is passed along to each person, either in writing or verbally or both. Copies of all memorandums from WRD and OSW are given to each employee, and the Data Chief, SWUC, and SWS communicate major points to personnel. Sometimes memorandums are posted as continuous reminders to section personnel. The Data Chief, SWUC, and SWS are available to answer questions and discuss procedures.

Collection of Precipitation Data

This section of the QA Plan includes descriptions of procedures and policies pertaining to the collection of precipitation data. Many of the procedures followed by the GaWSC coincide with those described in OSW Technical Memorandum 2006.01.

Rain-Gage Installation and Maintenance

Proper installation and maintenance of rain gages are critical activities for ensuring quality in precipitation data collection and analysis. The exposure of a rain gage is very important for obtaining accurate measurements. Rain gages should not be installed at sites that are exposed to excessive winds. Rain gages should not be located close to trees, buildings, or other structures. A 45-degree cone of clearance above the top of the rain gage generally is to be maintained. Rain gages should be installed as close to the ground as possible without being subject to splash or vandalism. Rain gages should also be attached to a sturdy structure that does not shake. Rarely will an ideal site be available, and judgment must be exercised in choosing an adequate site.

The Data Chief, SWUC, and (or) SWS are responsible for selecting sites for rain gages. The process of site selection includes analyzing the terrain by using topographic maps and field reconnaissance and evaluating types of installation. The GaWSC currently uses Design Analysis H-340 self-calibrating tipping-bucket rain gages to collect precipitation data. The cumulative (running total) values from the rain gage are logged into the DCP every 15 minutes.

A program of careful inspection, maintenance, and calibration of rain gages promotes the collection of reliable and accurate data. Allowing the rain gage to fall into disrepair can result in unreliable data. It is GaWSC policy that field personnel perform a thorough inspection of the rain gage during each site visit. The inspection includes inspecting 45-degree cone clearance; noting the condition of cup, screen, and funnel; cleaning the cup, screen, and funnel; and re-leveling the rain gage if necessary. In addition, manual test tips are performed to ensure the rain gage is working properly. When performing test tips, the rain gage cover is removed, and the bucket mechanism is gently tipped 10 times at a rate of about one tip every 3 seconds. This is repeated two additional times with a time period of about 15 seconds between each set of tips. The number of tips from the data logger or field computer is recorded in the field notes. If the number of recorded tips is not equal to 30, the test is rerun. If the rain gage fails a second time, the rain gage is replaced. The rain gage cover should be replaced carefully so that erroneous tipping of the bucket does not occur. The test tips must then be deleted from the data logger or Web site (if transmitted during inspection).

Each rain gage is calibrated at least twice a year using a constant head bottle with a nozzle that simulates an intensity of 2 inches per hour. The calibration bottle is filled with a known volume of water, which corresponds to a specific number of inches of rain or number of bucket tips. The permissible error range in the number of tips in subsequent calibration tests for a particular site must be no more than 5 percent. If the calibration is found outside the allowable range of 5 percent, the instrument is re-leveled and a second calibration is performed. If the second rain gage calibration test is not within 5 percent, the rain gage is replaced. A rain gage that has been removed is then sent back to the manufacturer for re-calibration. Before a calibration test is done, the current accumulated precipitation is noted. Once the calibration test is finished, the rain gage is reset to the accumulated value observed before the calibration test. The results of the calibration test are documented on a tipping-bucket precipitation-sensor test calibration form and filed in the station folder.

Rain-Gaging Station Descriptions

A station description is prepared for each rain-gaging station and becomes part of the permanent record for each station. It is GaWSC policy that the station description is complete by the time the first year's record is computed and analyzed. The station descriptions are compiled in SIMS. The field person, Data Chief, or SWUC is responsible for ensuring that station descriptions are prepared correctly and in a timely manner. The SWUC is responsible for ensuring that station descriptions are updated. Station descriptions are reviewed each year during the annual station-analysis report process and are updated as needed. A digital copy of the most recent station description for each site is kept on the GaWSC server by year and station.

Processing and Analyzing Precipitation Data

This section of the QA Plan includes descriptions of procedures and policies pertaining to processing and analyzing data associated with the computation of precipitation data. Many of the procedures followed by the GaWSC conform with those described in OSW Technical Memorandum 2006.01.

Processing of Real-Time Precipitation Data

It is GaWSC policy that real-time precipitation data presented on the GaWSC Web site is considered to be provisional and subject to revision. Web site users are cautioned about the inherent limitations of provisional data by providing prominent clickable headings that link to a detailed explanation of the meaning of the term *provisional data*. It is a goal of the GaWSC to process, check, and finalize all precipitation records by April 1 of the following water year.

Web-Site Presentation

Georgia real-time data can be accessed by computers from servers located and maintained in the GaWSC Atlanta office. The NWISWeb software is used to conform to national USGS standards. Links to real-time precipitation data are displayed prominently on the GaWSC Web site *http://ga.water.usgs.gov/*. By clicking on the word "Precipitation," the user can access a list of Georgia real-time rain-gaging stations grouped by county. All data from real-time rain gages on the public Web site will be published. Any modifications to the GaWSC Web site, whether it is the addition or deletion of Web links, the posting of USGS publications, or the addition of new Web pages, are approved and executed by the GaWSC Webmaster. The Webmaster is responsible for ensuring that all GaWSC Web pages conform to all USGS Web and publication policies. The GaWSC Director ultimately is responsible for approval of all content posted on the GaWSC Web site.

Review of Real-Time Precipitation Data

Real-time precipitation data disseminated on the public Web site must be reviewed frequently to ensure data quality and to prevent distribution of erroneous information. The GaWSC uses both automated and manual review procedures to meet this objective.

The GaWSC has implemented automated procedures that include the setting of minimum and maximum threshold values and rate-of-change threshold values. If these thresholds are exceeded, the automated system initiates warnings of potential errors that are displayed on the Georgia real-time precipitation Web site.

In addition to automated procedures, WRD Technical Memorandum 99.34 requires frequent and ongoing screening and review of data posted on the Web. The GaWSC also requires that all Web pages containing real-time precipitation data be reviewed regularly for accuracy and (or) missing data. The SWUC and field person responsible for the gage scan the real-time precipitation data visually each work day. The primary goal of the visual check is to identify stations that failed to transmit the real-time data and to identify real-time data that appear to be erroneous in some way, including a clogged rain-gage funnel. When problems with a rain gage are identified, the Data Chief or SWUC notifies the person responsible for maintaining the gaging station.

Handling Errors

Two general types of errors are associated with precipitation data delivered in real-time and disseminated on the Web. The first type of error is the persistent-type problem that usually is associated with equipment failure, whether in data collection or transmission. Because of the nature of these problems they generally occur on a continuing basis and affect more than a single recording interval. The second type of error is the intermittent-type problems that usually results in a data-transmission error that shows up either as a zero or an unreasonably large value. It is the GaWSC policy that intermittent-type errors, such as the transmittal of extremely large precipitation data, be identified as soon as is reasonably possible and the erroneous data either deleted or corrected as soon as is reasonably possible. For example, when the SWUC identifies a data transmission error during the daily visual check of the real-time data, actions are taken immediately by that individual to delete or correct the value and update the real-time Web site to reflect the corrected data. When real-time precipitation data shown on the Web for a particular station are clearly in error, possibly because of malfunctioning equipment, vandalism at the site, or other similar problems, the Data Chief is responsible for deciding when to remove data from the Web. After repairs have been made to the rain gage and the data are determined to be accurate, the Data Chief is responsible for deciding when to resume posting of the real-time data on the Web.

Continuous Record

Cumulative (running total) precipitation data are collected as continuous record (at 15-minute intervals) and transmitted electronically by satellite. Precipitation record is assembled for the period of analysis in as complete a manner as possible. The SWUC or record processor determines and deletes, as appropriate, periods of inaccurate precipitation data.

Immediately following a data-collection field trip, all precipitation data that were loaded onto a computer in the field are transferred into ADAPS by using DECODES. Data that are transmitted by satellite are automatically entered into the ADAPS database using DECODES. Raw data are maintained unaltered for future reference in a file on the data-entry PC and on backup tapes as part of a backup system created by the GaWSC system administrator. Erroneous precipitation data from the primary recorder can be overwritten with correct data obtained from a backup recorder if a backup recorder is maintained at the site.

The person inserting backup record into the primary DD record is responsible for ensuring that correct data are inserted. Any such modification of data should be quality controlled, using graphical methods. All precipitation data are to be reviewed by the person entering the data, using database graphics routines, immediately after entering the data into ADAPS. Any problems with the gages should be reported to the SWUC and corrected without delay.

Records and Computation

The field person who is responsible for the data-collection activities at a gaging station normally computes precipitation data for that station. Other field personnel check records for each station and track their progress in the RMS. Similar procedures are incorporated at each field office. Each field office is responsible for setting up the necessary office files for storing collected data.

Procedures for Processing and Checking Records

Procedures for ensuring the thoroughness, consistency, and accuracy of precipitation records are described in this section of the QA Plan. The goals, procedures, and policies presented in this section are grouped in association with the separate components that are part of the records-computation process.

Data Corrections

The GaWSC does not apply data corrections to precipitation data. If a calibration test indicates that a rain gage is in error by more than 10 percent, the precipitation data recorded by that rain gage are removed from the record.

Estimating Missing Record

The GaWSC does not estimate missing precipitation record. If the rain gage is affected by a plugged funnel or by snow or ice effects, the data for the affected period are deleted and classified as missing. If precipitation data are missing for part of a day, the daily sum value for that day can be accurately computed as long as values are recorded at the 00:00:00 time stamp for consecutive days and the rain gage accumulator is not reset during this period. In addition, if values are missing for consecutive 00:00:00 times, the daily sum value for that day can be accurately computed as long as no precipitation occurred during the period of missing data.

Station Analysis

A complete analysis of the data collected, procedures used in processing the data, and the logic used in the computations is documented for each year of record for each gaging station, which provides a basis for review and serves as a reference if questions arise about the records at some future date (Rantz and others, 1982, p. 580). Topics discussed in detail in the station analysis include, but are not limited to, location, equipment, precipitation record (including when and why record is missing), computations and calibrations, recommendations, and remarks concerning the quality of the records. The person who processes the record writes the station analysis, which usually is incorporated with station analysis for stage and discharge.

The station analysis is constructed by using SIMS. Completed and checked analyses for previous years are grouped in a separate folder in the station backfile. The hard copy of the analysis, signed and dated by the original record processor and the checker, is considered to be a permanent document for the station file. Electronic files of the station analysis are stored on the GaWSC server by station and water year.

The person who processes the station record is responsible for ensuring that the computation is comprehensive and complete and that all aspects of the process are documented fully in the station analysis and associated material. Likewise, the checker is responsible for ensuring that all aspects of the records-computation process for the station were carried out correctly and completely and that the documentation is clear, complete, and accurate.

In the event that the checker disagrees with any of the methods or interpretations used, it is the checker's responsibility to discuss any potential changes with the person who processed the station records. It is the responsibility of the person who processes the record to make the recommended changes. If a consensus cannot be reached between the two parties, it is their responsibility to present the issue to the Data Chief or SWUC who will make the final determination.

Daily Sum Values Table

Daily sum values are the published product of the precipitation records-computation process. The person processing the record is responsible for ensuring that the daily sum values table, which includes the values stored in the daily-values computer file, contains correct data. In turn, the checker confirms the accuracy of this information. A hard copy of the daily sum values table is included in the station primary folder. The finalized daily sum values are stored in the NWIS database for future retrieval and analysis.

Manuscript and Annual Report

When records computation for the water year has been completed and the data collected and analyzed by GaWSC personnel have been determined to be correct and finalized, the precipitation data for that water year are published with other data in the GaWSC's WDR. Information contained in the manuscript includes physical descriptions of the gage and basin, history of the gaging station and data, and statements of cooperation.

Review of Records

After the precipitation records for each station have been computed and checked, senior personnel, who are chosen by the Data Chief, review records for all of the GaWSC's rain-gaging stations. The goal of the review is to ensure that proper methods were applied throughout the process of collecting precipitation data and computing the record. Comparison with nearby rain gages is a critical step in the review of precipitation records. If deficiencies are identified during the record review, the individual responsible for compiling the station-analysis data is notified in writing or verbally. The individual is responsible for correcting identified deficiencies and re-documenting the station data as necessary. If questions arise concerning the validity of the identified deficiencies, the Data Chief or SWS resolves the questions.

The Data Chief is responsible for ensuring that any deficiencies identified in the review are corrected and that actions are taken to prevent recurrence of the deficiencies. The Data Chief also is responsible for ensuring that positive aspects of the review are communicated to GaWSC personnel to recognize good work and reinforce the continued use of correct methods and procedures.

Collection of Sediment Data

Surface-water activities in the GaWSC include the collection, analysis, and publication of sediment data. The GaWSC operates in adherence to OSW policies related to sediment data.

Responsibility for the sediment discipline was transferred from the Office of Water Quality (OWQ) to the OSW in 1985 (OSW Technical Memorandum 92.08). The sediment policies and procedures followed by the GaWSC are described in selected WRD publications and in memorandums issued by OSW, OWQ, and WRD. Techniques adopted by the USGS and followed by the GaWSC are presented in Knott and others (1992). The GaWSC also follows procedures described in three USGS TWRI publications:

1. TWRI book 3, chap. 1: "Fluvial sediment concepts," by Guy (1970);
2. TWRI book 3, chap. 2: "Field methods for measurement of fluvial sediment," by Guy and Norman (1970); and
3. TWRI book 3, chap. 3: "Computation of fluvial-sediment discharge," by Porterfield (1972).

Although no subsequent TWRI chapters have been written to officially supersede these three reports, the methods presented in Edwards and Glysson (1988) essentially replace those presented in TWRI book 3, chap. 2 (WRD Technical Memorandum 71.73; OSW Technical Memorandums 88.17, 93.01). Additional guidance on sediment sampling methods also is provided by Nolan and others (2005).

A summary of memorandums issued since 1971 related to sediment and sediment transport is provided in OSW Technical Memorandum 92.08. A summary of documentation that describes instrumentation and field methods for collecting sediment data is provided in OSW Technical Memorandum 93.01.

Sampling Procedures

Suspended-sediment data are collected by GaWSC personnel by using sampling methods that include the single vertical method, the equal-discharge increment (EDI) method, the equal-width increment (EWI) method, and the point-sample method. For installation and use of automatic pumping-type samplers, the GaWSC personnel follow the criteria described in Edwards and Glysson (1988, p. 26-34).

Field methods for sediment sampling are documented in OSW Technical Memorandum 93.01. Water samples obtained for the analysis of sediment concentration and particle size are not composited (OWQ Technical Memorandum 76.17; OSW Technical Memorandum 93.01). The cone splitter is used for samples that are split (OWQ Technical Memorandum 80.17). If the total suspended solids (TSS) analytical method is used to determine suspended-sediment concentration (SSC) in a stream, it is GaWSC policy to develop a relation between SSC and TSS by using the guidelines in OSW Technical Memorandum 2001.03 to compute SSC.

Guidelines for the collection and publication of bedload data are provided in OSW Technical Memorandum 90.08. This memorandum supersedes policy and guidelines previously provided in OWQ Technical Memorandums 76.04, 77.07, 79.17, and 80.07, as well as in WRD Technical Memorandum 77.60. Among the policies stated in OSW Technical Memorandum 90.08, which are followed by the GaWSC, is one stating that three cross-sectional methods are used for bedload sampling—the single equal-width increment (SEWI) method, the multiple equal-width increment (MEWI) method, and the unequal-width increment (UWI) method. Additionally, it is stated in OSW Technical Memorandum 90.08 that field personnel are responsible for selecting the procedure that is optimal for the local condition. Bedload samples are analyzed individually in some situations and as a composite in other situations. Until sampling variability for a particular site is understood by those analyzing the data, all samples are required to be analyzed individually.

Project personnel involved in sediment-related hydrologic investigations are responsible for scheduling sediment-collection activities at specific sites. The SWS is responsible for ensuring that GaWSC personnel use correct procedures to collect sediment data. The SWS establishes whether or not correct procedures are being used by conducting periodic reviews of sediment field trips, sample processing, and records computation. Qualified staff remedy deficiencies through in-house training. Questions concerning sediment-sampling techniques should be directed to the SWS or other qualified personnel who have proper training in sediment-related disciplines.

Field Notes

It is GaWSC policy that personnel must fill out note sheets each time a site is visited for the purpose of sediment sampling and complete the note sheet in its entirety before leaving the site. Original observations written on the note sheets are not to be erased; data are corrected by crossing out the original observations and writing the correct information near the original value. The goal of placing information on the field note sheet is to describe the equipment and methods used during the site visit as well as to describe relevant conditions or changes (OSW Technical Memorandum 91.15). For each site visit, information included on the note sheet includes, at minimum, the site identification, field personnel name(s), date, time, sampling equipment, and method, as covered in OSW Technical Memorandum 91.15.

Upon completion of each field trip, field notes are placed in office files for future reference. Data section personnel, other than those who collected the sediment samples, check the field notes.

Equipment Use, Care, and Maintenance

Field personnel who use sediment-sampling equipment are responsible for the care and maintenance of the equipment. Major parts replacement and repair of damaged equipment are accomplished through contracts with the Federal Interagency Sedimentation Program (FISP) in Vicksburg, Mississippi. Minor repairs are made in-house by qualified personnel. The SWS and project personnel are responsible for ensuring that appropriate equipment is used at all sampling sites. Sampling equipment is selected based on the constituents being investigated, the type of analyses that are to be performed, and the site conditions, including velocity and maximum depth of the water. The GaWSC follows equipment-design criteria and guidelines referenced in OSW Technical Memorandum 93.01.

Sample Handling and Storage

The quality of sediment data provided by a sediment laboratory is affected by the quality of the samples received from the field (Knott and others, 1993, p. 2). The GaWSC personnel are required to prepare sample labels, analysis instructions, and sample documentation according to guidelines presented in Knott and others (1993).

Sediment-sample containers and sediment samples are stored in the GaWSC on-site warehouse. Samples are shipped to the appropriate laboratory for sediment analysis. Because sediment-sample containers are glass, they are securely taped and packed for shipment in foam-filled plastic crates to minimize the risk of breakage.

High-Flow Conditions

High-flow conditions at most streams, unless the streams are subject to the effects of backwater, are associated with high-energy conditions. The sediment flux and particle sizes associated with high flows are important factors in sediment studies conducted by the GaWSC. To ensure that field personnel are aware of their responsibilities in obtaining sediment samples at appropriate sites during high-flow conditions, the project and section chiefs involved in sediment studies provide a list of sediment-sampling sites and sampling requirements to appropriate field personnel. These individuals are responsible for ensuring that sediment samples are obtained during opportunities provided by high-flow events and for ensuring that proper sampling equipment and methods are used during high-flow conditions The SWS and qualified project personnel are responsible for answering questions from GaWSC personnel concerning high-flow sampling equipment or sampling procedures.

Cold-Weather Conditions

Sediment-sampling activities in the GaWSC occasionally include obtaining samples during periods of subfreezing temperatures. During cold-weather conditions, field personnel should take every precaution to ensure their personal safety. Additionally, field personnel should attempt to ensure that equipment is not damaged by floating slabs of ice and that nozzles are not clogged with ice crystals.

When floating slabs of ice pose a danger of damaging sampling equipment, such as during spring thaw, field personnel may be able to obtain only surface samples between the floating slabs of ice (Edwards and Glysson, 1988, p. 86). This procedure is noted on the field note sheet and sample label. When anchor ice and frazzle ice are present, it may be necessary to move the sampling equipment quickly through ice crystals to avoid clogging the nozzle. This procedure is also noted on the field note sheets and sample label.

Site Documentation

A station description is prepared for each new sediment-sampling site. At sampling sites where streamflow-gaging activities occur, the description of sediment activities is included in the streamflow-gaging station description in SIMS. A list of elements included in each station description with an explanation of the items included with each element is presented in the attachment to OSW Technical Memorandum 91.15. At sites where only sediment samples are collected, the station descriptions are structured similarly to those for streamflow-gaging stations and contain similar informational items (Kennedy, 1983, p. 2). At sampling sites where gage houses have been installed, station descriptions are kept in the gage house to provide field personnel with information pertinent to sediment-sampling procedures for that particular site. Station descriptions and the five most recent station analyses are included in the field folder and are maintained in the office files. Each description includes specific information explaining where the samples are to be collected and what method is to be used. Recent station analyses contain pertinent information about the sampling conditions and problems that may have been encountered recently.

Field personnel assigned to regularly run specific field trips are responsible for ensuring that field copies of station descriptions and recent station analyses are located at gage houses and kept current. The individual who processes the sediment-station data keeps station descriptions current by periodic review and updates. The section chief, or qualified project personnel, reviews station descriptions and analyses to ensure that they are current. These reviews are made at least once each year. When a deficiency is identified during the review of station descriptions or analyses, the responsible person corrects and documents the deficiency.

At sampling sites with gage houses, logs of sampling activities are maintained. The information recorded in these logs includes the names of individuals who conducted the sampling, dates and times of sample collection, and the project for which the samples were collected.

Processing and Analysis of Sediment Data

Sediment and associated streamflow data are compiled to produce sediment records for specific sites. Data processing of periodic measurements consists of four steps: tabulation, evaluation, editing, and verification (OSW Technical Memorandum 91.15). The GaWSC follows the considerations and guidelines presented in Guy (1969), Porterfield (1972), and OSW Technical Memorandum 91.15 in carrying out these four steps. The GaWSC follows the guidelines and procedures outlined by Rasmussen and others (2009) when computing sediment concentrations using surrogates, such as turbidity or streamflow (OSW Technical Memorandum 2010.01).

The SWS and qualified project personnel are jointly responsible for ensuring that appropriate procedures are applied correctly in processing sediment data. During the time the sediment data are being processed for the year by qualified personnel, field notes and work sheets for each site are maintained in appropriate office files. After the record has been completed, field notes and work sheets are maintained in office archive files.

Sediment Laboratory

The GaWSC has a sediment laboratory, which accommodates limited sediment analyses. If a more detailed sediment analysis is needed, the samples are shipped to the appropriate laboratory for analysis.

Sediment-Station Analysis

A sediment-station analysis is written in SIMS for each sediment station operated by the GaWSC each water year. The sediment-station analysis is a summary of the sediment activities at the station for a given year. The analysis includes the hydrograph coverage of sampling, the types of samples collected and sampling procedures used, changes that might affect sediment transport or the record, and the methods and reasoning used to compute the record. Information included in the sediment-station analysis is presented in a thorough manner that enables the checker and reviewer to determine, from the analysis, the adequacy of the activities in defining the record and accomplishing the objectives defined for the station (OSW Technical Memorandum 91.15).

Elements included in each sediment-station analysis are listed in OSW Technical Memorandum 91.15, including descriptions of the elements and examples. Station analyses are filed in appropriate office files by project personnel and are backfiled every 5 years.

Sediment-Analysis Results

Sediment concentration, sand-silt split, and particle-size data are published in the WDR and also in open-file and interpretive project reports when appropriate.

Sediment-Data Storage

Sediment data collected for the GaWSC are stored both in paper files and in the NWIS Water-Quality (QWDATA) subsystem (OSW Technical Memorandum 2004.01; OSW Technical Memorandum 2010.03). Those responsible for ensuring that the data are processed properly and maintained include the SWS, project personnel, and database administrators. Paper and computer-file records are reviewed on an annual basis, and any discrepancies are resolved among these people.

Database Management

The overall process of storing surface-water data collected at continuous-record gaging stations includes electronic entry of the unit-value stage data by using NWIS, the standard USGS national database; computing corresponding discharge values; computing daily mean discharges based on the unit discharges; and storing the daily means in the NWIS database. In addition, the instantaneous annual peak discharges, associated peak gage heights and peak discharges above base, and the associated gage heights are determined for each gaging station and stored in the peak-flow file.

Ultimately, the Data Chief is responsible for ensuring that surface-water data files are updated and accurate. The Data Chief also oversees all aspects of data entry and data management.

The field person who collects the unit-value data is responsible for entering the data electronically. Depending on the equipment used at each site, the data generally are entered manually, automatically by satellite, or by downloading electronically recorded data on a personal computer or data card.

The Data Chief can delegate the task of entering the unit values electronically to individuals other than those who collect the original data. The person who computes the records is responsible for ensuring that the correct data are contained in the appropriate files for each gaging station and for ensuring that the correct daily mean discharges are stored for each station.

A second individual independently checks to see that the appropriate data are contained in appropriate computer files for each station. The Data Chief assigns a specific individual to be responsible for maintaining the local computer programs and files and for updating the national database.

The SWS is responsible for updating the peak-flow file and ensuring that the data are correct. After streamflow records for a water year have been computed and checked and the data have been finalized, the SWS ensures that the peak-flow file is updated to include the published peak discharges and gage heights for each gaging station for the water year. Following the computer-update procedure, the SWS ensures the correctness of the data by comparing all stored values for the year with the published values.

Publication of Surface-Water Data

The act of Congress (Organic Act) that created the U.S. Geological Survey in 1879 established the Survey's obligation to make public the results of its investigations and research and to perform, on a continuing, systematic, and scientific basis, the investigation of the geologic structure, mineral resources, and products of the national domain (U.S. Geological Survey, 1986, p. 4). Fulfilling this obligation includes the publication of surface-water data and interpretive information derived from the analyses of surface-water data.

Publication Policy

The USGS and WRD have specific policies pertaining to the publication of data and interpretations of data. All WRD personnel, including those of the GaWSC, are required to adhere to these policies. A brief summary of goals, procedures, and policies is presented in U.S. Geological Survey (1986, p. 4–37).

All information obtained through investigations and observations by the staff of the USGS or by its contractors must be held confidential and not be disclosed to the public until the information is made available to all, impartially and simultaneously, by approval of the USGS Director. In some cases, approval for release of information to the public is delegated to the area regional executive (REX) or to the local Science Center Director. Data and interpretive information is released by formal publication or other means of public release, except to the extent that such release is mandated by law (U.S. Geological Survey, 1986, p. 14). With delegated approval, hydrologic measurements resulting from observations and laboratory analyses that have been reviewed for accuracy by designated WRD personnel are excluded from the requirements to hold unpublished information confidential (U.S. Geological Survey, 1986, p. 15).

All interpretive writings in which the USGS has a proprietary interest—including abstracts, letters to the editor, and all writings that show the author's title and USGS affiliation—must be approved by the USGS Director for release to the public. The objectives of the approval review are to final-check the technical quality of the writing and to make certain that it meets USGS publication standards and is consistent with policies of the USGS and Department of the Interior. Approval by the Director or the Director's designee ensures that each publication or document (1) is impartial and objective, (2) has conclusions that do not compromise the USGS's official position, (3) does not take an unwarranted advocacy position, and (4) does not criticize or compete with other governmental agencies or the private sector (U.S. Geological Survey, 2006a).

Types of Publications

Various types of USGS publications are available in which surface-water data and data analyses are presented. Publications in the USGS series include Professional Papers, Scientific Investigations Reports, Scientific Investigations Maps, Data Series, Techniques and Methods (replaces the TWRIs), Circulars, Fact Sheets, General Information Products, Open-File Reports, and Administrative Reports (U.S. Geological Survey, 2003, app. A). Water-resources data, including surface-water data collected by the GaWSC, are published annually in the Water Resources of the United States—Water Data Report (also referred to as the annual data report, or ADR). Currently, the report is accessible online at *http://wdr.water.usgs.gov/*. Factors considered by the GaWSC personnel when choosing the appropriate publication series to use in presenting various types of information are presented in U.S. Geological Survey (2003).

Review Process

The USGS procedures for publication and requirements for manuscript review are summarized in U.S. Geological Survey (2009). It is GaWSC policy to adhere to the USGS requirements for review and approval of reports prior to release to the public. At least two technical reviews are required for each report (U.S. Geological Survey, 2006b). Competent and thorough editorial and technical reviews are the most certain ways to improve and assure the high quality of the final report. Principles of editorial review and responsibilities of reviewers and authors are presented in Moore and others (1990, p. 24–49).

Safety

Performing work activities in a manner that ensures the safety of personnel and others is of the highest priority for the USGS and the GaWSC. Beyond the obvious negative impacts that unsafe conditions have on personnel, such as accidents and personal injuries, unsafe conditions also can have a negative effect on the quality of surface-water data and data analysis. For example, errors are more likely to be made when an individual's attention to important details is compromised by dangerous conditions. To help personnel be aware of and follow established procedures and policies that promote all aspects of safety, the GaWSC communicates current information and directives related to safety to all personnel by in-house training classes, memorandums, and online training courses. Specific policies and procedures related to safety can be found in the GaWSC Safety Plan. The Safety Officer is responsible for ensuring that each employee reads and familiarizes himself or herself with pertinent safety memorandums or manuals and attends required training classes. The GaWSC also has a Safety Committee that is composed of representatives from different sections of the GaWSC Questions or concerns pertaining to safety, or suggestions for improving safety, should be directed to either the Safety Officer or the Safety Committee.

Training

Ensuring that the GaWSC personnel obtain knowledge of correct methods and procedures is a vital aspect of maintaining the quality of surface-water data and data analysis. Providing appropriate training to GaWSC personnel increases the quality of work and eliminates the source of many potential errors. Much of the training provided to GaWSC personnel is on-the-job training provided as a form of mentoring. On-the-job training for new employees is standard protocol. Designees of the Data Chief teach acceptable field practices. In all cases, instructors are experienced and knowledgeable concerning prescribed techniques and proper procedures. Data collected by inexperienced field personnel are closely examined for completeness, accuracy, and adherence to prescribed collection techniques by the SWUC and designated members of the Hydrologic Monitoring and Analysis Section. The intensity of the examinations remains at a high level until such time as the employee is deemed to possess a thorough knowledge of the technical concepts and demonstrates acceptable practical skills.

Other types of training pertaining to data-collection and analysis procedures are accomplished by in-house training by supervisors or specialists, regional training courses, online training courses, or training courses through the USGS National Training Center. The goal of this type and all types of training is to ensure that field and office activities are performed in accordance with specified OSW and WRD standard practices and policies, and that these activities are performed by adequately qualified, experienced, and supervised personnel.

Requests for training and career-enhancement opportunities are discussed at least annually with individuals. The GaWSC Training Officer determines training needs and requests formal training. Each employee receives notifications of regional and national training courses that are available each year. Training courses completed by employees are documented in the Department of Interior's Learning Management System (DOI Learn).

References Cited

Arcement, G.J., and Schneider, V.R., 1989, Guide for selecting Manning's roughness coefficients for natural channels and flood plains: U.S. Geological Survey Water-Supply Paper 2339, 38 p.

Barnes, H.B, 1967, Roughness characteristics of natural channels: U.S. Geological Survey Water-Supply Paper 1849, 3 p.

Benson, M.A., and Dalrymple, Tate, 1967, General field and office procedures for indirect discharge measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A1, 30 p.

Bodhaine, G.L., 1982, Measurement of peak discharge at culverts by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A3, 60 p.

Buchanan, T.J., and Somers, W.P., 1969, Discharge measurements at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A8, 65 p.

Buchanan, T.J., and Somers, W.P., 1968, State measurement at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A7, 38 p.

Carter, R.W., and Davidian, Jacob, 1968, General procedures for gaging streams: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A6, 13 p.

Dalrymple, Tate, and Benson, M.A., 1967, Measurement of peak discharge by the slope-area method: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A2, 12 p.

Davidian, Jacob, 1984, Computation of water-surface profiles in open channels: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A15, 48 p.

Edwards, T.K., and Glysson, G.D., 1988, Field methods for measurement of fluvial sediment: U.S. Geological Survey Open-File Report 86–531, 118 p.

Fulford, J. M., 1994, User's guide to SAC, a computer program for computing discharge by slope-area method: U.S. Geological Survey Open-File Report 94–360, 31 p.

Fulford, J. M., 1995, User's guide to the culvert analysis program: U.S. Geological Survey Open-File Report 95–137, 35 p.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. C1, 58 p.

Guy, H.P., 1970, Fluvial sediment concepts: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C1, 55 p.

Guy, H.P., and Norman, V.W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. 2, 59 p.

Hubbard, E.F., 1992, Policy recommendations for management and retention of hydrologic data of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 92–56, 32 p.

Hubbard, E.F., and Barker, A.F., 1995, Selected surface-water technical memorandums of the U.S. Geological Survey, 1969 to 1995: U.S. Geological Survey Open-File Report 95–354, 497 p.

Kennedy, E.J., 1983, Computation of continuous records of streamflow: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A13, 53 p.

Kennedy, E.J., 1984, Discharge ratings at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A10, 59 p.

Kennedy, E.J., 1990, Levels at streamflow gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A19, 31 p.

Kenney, T.A., 2010, Levels at gaging stations: U.S. Geological Survey Techniques and Methods 3-A19, 60 p.

Kilpatrick, F.A., and Schneider, V.R., 1983, Use of flumes in measuring discharge: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A14, 46 p.

Knott, J.M., Glysson, G.D., Malo, B.A., and Schroder, L.J., 1993, Quality assurance plan for the collection and processing of sediment data by the U.S. Geological Survey, Water Resources Division: U.S. Geological Survey Open-File Report 92–499, 18 p.

Knott, J.M, Sholar, C.J., and Matthes, W.J., 1992, Quality assurance guidelines for the analysis of sediment concentration by the U.S. Geological Survey sediment laboratories: U.S. Geological Survey Open-File Report 92–33, 22 p.

Matthai, H.F., 1967, Measurement of peak discharge at width contractions by indirect methods: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A4, 44 p.

Moore, J.E, Aronson, D.A., Green, J.H., and Puente, Celso, 1990, Report planning, preparation, and review guide: U.S. Geological Survey Open-File Report 89–275, 81 p.

Mueller, D.S., and Wagner, C.R., 2009, Measuring discharge with acoustic Doppler current profilers from a moving boat: U.S. Geological Survey Techniques and Methods 3A-22, 72 p.

Nolan, K.M., Gray, J.R. and Glysson, G.D., 2005, Introduction to suspended-sediment sampling: U.S Geological Survey Scientific Investigations Report 2005–5077.

Novak, C.E., 1985, WRD data reports preparation guide, Water-Resources Investigations, book 3, chap. C3, 66 p.

Porterfield, George, 1972, Computation of fluvial-sediment discharge: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C3, 66 p.

Rantz, S.E., and others, 1982, Measurements and computation of streamflow, volumes 1 and 2: U.S. Geological Survey Water-Supply Paper 2175, 631 p.

Rasmussen, P.P., Gray, J.R., Glysson, G.D., and Ziegler, A.C., 2009, Guidelines and procedures for computing time-series suspended-sediment concentrations and loads from in-stream turbidity-sensor and streamflow data: U.S. Geological Survey Techniques and Methods book 3, chap. C4, 53p.

Sauer, V.B., and Meyer, R.W., 1992, Determination of errors in individual discharge measurements: U.S. Geological Survey Open-File Report 92–144, 21 p.

Shearman, J.O., 1990, User's manual for WSPRO—A computer model for water surface profile computations: U.S. Federal Highway Administration Report, FHWA-IP-89-027, 187 p.

Smoot, G.F., and Novak, C.E., 1968, Calibration and maintenance of vertical-axis type current meters: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. B2, 15 p.

U.S. Geological Survey, 1986, Water Resources Division publications guide, vol. I, Publications policy and text preparation, 2d ed., revised by D.W. Alt and K.T. Iseri: U.S. Geological Survey Open-File Report 87–0205, 429 p.

U.S. Geological Survey, 2003, U.S. Geological Survey Publications Series: U.S. Geological Survey Manual 1100.3, accessed in November 2009 at *http://www.usgs.gov/usgs-manual/1100/1100-3appendixa.pdf*.

U.S. Geological Survey, 2006a, Authority to approve information products: U.S. Geological Survey Manual, 205.18, accessed in November 2009 at *http://www.usgs.gov/usgs-manual/200/205-18.html*.

U.S. Geological Survey, 2006b, Fundamental science practices: Peer review: U.S. Geological Survey Manual 502.3, accessed in November 2009 at *http://www.usgs.gov/usgs-manual/500/502-3.html*.

U.S. Geological Survey, 2009, Fundamental science practices: Review, approval, and release of information products: U.S. Geological Survey Manual 502.4, accessed in November 2009 at *http://www.usgs.gov/usgs-manual/500/502-4.html*.

Appendix 1. U.S. Geological Survey Technical Memorandums Cited

The following technical memorandums are available online at *http://water.usgs.gov/admin/memo/*.

Office of Surface Water (OSW)

OSW Technical Memorandum 2010.03
OSW Technical Memorandum 2010.01
OSW Technical Memorandum 2009.05
OSW Technical Memorandum 2009.01
OSW Technical Memorandum 2008.03
OSW Technical Memorandum 2008.02
OSW Technical Memorandum 2007.01
OSW Technical Memorandum 2006.05
OSW Technical Memorandum 2006.04
OSW Technical Memorandum 2006.01
OSW Technical Memorandum 2005.08
OWS Technical Memorandum 2004.04
OSW Technical Memorandum 2004.01
OSW Technical Memorandum 2001.03
OSW Technical Memorandum 99.06
OSW Technical Memorandum 97.01
OSW Technical Memorandum 96.04
OSW Technical Memorandum 93.07
OSW Technical Memorandum 93.01
OSW Technical Memorandum 92.11
OSW Technical Memorandum 92.10
OSW Technical Memorandum 92.09
OSW Technical Memorandum 92.08
OSW Technical Memorandum 92.04
OSW Technical Memorandum 91.15
OSW Technical Memorandum 91.09
OSW Technical Memorandum 90.10
OSW Technical Memorandum 90.08
OSW Technical Memorandum 90.01
OSW Technical Memorandum 89.07
OSW Technical Memorandum 88.18
OSW Technical Memorandum 88.17
OSW Technical Memorandum 88.07
OSW Technical Memorandum 87.05
OSW Technical Memorandum 85.17
OSW Technical Memorandum 85.14
OSW Technical Memorandum 84.05

Water Resources Discipline (WRD)

WRD Technical Memorandum 2009.02
WRD Technical Memorandum 99.34
WRD Technical Memorandum 95.19
WRD Technical Memorandum 92.59
WRD Technical Memorandum 77.83
WRD Technical Memorandum 77.60
WRD Technical Memorandum 71.73
Memorandum from the Chief,
Branch of Operational Support, May 7, 1993

Office of Water Quality (OWQ)

OWQ Technical Memorandum 80.17
OWQ Technical Memorandum 80.07
OWQ Technical Memorandum 79.17
OWQ Technical Memorandum 77.07
OWQ Technical Memorandum 76.17
OWQ Technical Memorandum 76.04

Appendix 2. Hydrologic Monitoring and Analysis Section—Surface-Water Electronic Archiving

This addendum to the GaWSC Surface-Water Quality-Assurance Plan documents the archiving of electronic files related to surface-water activities of the Hydrologic Monitoring and Analysis Section. All electronic files will be archived, grouped by streamflow-gaging station. The archival structure is documented below.

Archive Directory Structure for Station Description, Station Manuscripts, Station Analysis, and Station Photo Files

The station descriptions, station manuscripts, station analysis, and station photos are stored electronically on the GaWSC computer network.

The directory structure for Station Description Files is:

\groups\sw\Station_Descriptions\YYYY

Where:

YYYY is the water year.

EXAMPLE: *\groups\sw\Station_Descriptions\2008*

Each of the Station Description Files has the following naming convention:

YYYY.sd.station#.pdf

Where:

YYYY is the water year of the station description.

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: The station description for 02335000 Chattahoochee River near Norcross for the 2008 water year will have the file name 2008.sd.02335000.pdf.

The directory structure for Station Manuscript Files is:

\groups\sw\Station_Manuscript\YYYY

Where:

YYYY is the water year.

EXAMPLE: *\groups\sw\Station_Manuscripts\2008*

Each of the Station Manuscript Files has the following naming convention:

YYYY.sm.station#.pdf

Where:

YYYY is the water year of the station description.

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: The station manuscript for 02335000 Chattahoochee River near Norcross for the 2008 water year will have the file name 2008.sm.02335000.pdf.

The directory structure for Station Analysis Files is:

\groups\sw\Station_Analyses\YYYY

Where:

YYYY is the water year.

EXAMPLE: *\groups\sw\Station_Analyses\2008*

Each of the Station Analysis Files has the following naming convention:

YYYY.sa.station#.pdf

Where:

YYYY is the water year of the station description.

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: The station analysis for 02335000 Chattahoochee River near Norcross for the 2008 water year will have the file name 2008.sa.02335000.pdf.

The directory structure for Station Photos Files is:

\groups\sw\Station_Photos\station#

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: *\groups\sw\Station_Photos\02335000*

Each of the Station Photos Files has the following naming convention:

station#_xx.jpg

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

is the photo number.

EXAMPLE: The station photo for 02335000 Chattahoochee River near Norcross will have the filename 02335000_01.jpg.

Archive Directory Structure for Electronic Data Logger (EDL) Data Files

EDL Data Files are stored on the GaWSC computer network, and the directory structure for EDL Data Files is:

/groups/sw/edldata/station#/datalogger/WY2XXX/

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

datalogger is type of datalogger that generated the data file.

WY2XXX is the water year.

EXAMPLE: */groups/sw/edldata/02335450/H510/WY2004/*

Each of the EDL Data Files have the following naming convention:

YYMMDD_station#_datalogger.txt

Where:

YYMMDD is the year, month, and day the edl data file was downloaded.

station# is the unique 8-digit downstream order number for each individual gaging station.

datalogger is the type of datalogger that generated the data file.

EXAMPLE: A edl data file that was downloaded from the 555 at Chattahoochee River above Roswell, GA (02335450) on May 19, 2004, will have the filename 040519_02335450_555.txt and will be placed in the */groups/sw/edldata/02335450/555/WY2004/* folder on the GaWSC computer network.

Archive Directory Structure for ADCP Files

ADCP Measurement Files are stored on the GaWSC computer network, and the directory structure for ADCP Measurement Files is:

/groups/sw/ADCP/station#/measurement#/

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

measurement# is the measurement number of the discharge measurement.

All the files (.mmt, .pd0, LBT.pd0, SBT.pd0, ASC.txt, LBT_ASC.txt, SBT_ASC.txt) associated with the ADCP measurement will be placed in the measurement folder.

The .mmt, .pd0, LBT.pd0, SBT.pd0, ASC.txt, LBT_ASC.txt, and SBT_ASC.txt have the following format:

station#_measurement#.mmt
station#_measurement#_transect#.pd0
station#_measurement#_transect#_LBT.pd0
station#_measurement#_transect#_SBT.pd0
station#_measurement#_transect#_ASC.txt
station#_measurement#_transect#_LBT_ASC.txt
station#_measurement#_transect#_SBT_ASC.txt

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

measurement# is the measurement number of the discharge measurement.

transect# is the transect number.

LBT is loop bed test.

SBT is stationary bed test.

ASC is ascii output.

The .mmt file includes the moving bed test, RGTest, Q measurement summary, and CompCal information. All files should be locked before being archived. The output from the LC.exe program is also stored with the ADCP measurement.

Each of the LC.exe Output Files have the following naming convention:

station#_ measurement#.lcf

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

measurement# is the measurement number of the discharge measurement.

EXAMPLE: A four transect discharge measurement, # 55, with one loop test made at Chattahoochee River near Norcross, GA has the files 02335000_55.mmt, 02335000_55_000.pd0, 02335000_55_001.pd0, 02335000_55_002.pd0, 02335000_55_003.pd0, 02335000_55_000_ASC.txt, 02335000_55_001_ASC.txt, 02335000_55_002_ASC.txt, 02335000_55_003_ASC.txt, 02335000_55_000_LBT.pd0, 02335000_55_000_LBT_ASC.txt, and 02335000_55.lcf. All twelve files are placed in the */groups/sw/ADCP/02335000/55/* folder.

Archive Directory Structure for ADV Files

ADV Files are stored on the GaWSC computer network, and the directory structure for ADV Files is:

/groups/sw/ADV/station#/measurement#/

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

measurement# is the measurement number of the discharge measurement.

All five files (.wad,.ctl,.dat.,.dis,.sum) will be placed in the measurement folder.

The .wad,.ctl,.dat,.dis, and .sum files have the following format:

station#.measurement#.wad
station#.measurement#.ctl
station#.measurement#.dat
station#.measurement#.dis
station#.measurement#.sum

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

measurement# is the measurement number of the discharge measurement.

EXAMPLE: A discharge measurement, # 65, made at Crooked Creek near Norcross, GA has the files 02335350.065.wad, 02335350.065.ctl, 02335350.065.dat, 02335350.065.dis, and 02335350.065.sum. All five files are placed in the */groups/sw/ADV/02335350/65/* folder.

Beamcheck Files are stored on the GaWSC computer network, and the directory structure for Beamcheck Files is:

/groups/sw/ADV/Beamchecks/serial#/

Where:

serial# is the serial number of the ADV.

The output file from the beamcheck is saved in the following format:

serial#.YYMMDDHHMM.bmc

Where:

serial# is the serial number of the ADCP.

YYMMDDHHMM is the year, month, day, hour, and minute the beamcheck was run.

EXAMPLE: A beamcheck that was run on May 19, 2004, at 09:12 using the ADV with a serial number of P589 has the file name P589.0405190912.bmc. This file is placed in the */groups/sw/ADV/Beamchecks/P589/* folder.

Archive Directory Structure for Index Velocity Files

Index Velocity Configuration Files are stored on the GaWSC computer network, and the directory structure for Index Velocity Configuration Files is:

/groups/sw/Index_Velocity_Sites/station#/Config_file/

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: The configuration of the index velocity meter at Chattahoochee River at US 27, at Franklin, GA was saved to a file on May 19, 2004. The configuration file, 040519_02338500_CONFIG.txt, is placed in the */groups/sw/Index_Velocity_Sites/02338500/Config_file/* folder.

The Configuration File for an Index Velocity is saved in the following format:

YYMMDD_station#_CONFIG.txt

Where:

YYMMDD is the year, month, and day the configuration file was saved.

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: A configuration file that was saved on May 19, 2004 at Chattahoochee River at US 27, at Franklin has the file name 040519_02338500_CONFIG.txt

Index Velocity Beam Check Files are stored on the GaWSC computer network, and the directory structure for Index Velocity Beam Check Files is:

/groups/sw/Index_Velocity_Sites/station#/Beam_Check_file/

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: A beam check was saved to a file for the index velocity meter at Chattahoochee River at US 27, at Franklin, GA on May 19, 2004. The beam check file, 040519_02338500.bmc, is placed in the */groups/sw/Index_Velocity_Sites/02338500/Beam_Check_file/* folder.

The Beam Check File for an Index Velocity is saved in the following format:

YYMMDD_station#.bmc
Where:

YYMMDD is the year, month, and day the configuration file was saved.

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: A beam check file that was saved on May 19, 2004, at Chattahoochee River at US 27, at Franklin has the file name 051904_02338500.bmc.

Index Velocity Data Files are stored on the GaWSC computer network, and the directory structure for Index Velocity Data Files is:

/groups/sw/Index_Velocity_Sites/station#/Data_file/

Where:

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: The data from the index velocity meter at Chattahoochee River at US 27, at Franklin, GA was saved to a file on May 19, 2004. The data file, 040519_02338500.arg, is placed in the */groups/sw/Index_Velocity_Sites/02338500/Data_file/* folder.

The Data File for an Index Velocity is saved in the following format:

YYMMDD_station#.arg

Where:

YYMMDD is year, month, and day the configuration file was saved.

station# is the unique 8-digit downstream order number for each individual gaging station.

EXAMPLE: A data file that was saved on May 19, 2004, at Chattahoochee River at US 27, at Franklin has the file name 040519_02338500.arg.

Responsibilities

It is the responsibility of the individual who generates an electronic file to archive the file in a timely manner. Persons who generate edl, measurement, or other applicable files in the field should archive the files according to this addendum within 5 working days of returning to the office. Occasionally, files are created in the office prior to implementation in the field—such files should be archived within 5 working days of their creation.

Appendix 3. Hydroacoustic Instrumentation—Standards, Policies, and Procedures

This addendum to the GaWSC Surface Water Quality-Assurance Plan presents standards, policies, and procedures used by the GaWSC specifically related to hydroacoustic instrumentation. Many standards, policies, and procedures documented in the main body of the Surface-Water Quality-Assurance Plan apply to the use of hydroacoustics. These include, for example, maintenance of gaging-station infrastructure, site documentation, and general records-working procedures. This addendum documents standards that are unique to the hydroacoustic instruments used by the GaWSC. It is expected that this addendum will be updated as the use of hydroacoustics increases and as new instruments, software, and firmware are introduced. This addendum is subdivided by instrument category:

1. Acoustic Doppler current profiler (ADCP or ADP)
2. Acoustic Doppler Velocimeter (ADV)
3. Index-velocity meter

Acoustic Doppler Current Profiler

Acoustic Doppler current profilers are used by the GaWSC to make medium- and high-water discharge measurements. All ADCP operators read and become familiar with the information contained in the following policy memorandums and reports:

- OWS Technical Memorandum 2006.04, Availability of the report “Application of the Loop Method for Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport” by David S. Mueller and Chad R. Wagner (Scientific Investigations Report 2006–5079) and guidance on the application of the Loop Method
- USGS Scientific Investigations Report 2006–5079, Application of the Loop Method for Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport
- OSW Technical Memorandum 2008.02, Upgrade for Rio Grande/Workhorse Firmware to Address Potential Bias in Discharges Measured Using Water Mode 12
- OSW Technical Memorandum 2008.03, Hydroacoustics Work Group—Charter, Membership, and Activities
- OSW Technical Memorandum 2009.02, Release of WinRiver II Software (version 2.04) for Computing Streamflow from Acoustic Doppler Current Profiler
- OSW Technical Memorandum 2009.05, Publication of the Techniques and Methods Report Book 3, Section A22, “Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Bed
- USGS Techniques and Methods Book 3, Section A22, Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Bed

ADCP Quality-Assurance Folder

An ADCP Quality-Assurance Folder is maintained by the designated GaWSC Hydroacoustic Specialist. The folder is placed in the Hydrologic Monitoring and Analysis Section and contains the following:

1. A list of ADCPs and serial numbers
2. ADCP maintenance logs
3. Current firmware and software for each ADCP
4. A list of trained operators in the GaWSC
5. Quality-assurance logs
6. Archival procedures and examples
7. A processing and reviewing guide

Field Procedures

1. Prior to going into the field, the operators ensure that: the ADCP is in working order with the latest approved firmware; their laptop contains the latest approved software; they have sufficient space on the PCMCIA memory card or CD–R; and they have a working laser range finder for measuring edge distances.
2. Each day the ADCP is used, a diagnostic test is performed and the results are recorded. The filename of the diagnostic test is included on notes of any measurement made with the ADCP that day.

3. Prior to each measurement, a moving-bottom check is performed by using the loop method documented in Mueller and Wagner (2005). The moving-bottom check is recorded and archived with the rest of the measurement-data files. The LC.exe program must be used to compute the moving bed adjustment for the loop method test. The program, installation files, and installation instructions can be found at *http://hydroacoustics.usgs.gov/*. If conditions at the site do not allow for the use of the loop method, then multiple (at least three) stationary moving bed tests need to be performed throughout the measuring section. Each stationary moving bed test should be at least 5 minutes if the boat is held stationary by either tether or anchor. However, if the ADCP cannot be held precisely, a moving-bottom check of 10 minutes is needed to differentiate actual boat movement from apparent upstream movement caused by a moving-bottom condition.

4. The water temperature near the ADCP needs to be measured with an independent field thermometer before every measurement to ensure that the thermistor in the ADCP is working properly. If the independent thermometer reading differs from the ADCP water temperature reading by more than 1 degree Fahrenheit, then the ADCP must be sent back to the manufacturer to correct the problem with the thermistor.

5. The estimates used for edge distances shall always be measured. Distance may be measured, using a laser range finder, tag line, or rule.

6. When using an RD Instruments Rio Grande with WinRiver software, operators use the Configuration Wizard to set up the measurement. If any settings other than the Configuration Wizard settings are used, the reasons for the user settings are explained on the measurement note sheet.

7. The depth to the transducer below water surface shall always be verified before each measurement.

8. In accordance with OSW requirements, if all of the first four transects are not within 5 percent of the mean, at least four additional transects shall be made. Note: There are exceptions for unsteady flow.

9. After each measurement, or at least once a day, all measurement data and diagnostic tests are backed up temporarily on a removable medium such as a PCMCIA flash card (recommended), CD–R, or USB memory stick.

Office Post-Field Procedures

ADCP measurements are processed, archived, and reviewed within 5 working days after returning from the field. Data are archived in accordance with the Hydrologic Monitoring and Analysis Section Archiving Addendum. An example of data archival for ADCP measurements can be found in the ADCP Quality-Assurance Folder.

The ADCP operator is responsible for archiving all ADCP measurement and diagnostic files, processing all measurements, entering the measurement data into the database, and finding a trained ADCP operator to review each measurement.

The reviewer of an ADCP measurement is responsible for ensuring that correct methods were used to collect and process the measurements, measurement notes are accurate, measurement data have been archived correctly, and that the measurement notes have been filed. If any changes are made during the review process, the changes should be discussed with the original ADCP operator, the database updated, and measurement notes filed.

Acoustic Doppler Velocimeter

Acoustic Doppler velocimeters (ADVs), designed for use with a standard USGS top-setting wading rod, are used by the GaWSC to make wading discharge measurements. The make and model ADV used for this application is the SonTek® Flowtracker. All Flowtracker operators read and become familiar with the information contained in the following policy memorandum:

- OSW Technical Memorandum 2004.04, Policy on the Use of the Flowtracker for Discharge Measurements
- OSW Technical Memorandum 2007.01, SonTek/YSI FlowTracker firmware version 3.10 and software version 2.11 upgrades and additional policy on the use of FlowTrackers for discharge measurements
- OSW Technical Memorandum 2009.04, Application of FlowTracker firmware and software mounting correction factor for potential bias

Field Measurements

1. Prior to use of the Flowtracker, the users familiarize themselves thoroughly with the instrument by reading the Flowtracker Handheld ADV Technical Documentation, including the Introductory Documentation, Operation Manual, and Principles of Operation. Users also familiarize themselves with the Flowtracker handheld controller, including all keypad operations, prior to collecting field data.

2. Prior to and after a field trip, the users perform a full diagnostic test on the ADV, called a beamcheck, using the manufacturer's Flowtracker Software. The test procedures are described in the Flowtracker Operations Manual. The software displays signal-strength plots for each ADV receiving transducer. The Flowtracker Operations Manual describes the beamcheck and provides examples of good and problem signal-strength plots. If signal-strength plots indicate a possible malfunction, the Flowtracker is not used to collect field data. In all instances every diagnostic test is logged to a file, and the filename is noted on the measurement note sheet. All diagnostic files are archived electronically. In the event of an instrument malfunction, diagnostic files can be provided to the manufacturer for troubleshooting. If a malfunction is suspected or if there has been a shock to the probe (such as striking a hard object), a beamcheck is performed prior to further collection of field data.

3. Prior to each discharge measurement or velocity-collection run, the user checks the ADV, using the hand-held controller Systems Functions Menu. The following items are checked:

    - *System clock.* The clock displays the correct date/time.
    - *Recorder status.* There is adequate data-storage capacity for the discharge measurement or velocity data run.
    - *Temperature data.* The ADV probe is immersed in the stream and the temperature noted. At least once daily, the temperature recorded by the ADV is checked against a temperature reading from an independent source, such as a digital thermometer. It is very important for velocity and discharge accuracy for the ADV to record water temperature accurately. A 5-degree (Celsius) error in temperature would result in a 2-percent error in the velocity and discharge measurement. The user ensures that the temperature has stabilized prior to start of data collection. The temperature is noted on the discharge measurement note sheet. If the independent thermometer reading differs from the ADV water temperature reading by more than 1 degree Fahrenheit, then ADV must be sent back to the manufacturer to correct the problem with the thermistor.
    - *Battery data.* Battery voltage is checked to ensure adequate capacity for the discharge measurement or velocity data run.
    - *Signal-to-noise ratios.* The Flowtracker technical memorandum recommends that SNRs be greater than 10. Analysis of field data indicates that SNRs can be as low as 4 and adequate data still can be collected. However, data collected with SNRs below 10 are scrutinized carefully, using other quality-assurance parameters described in the Measurement Quality-Assurance section of this memorandum. If low SNRs appear to be causing data-quality problems, a different measurement section might be investigated. Back-scatter can change with measurement location.

4. If the Flowtracker is being used in water other than freshwater, the salinity at the data-collection location is measured with an approved sensor, and the measured salinity is entered in the handheld controller Setup Parameters Menu. A 12 parts-per-thousand error in salinity can result in a 2-percent error in velocity and discharge measurement.

5. The Flowtracker is designed for mounting on a standard top-setting wading rod. It is recommended that an offset bracket available from the Flowtracker manufacturer be used to mount the Flowtracker probe head to the wading rod. Without the bracket, the Flowtracker sample volume is located about 4 inches from the wading rod. With the bracket, the sample volume is located about 2 inches from the wading rod, closer to the point of depth measurement. The bracket was designed to move the sample volume as close to the wading rod as possible while remaining outside the flow disturbance caused by the wading rod.

6. When mounting the Flowtracker, special care is taken to protect the cable from abrasion. The cable is very prone to environmental noise that can degrade measurement quality.

7. The Flowtracker probe head should be oriented so that the longitudinal axis passing through the center transmitting transducer is parallel to the tagline, and the receiving arm with the red band should be downstream. Effort is made to hold the wading rod level so that the sample volume does not strike a boundary. Pay close attention to the flow angle reported by the Flowtracker.

8. To avoid striking a boundary, the user should have a sense of where the sample volume is located. The sample volume should be more than 2 inches from any boundaries. If a boundary cannot be avoided and a point velocity measurement has to be made less than 2 inches from a boundary, then the point velocity measurement should be scrutinized carefully and quality-assurance parameters should be used to assess the quality of the measured velocity.

9. All policies and recommendations for making wading discharge measurements with Price-type current meters are followed when using Flowtrackers, with the exception of the minimum recommended velocity thresholds and the application of alternative means of measuring velocities in the vertical (Rantz, 1982, p. 132).

10. The minimum recommended velocity threshold for the Flowtracker is 0.1 ft/s; the instrument velocity error at 0.1 ft/s is about 4 percent. If measured velocities are less than 0.1 ft/s, the measurement should not be rated better than "fair."

11. The one-point (0.6 times depths) vertical-velocity method is used for depths equal to or less than 1.5 feet. For depths greater than 2.5 feet, the two-point (0.2 and 0.8 times depth) method is used. If the depths are between 1.5 and 2.5 feet, then either the one-point or two-point method is used. The method to use in this range depends if velocity follows a standard profile. If, when using the two-point method, the 0.2 measured velocity is less than the 0.8 velocity, or if the 0.8 velocity is less than half of the 0.2 velocity, the handheld controller screen informs the user, and the user then has the option to measure the velocity at the 0.6 position (three-point method). The user, in this situation, should measure velocity at the 0.6 position.
12. Special care is taken with the Flowtracker to protect the probe head. If the probe receiver arms are bent or the transducers scratched, the unit is no longer usable and needs to be repaired by the manufacturer. The unit always should be transported by securing it in the manufacturer's carrying case to prevent damage. Other maintenance considerations included Operator's Manual also are followed.
13. It is recommended that measurement files recorded on the handheld controller be downloaded at least once a day for backup purposes.
14. Standard USGS measurement notes may be used to document the discharge measurement.
15. If a discharge measurement made with a Flowtracker warrants a check measurement, then the check measurement should be made with a conventional meter, such as the Price AA or pygmy current meter.

Measurement Documentation

For each measurement run of discharge or velocity, a file with a .WAD extension is generated and stored on the handheld controller. The .WAD file is downloaded from the controller, then the Flowtracker software is used to extract four files from the .WAD file:

1. .CTL file — an ASCII file containing the Flowtracker configuration.
2. .DAT file — an ASCII file containing 1-second velocity component and signal-to-noise ratios.
3. .SUM file — an ASCII file containing station information and summary statistics from each measurement.
4. .DIS file — an ASCII file containing a discharge-measurement summary.

A paper copy of the .DIS file is printed and attached to the measurement note sheet for filing. All four extracted electronic files plus the .WAD file are archived permanently as specified in the Hydrologic Monitoring and Analysis Section Surface-Water Electronic Archiving appendix. The .WAD file contains important data that are not extracted with any of the four files and could be valuable for instrument diagnostics in the event of malfunctions.

Measurement Quality Assurance

The following is a list of recommendations for using Flowtracker parameters to help assess the quality of discharge measurements. These parameters are not available with Price-type meters. Guidelines for using the parameters are:

- *Velocity standard error.* If the average standard error for the measurement exceeds 8 percent of the mean measurement velocity, the measurement should be rated no better than "fair." If the standard error exceeds 10 percent of the mean measurement velocity, the measurement should be rated no better than "poor."
- *Boundary flag.* There are four possible boundary flags assigned to each station: "best," "good," "fair," and "poor." A boundary flag of "best" does not guarantee a lack of boundary interference (see the Flowtracker Technical Documentation). If the ADV sample volume was striking a solid boundary, a "best" flag likely still would be displayed, but the measured velocity could be biased toward zero.
- *Velocity spikes.* An excessive number of velocity spikes (more than 10 spikes per measurement) could be cause to downgrade the measurement.
- *Flow angles.* A good measurement section typically shows some flow-angle variations, but with angles less than 20 degrees.

Periodic Quality-Assurance Checks

Each Flowtracker must be checked for discharge-measurement accuracy at least annually and also after any hardware or firmware changes. The check consists of making a discharge measurement at a site where the Flowtracker-measured discharge can be compared with a known discharge derived from some other source. Appropriate sources of comparison discharge would be discharge obtained from a stable discharge rating, or discharge measured with a second Flowtracker or mechanical meter known to meet USGS calibration standards.

Index-Velocity Meter

The GaWSC uses acoustic Doppler velocity meters (ADVMs) installed at gaging stations to index mean channel velocities for the computation of records of discharge.

Personnel who use index-velocity instruments for the production of discharge records obtain training by attending the Office of Surface Water class "Streamflow Records Computation using Hydroacoustic Current Meters and Index-Velocity Methods" that is offered periodically.

Installation

1. A thorough site reconnaissance is required prior to installation of an index-velocity meter at an existing gaging station or establishment of a new index-velocity-meter station. The site reconnaissance includes channel surveys and the collection of velocity and temperature profiles. The channel bed is characterized for stability. The site hydraulics are analyzed carefully for factors that potentially could cause rating instabilities. Other considerations include protection of the instrument, power/communications cable-length limitations, and adequate power supply. The data collected from the reconnaissance are used to ascertain the success of using an index-velocity meter. For ADVMs, aspect ratios (range/depth) and bridge-pier wake-turbulence zone can be computed to see if the ADVM sample volume will reach a zone of stable velocities.

2. Gage-site-selection criteria documented in Rantz and others (1982, p. 5–9) remain applicable for index-velocity sites.

3. The index-velocity-meter deployment program is recorded and archived. If the index-velocity-meter deployment program can be saved, the deployment program is archived. Some index-velocity-meter programs cannot be saved directly. In these instances, a screen capture of the instrument deployment can be used to save the program parameters. A paper copy of the pertinent parameters is placed in the gage-house folder.

Field Procedures

The following procedures are followed during visits to stations equipped with index-velocity meters:

1. A temperature reading from an independent source, such as a digital thermometer, is taken near the instrument. The temperature is recorded in the field notes along with the time of the reading. If the independent thermometer reading differs from the ADVM water temperature reading by more than 1 degree Fahrenheit, then ADVM must be sent back to the manufacturer to correct the problem with the thermistor.

2. For ADVMs, a beam-amplitude diagnostic test is run and logged in a file. All such files are archived according to the Hydrologic Data Section Surface-Water Electronic Archiving appendix. Beam-amplitude checks are an invaluable diagnostic and quality-assurance tool. The beam-amplitude checks must show that the ADVM sample cell is free of obstructions and is sized so that beam amplitudes at the end of the sample cell are a minimum of 5 counts above the instrument noise level. If these criteria are not met, the ADVM sample cell must be adjusted until the requirements are met. All sample-cell changes must be noted on the station log and in field notes and the new instrument deployment saved. If the sample-cell size changes significantly, a new index-velocity rating likely is needed.

3. If the gage does not have data telemetry or if all logged parameters are not transmitted, the datalogger data are downloaded for each site visit and the data are input to NWIS at the office.

4. At least once annually, the standard cross section is checked to ensure that the channel geometry has not changed significantly. For channels with known scour or fill potential or for channels with the potential for dredging, the standard cross section may need to be checked more frequently. If possible, discharge measurements can be made at the standard cross-section location. The advantage of this approach is that for every measurement, the standard cross section is checked.

5. The frequency of discharge measurements is dictated by stability of the stage-area and index-velocity ratings and by the range of measurements used to define the ratings. Changes in index-velocity instrumentation or changes to existing instrument program parameters (for example, ADVM sample-cell-size changes) likely necessitate the need for a new index-velocity rating and, hence, more-frequent measurements to establish the new rating. It may be possible to reduce measurement frequency once stable ratings have been established for a wide range of flows. All sites, however, must be measured at least two times a year.

Data Quality Assurance

All data quality parameters available are used to assess the quality of the velocity (and stage) record used to generate discharge records. For ADVMs, these parameters can include cell end, velocity standard deviation, velocity y-component, water temperature, and signal strength (average backscatter amplitude). Unit-value plots are valuable for examining these quality-assurance parameters.

Discharge Computation

The same general USGS policies and recommendations that apply to stage-discharge methods used to produce discharge records apply to index-velocity methods. Thus, guidelines for the production of streamflow records presented in the section entitled Processing and Analysis of Streamflow Data outlined in the GaWSC Surface-Water Quality-Assurance Plan apply to index-velocity methods. Polices and recommendations regarding stage data, such as the editing or deleting of unit values, apply to velocity unit values as well. Likewise, guidelines for records documentation—including the station analysis, daily values tables, and other supporting materials—are applicable to index-velocity records.

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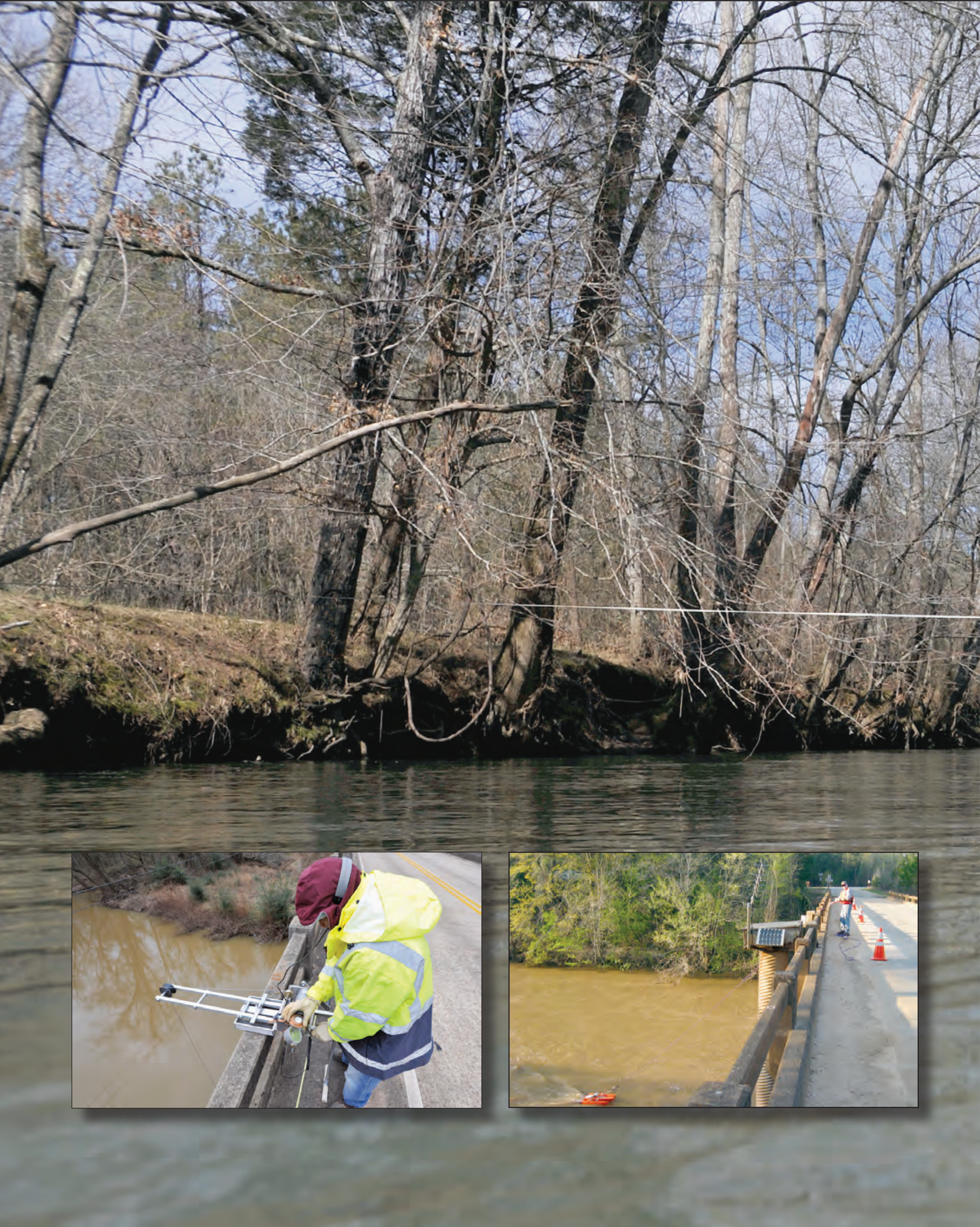

Gotvald, A.J.—**Surface-Water Quality-Assurance Plan for the U.S. Geological Survey Georgia Water Science Center, 2010**—Open-File Report 2010–1263