Surface-Water Quality-Assurance Plan for the USGS Georgia Water Science Center

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U.S. Department of the Interior
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Cover photograph: U.S. Geological Survey Hydrologic Technician making a streamflow measurement from the Georgia Highway 124 bridge over the Yellow River.

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Contents

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Abstract

The U.S. Geological Survey (USGS), Water Resources Discipline, has a policy that requires each Water Science Center (WSC) to prepare a Surface-Water Quality-Assurance Plan. The plan for each WSC describes the policies and procedures that ensure high quality in the collection, processing, analysis, computer storage, and publication of surface-water data. The USGS Georgia Water Science Center (GWSC) Surface-Water Quality-Assurance Plan documents the standards, policies, and procedures used by the GWSC for activities related to the collection, processing, storage, analysis, and publication of surface-water data.

Introduction

The U.S. Geological Survey (USGS) was established by 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 USGS Georgia Water Science Center (GWSC) are part of the Water Resources Discipline's (WRD) overall mission of appraising the Nation's water resources. Surface-water information—including streamflow, stage, and sediment data—is used at the Federal, State, and local levels for resources planning and management.

This GWSC Surface-Water Quality-Assurance Plan (QA Plan) documents the standards, policies, responsibilities, and procedures used by the GWSC for activities related to the collection, processing, storage, analysis, and publication of surface-water data.

The GWSC conducts surface-water data-collection activities through 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 QA Plan identifies individual responsibilities for ensuring that stated National policies and procedures are followed. The plan also serves as a guide for all GWSC 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 the policies and procedures followed by the GWSC for the collection, processing, analysis, storage, and publication of surface-water data. Specific types of surface-water data include stage, streamflow, precipitation, sediment, and basin characteristics. In addition, issues related to the management of the computer database and employee safety and training are presented. Although procedures and products of interpretive projects are subject to the criteria presented in this report, specific interpretive projects are required to have a separate and complete QA Plan.

This QA Plan is reviewed and revised at least once every 3 years in order that responsibilities and methodologies are kept current and in order for the ongoing procedural and instrumentation improvements to be 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 GWSC. Much of the responsibility rests with the field offices and the Hydrologic Monitoring and Analysis Section; however, the GWSC Director ultimately is responsible for quality assurance. The following list summarizes responsibilities of the GWSC personnel involved in the collection, processing, storage, analysis, or publication of surface-water data.

The GWSC Director is responsible for:

1. Managing and directing the GWSC program, including all surface-water activities.
2. Ensuring that surface-water activities in the GWSC meet the needs of the Federal Government, the GWSC, 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 the GWSC personnel. This is accomplished by the GWSC Director's direct involvement or through clearly stated delegation of this responsibility to other personnel in the GWSC.
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 GWSC are accurate and are in accordance with USGS policy.
6. Implementing USGS and GWSC safety policies.

The Chief of the Hydrologic Monitoring and Analysis Section (Data Chief) is responsible for:

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

The Surface-Water Specialist (SWS) is responsible for:

1. Assuring that proper methods are used for collecting all types of surface-water data in the GWSC.
2. Performing checks of individual personnel for proper field and data-collection procedures.
3. Assuring that GWSC surface-water programs and projects are planned to provide efficiently and effectively information required to solve high-priority local or National water problems.
4. Working with the Data Chief by evaluating surface-water data collection and analysis methods that are applied in the GWSC and discussing needed improvements in those methods with the Data Chief.
5. Reviewing all indirect streamflow measurements performed by the GWSC and annually reviewing a portion of the surface-water records.

The Surface-Water Unit Chief (SWUC) is responsible for:

1. Examining data collected by field personnel for completeness, accuracy, and adherence to prescribed collection techniques.
2. Providing training in data collection, analysis procedures, and instrumentation to individuals assigned to their field office.
3. Ensuring that field visitations are scheduled to allow for adequate numbers of measurements to promote the 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 the GWSC as implemented by the GWSC Director.
5. Ensuring that data collected by the unit are computed, reviewed, and checked in a timely manner so that the data are available in final form 3 weeks ahead of the GWSC annual data-report publication target date.
6. Performing intensive examinations of employee's data collection and field procedures to ensure that the employee possesses a thorough knowledge of technical concepts and demonstrates acceptable practical skills.

The Hydroacoustic Specialist is responsible for:

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

Field Personnel are responsible for:

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

The Safety Officer is responsible for:

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

Overall responsibilities of personnel in Hydrologic Monitoring and Analysis Section:

1. Understanding and following the policies and procedures presented in this report.
2. Collecting, processing, analyzing, storing, and preparing for publication surface-water data 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 streamflow-gaging stations (referred to hereinafter of this report as gaging stations) and other water-resource studies performed by the USGS and the GWSC.

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 is obtained by installing instruments that sense and record water-surface elevation of the stream. 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 that relation.

It is the policy of the GWSC that all personnel involved in the data-collection activities are in conformance of the WRD guidelines pertaining to the collection of stage and streamflow data. All employees are informed of and follow the surface-water data-collection policies and procedures established by WRD. The highest priority in collecting streamflow data is employee safety.

Gage Installation and Maintenance

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

Sites for installation of gaging stations are selected with the intent to meet the purpose of each specific gage. 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 the means for efficient access to the gage and measuring location. Other aspects of controls considered by GWSC personnel when planning gage-house 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 discussion with cooperators on the purpose of the gage, analysis of terrain with the use of topographic maps, field reconnaissance, evaluation of types of installation and equipment options, and a file search to determine if discontinued stations or partial record stations existed 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 gages, and inspection and approval of the completed installation.

A program of careful inspection and maintenance of gages and gage houses promotes the collection of reliable and accurate data. Allowing the equipment and structures to fall into disrepair can result in unreliable data and safety problems. It is GWSC policy that a visual inspection is performed at sites by field personnel during each site visit by comparing the inside and outside gage readings. In addition, all equipment is inspected to ensure that everything is operating properly. The inspection of equipment includes battery condition, structural stability, locking mechanisms, and the general working order of the gage. Inspection of the data collected at a streamflow-gaging station is an important means of ensuring accurate gage data records.

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

It is the responsibility of each field person to correct gage deficiencies immediately. If conditions cannot be corrected on site, then the immediate supervisor should be notified, and that person is responsible for initiating a plan of action. Plans are to be made to restore the record of the stage at the earliest possible time.

Measurement of Stage

Many types of instruments are available and are always improving to measure the water level or stage at gaging stations. There are nonrecording gages (Rantz and others, 1982, p. 24) and recording gages (Rantz and others, 1982, p. 32). Because the uses to which stage data may be used cannot be predicted, it is OSW policy that surface-water stage records be collected at stream sites having instrumentation and procedures to provide sufficient accuracy supporting computation of discharge from a stage-discharge relation, unless greater accuracy is required (OSW Technical Memorandum 93.07). Office of Surface Water technical memorandums from 1969 to current may be found online at the OSW Web page *http://water.usgs.gov/osw/*.

In general, operation of gaging stations for the purpose of determining daily discharge includes the goal of collecting stage data at the accuracy of ±0.02 foot (OSW Technical Memorandum 93.07). In these situations where lower accuracy is acceptable, the project proposal or station descriptions and analyses 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 types of instrumentation installed at any specific gage house operated by the GWSC 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 would influence the data-collection process. Types of water-level recorders operated by personnel in the GWSC include Vaisala 555; Handar 550, 560, and 570; and Design Analysis H350, H350XL, and H510. The devices used to sense stage at Georgia stations are H350/H355 and H350XL/H355 bubbler systems, Vaisala 436B and 436BD shaft encoders, Design Analysis H510 shaft encoders, and Design Analysis H360 radar sensors.

The Data Chief or SWUC is responsible for determining what type of water-level recorders and at what data collection increment that they are operated at for each gaging station. The Data Chief or SWUC is responsible for ensuring that new equipment has been installed correctly. Field personnel who service the gage proper are responsible for maintenance of gage instrumentation or replacement, if appropriate, of equipment.

Accurate stage measurement requires not only accurate instrumentation but also proper installation and continual monitoring of all system components to ensure the accuracy does not deteriorate with time (OSW Technical Memorandum 93.07). To ensure that instruments, located within the gage house, record water levels that accurately represent the water levels of the body of water being investigated, "inside" and "outside" water-level readings are obtained by independent means and are compared to the designated reference gage, as described in the station description and/or station analysis. The inside gage readings do not necessarily always equal outside readings, especially if the gages are not in the same pool at all ranges of stage. However, this situation is avoided in the GWSC when possible. At stations equipped with a stilling well, the base or reference gage usually is an instrument installed inside the gage house, and other gages are installed outside the gage house to indicate whether or not the intakes are operating properly (Rantz and others, 1982, p. 53 and 64).

At stilling well sites, the float-tape pointer serves as the reference gage. The readings from the float-tape pointer and shaft encoder should always be equal. If these values are not equal, then 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 the levels indicate that the float-tape indicator is reading incorrectly.

At bubbler system sites, the outside gage serves as the reference gage and is used to calibrate the reading of the bubbler system. Outside gages include a wire-weight gage, a staff plate, or a reference point (RP). The readings from the bubbler system do not necessarily 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 read 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 the 9-207 form. A failure in the consistency of readings usually indicates a failure of the system, and the system should be investigated. The outside gage should not be reset unless levels are run at the site and the levels indicate that the outside gage is reading incorrectly.

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

Field personnel for 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 the gages at the time the equipment was installed 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, the field personnel are to correct the deficiency by their own initiative or receive specific instruction from the SWUC. Individuals who have questions related to the calibration and maintenance of water-level recorders should contact the Data Chief, SWUC, and/or SWS. The standard procedures for documenting corrections to gage height data are covered in OSW Technical Memorandum 91.09.

Field personnel should carry equipment for most repairs. In the event that expensive dataloggers are needed for repair, the field person should contact the office and advise the SWUC of the need for equipment for repairs. Personnel who have questions related to the calibration and maintenance of water-level recorders should contact 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 base gage unless a lower accuracy standard has been set and documented for that site.

Field personnel do not reset gages in adverse conditions, such as surging wells, high-flow stages, or ice in the stilling well. It is important that bubbler gages are not reset during high flow in order to avoid reset errors that might be caused by the effects from drawdown. At stilling wells where data recorders are driven by floats with steel tapes, peak-stage indicator clips are attached to the steel tapes to identify or confirm maximum stages. It is the responsibility of the field person who inspects the gages to ensure that the peak-stage indicator clips are read and reset during each site visit. The clip readings are written on the field note sheet. At bubbler system sites, a Crest-Stage Gage (CSG) should be installed to verify the peak stage. It is the responsibility of the field person to check the CSG intakes and ground-cork level to ensure that all peaks are recorded.

Most of the basic concepts and procedures used in surface-water data collection activities are presented in the three “Techniques of Water-Resources Investigations of the U.S. Geological Survey” (TWRI) series chapters entitled “General Procedures for Gaging Streams,” “Stage Measurements at Gaging Stations,” and “Discharge Measurements at Gaging Stations.” A number of the important aspects contained in these references are enumerated and reinforced here. Generally, all surface-water data collection activities are in accordance with procedures as outlined in the TWRIs (Hubbard and Baker, 1995). For data collection activities not adequately covered by written instruction, supervisors only assign personnel who are capable through unique experience and/or special training.

On-the-job training of new employees is standard. 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 possesses a thorough knowledge of technical concepts and demonstrates acceptable practical skills.

Gage Documents

It is GWSC policy that certain documents are placed in each gage house for the purpose of keeping an on-site record of observations, equipment maintenance, structural maintenance, and other information helpful 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 listing 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 clipboard containing a copy of previous gage inspection sheets; (5) important telephone numbers; (6) a bridge-safety plan; and (7) a job-hazards analysis. Each gage is a representation 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 also keep the gage-house exterior and surrounding area neat in appearance.

During a gage inspection, all gage readings are noted on a triplicate inspection sheet or the measurement note sheet. The triplicate inspection sheet is a carbon-copy document that imprints the readings of the first sheet onto the second and third sheets. The second sheet or yellow sheet is kept in the station field folder. The third or pink sheet is kept in the gage house.

The field person who runs the field trip regularly is 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 on an inspection sheet and uses this note as a reminder to bring the documents on the next field trip. Individuals having questions related to what 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 contact the Data Chief or SWUC.

Levels

The various instruments at a gaging station are set to register the altitude of a water surface above a selected level reference surface called the gage datum. The gage's supporting structures—such as stilling wells, backings, shelters, bridges, and other type structures—tend to settle or rise as a result of earth movement, static or dynamic loads, vibration, or battering by floodwaters and flood-borne debris. Vertical movement of a structure makes the attached gages read too high or too low and, if the errors go undetected, may 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 the gages and to 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 for the purpose of determining if any datum changes have occurred (Rantz and others, 1982, p. 545).

It is GWSC policy that levels are run at newly installed gaging stations either at the time of construction or within 6 weeks of when record collection begins. Levels are run to established gaging stations once every 3 years or more often as conditions warrant as covered by TWRI, book 3, chap. A19, "Levels at Streamflow Gaging Stations," Kennedy (1990, p. 14), and OSW Technical Memorandum 90.10. Gages are reset to agree with levels when the levels indicate at least a 0.02-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 on level field notes and/or miscellaneous note sheets. Standard field note forms indicate the information requirements for routine operational activities, such as current-meter discharge measurements and stream-gage recorder servicing. However, supplemental notes are required for reporting unusual conditions, deviations from standard practice, personal judgments, and all other information that may be of subsequent value.

Field notes identify procedures, specifications, and regulations 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.

All field measurements and observation notes are recorded in an acceptable format as a permanent record. Field notes are neat, readable, and leave no doubt about interpretation. The level notes need to include a sketch that shows the location of the reference marks, reference points, outside gage, and gage house. The level notes also need to contain a clear and detailed written description of the location of the reference marks and points. All information is recorded as it is collected and never documented from memory.

Levels are run by use of field methods and documentation methods described in Kennedy (1990) and in TWRI, book 3, chap. A19. Level procedures followed by GWSC personnel pertaining to circuit closure, instrument reset, and repeated use of turning points are described in Kennedy (1990), in OSW Technical Memorandum 93.12, and in TWRI, book 3, chap. A19. The level instruments are kept in proper adjustment by proper care and handling of equipment. Annual peg tests are performed and documented and any corrections made are noted on the peg-test form. 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.

The field person and SWUC are responsible for ensuring that field level notes are checked. Field personnel involved in running the levels enter the level information in the level-summary form; this information is checked during the station analysis procedures for the year. The field person and SWUC are responsible for ensuring that levels are run correctly and that all level notes are completed correctly. The SWUC is the 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 form of a station description 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 GWSC policy that the station description is written 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. Station descriptions are reviewed each year during the annual station analysis report process and are updated as needed.

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 gage structure, descriptions of control, statements on measurement cross sections, information on extremes of stage, datum of gage, elevations of reference marks, and a photocopy of an area map. Also included is other helpful information about observers, regulation or diversion of flow, and anything that will assist in collection of data under various conditions and ranges of flow. A digital copy of the most recent station description for each site is kept on the GWSC computer network.

Photographs

Photographs of gaging stations and control sections are made by field personnel for the purpose of documentation. Additional reasons to take photographs in the field are: gage-house construction; damage to gage structures or equipment resulting from storms, floods, or vandalism; significant changes in control conditions; or supplements to various forms of written description. 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 GWSC in data-collection activities.

Historic photographs are backfiled in the historic-site files. Photographs taken with a digital camera are kept on the on the GWSC computer network. In this Archive Station Photos folder, there is a site folder for each station. Only those photographs that are important to the gage record are kept.

Direct Measurements

Direct measurements of discharge are made with any one of a number of methods approved by WRD. The most common is the current-meter method.

A current-meter measurement is the summation of the products of the subsection areas of the stream cross section and their respective average velocities (Rantz and others, 1982, p. 80). Rantz and others (1982, p. 139); Carter and Davidian (1968, p. 7), and Buchanan and Somers (1969, p. 1) described procedures used for current-meter measurements.

When personnel make measurements of stream discharge, attempts are made to minimize errors. Sauer and Meyer (1992) identified sources of errors. These include 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. These 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.

GWSC policies related to the measurement of discharge by use of the current-meter method, in accordance with WRD policies, include the following. Current meter discharge measurements are computed in the field and checked against the current rating curve. If the measurement exceeds normal tolerance or differs substantially from recent trends in measured discharge, a check measurement is made, computed, and also checked against the rating curve. The check measurement must be made with a different current meter than the one used for the original measurement. Normal tolerance is generally 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.

In order to ensure and document the accurate performance of meters used to make streamflow discharge measurements, the GWSC uses care and maintenance procedures and spin-test documentation as recommended by 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 field offices.

Depth criteria for meter selection—GWSC personnel 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 those 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 those meters are to be maintained and spin tested according to policies described in the "Acceptable Equipment" section of this QA Plan. For a conventional 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 sample is taken at 0.6 total depth. When depths are greater than 2.5 feet, then 0.2 and 0.8 samples are taken. These guidelines all assume a standard velocity profile.

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, the 0.2, 0.6, and 0.8 velocity measurements all must be taken. When average depths are less than 1.5 feet, the pygmy current meter is used. Field personnel of the GWSC make their meter selection for specific measurement conditions based on guidance provided by information found in OSW Technical Memorandum 85.14, Buchanan and Somers (1969), and Rantz and others (1982).

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

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). GWSC criteria are that observations of depth and velocity be made at a minimum of about 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, the 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 maintained, such as for measurements during rapidly changing stage (Rantz and others, 1982, p. 174). Fewer verticals than are ideal are sometimes 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 GWSC policy that WRD and OSW techniques and guidelines are followed when discharge measurements are made with any selected method. These methods include using the Acoustic Doppler Current Profiler (ADCP). The GWSC uses ADCPs that are manufactured by RD Instruments to make discharge measurements at sites that are applicable for the use of ADCPs. The ADCP methods used are in accordance with USGS standard procedures and are documented as described by (Lipscomb, 1995) along with OSW Technical Memorandums 2002.01 and 2002.02, along with the report *Quality Assurance Plan for Discharge Measurements Using Broadband Acoustic Doppler Current Profiler* (Lipscomb, 1995). Most of that report is applicable for policies and guidance on the use of ADCPs for discharge measurements. However, that report is under revision, so the OSW technical memorandums add additional policies and guidance in areas were the report is outdated. Personnel collecting and reviewing ADCP data for discharge measurements must have completed the USGS training class *Measurement of Streamflow using ADCPs*. The GWSC has implemented a separate QA Plan for Hydroacoustics, which includes the use ADCPs for measuring discharge. Appendix C contains the GWSC QA Plan for Hydroacoustics.

The GWSC also uses Acoustic Doppler Velocimeters (ADVs) that are manufactured by SonTek® to make discharge measurements at sites that are applicable for the use of ADVs. The ADV measurements are in accordance with OSW Technical Memorandum 2004.04. The use of ADVs is also included in the GWSC Hydroacoustics QA Plan, which is contained in Appendix B. Personnel using ADCPs and ADVs must read and become familiar with the GWSC Hydroacoustics QA Plan.

Volumetric techniques and methods involving portable weirs and flumes are rarely used. However, when volumetric techniques are used, then they are made in accordance with prescribed procedures as covered by Rantz and others (1982), Buchanan and Somers (1969), and Kilpatrick and Schneider (1983).

Computation of mean gage height—GWSC personnel use 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 a first 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. 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 somewhat permanent changes in the control are observed.

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 another cross-section location for wading measurements, using another meter, using verticals offset from the locations of the original verticals used for a bridge measurement, using spin tested meters, and using other such procedures.

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—Personnel who have questions concerning the appropriate procedures for making stage and discharge measurements should address their questions to the 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 record discharge measurements on measurement form series 9-275 (typically 9-275-F or 9-275-G). Notations are made in the manner presented in Buchanan and Somers (1969, p. 2). Original observations, once written on the note sheet, are not erased. Original data are corrected by crossing the value out, then writing the correct value. Some examples of original data on a discharge-measurement note sheet include gage readings, depth, times, peak-stage indicator-clip readings, and meter velocities at sections. Examples of information on a discharge-measurement note sheet that is derived from original data, but is not in itself original data, include computed total discharge, mean gage height, measurement number, and calculated extreme stages that have been determined from a peak-stage indicator-clip reading. Derived data can be erased for the purpose of correction.

It is GWSC policy that all discharge measurements are calculated in their entirety before field personnel leave the field site, unless emergency evacuation is required for reasons of safety. Information required on the measurement note sheet include, at minimum, initials and last name of all field-party members; station name; station number; date; times associated with 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 Miscellaneous Field Notes Form 9-275-D (January 1988). All miscellaneous notes are required to include, at minimum, initials and last name of field-party members, station name, station number, date, time associated with observations, purpose of the site visit, and any descriptive comments that the field personnel consider applicable and appropriate.

A review of field note sheets is required annually at the time station records are completed by the individual who computes the record for each station and the individual who checks the record for each station. Deficiencies found 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. The deficiencies are remedied by providing specific instructions from the SWUC to individuals who fail to record notations that meet USGS and GWSC standards.

Acceptable Equipment

Equipment used by the GWSC for the measurement of surface-water discharge has been found acceptable by the WRD through use and testing. An array of acceptable equipment for measuring discharge includes current meters, timers, wading rods, bridge cranes, tag lines, and others (Rantz and others, 1982, p. 82; and Smoot and Novak, 1968). Although an official list of acceptable equipment is not available, Buchanan and Somers (1969), Carter and Davidian (1968), and Edwards and Glysson (1988) discussed the equipment used by the U.S. Geological Survey.

The meters most commonly used by GWSC personnel for measuring surface-water discharge are the Price AA current meter, pygmy current meter, ADCP, and ADV. Methods followed by GWSC personnel for inspecting, repairing, and cleaning these meters are described in Smoot and Novak (1968, p. 9), Rantz and others (1982, p. 93), and Buchanan and Somers (1969, p. 7). The GWSC has implemented a separate and specific Hydroacoustics QA Plan as an appendix to the GWSC surface-water QA Plan. This 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 good condition and accuracy of a current meter (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 GWSC 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, the meters that were used during the trip are timed spin tested to document condition, disassembled, inspected, cleaned, and repaired, making meters ready for their next period of use.

Spin tests—It is GWSC policy that office-timed spin tests are required 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 that lists all spin tests for all current meters 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 through the spin test or inspection. The SWUC is required to review, at least annually, this log. If deficiencies are observed during this 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 the 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, that cups spin freely, and cups do not come to an abrupt stop. The time of the spin test is noted on the measurement note sheet at the appropriate location. Descriptive notations are also made at the appropriate location on the measurement note sheet concerning the meter condition, such as “OK” or “free” or other such comments. To ensure that field personnel carry out their responsibilities to maintain the equipment they use, the SWUC or SWS inspects the equipment during annual review, and field personnel promptly correct any deficiencies.

Alternative Equipment

New conditions and the development of new technology sometime 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 means of a current meter. There may not be sufficient warning for personnel to reach the site to make a direct measurement, or physical access to the site during the event may not be feasible. The GWSC Flood Coordinator, assisted by other qualified personnel of the Hydrologic Monitoring and Analysis Section, directs 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 due to unusual physical conditions. The GWSC 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 portions 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 GWSC follows data-collection and computation procedures presented in Benson and Dalrymple (1967). That report includes policies and procedures related to site selection, field survey, identification of high-water marks, selection of roughness coefficients, computations, and written summary. The GWSC 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 GWSC follows guidelines presented in other reports that describe specific types of indirect measurements suited to specific 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 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 Open-File Report (OFR) 94-360 (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 which delineates six types of flow, is described in Bodhaine (1982). The computer-based tool, culvert-analysis program (CAP), as described in OFR 95-137 (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 with methods described in Matthai (1967) and with the Water-Surface Profile Computation model (WSPRO) (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 are performed that involve delineations of floodplains or when extensions are made to stage-discharge relations at streamflow sites, when needed. GWSC personnel are required to follow the procedures associated with step-backwater methods described in Davidian (1984). The computer-based tool used for assisting in the computations of water-surface profiles with step-backwater methods, WSPRO, is discussed in OSW Technical Memorandum 87.05.

General guidelines that are followed by the GWSC 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 GWSC SWS or Regional SWS is required to review procedures and documentation performed on each indirect measurement before finalization of the discharges into 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 and that actions actually correct the deficiencies. Specialists outside the GWSC 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 GWSC, it is a general rule that indirect measurements are made at sites when the peak flow at a site is estimated to be at least one and a half times the discharge of the greatest measured flow, or when it is essential that a peak discharge be determined.

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 available in their field vehicles flagging equipment, such as nails and plastic markers, spray paint, paint sticks, survey flagging, survey stakes, and other items as necessary. Because selection of a suitable reach of channel is an extremely important element in making an indirect measurement, at some streamflow-gaging-station sites the stream reach for indirect measurements at specified ranges of stage has been preselected, and that information has been included in the station description.

After each indirect measurement is computed, the SWS checks 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 GWSC is responsible for maintaining the accuracy of the peak-flow data files, including computer data-base files (OSW Technical Memorandum 92.10). 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 the peak-flow files are correct. For further discussion on the update and review of the peak-flow files, refer to the "Database Management" section in this QA Plan.

Crest-Stage Gages

Crest-stage gages (CSG) 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 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 crest-stage gages and for the computation of annual peaks at crest-stage gages (OSW Technical Memorandum 88.07). Because of this, the GWSC has a CSG coordinator to ensure continuity of CSG data activities statewide.

The operation of crest-stage gages is part of the GWSC's surface-water program. Procedures followed by the GWSC in the operation of crest-stage gages are presented in Rantz and others (1982, p. 9, 77, and 78). One or more gages are maintained at each selected site where peak water-surface elevations are required on a stream. 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. Crest-stage gages are required at all sites with bubbler systems in order to confirm peaks recorded by the bubbler systems.

Except at sites where crest-stage gages 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 obtained as site conditions warrant to verify or adjust the rating. Levels are run to the gage every 3 years or as soon as possible after significant changes in the gage because of damage to the gage, reconstruction, or other such situation. When extremely high peaks occur, an outside high-water mark to confirm the gage reading is found when possible, is described on the note sheet, and is flagged by a durable indicator 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 name of field personnel, station name, station number, date, time of observation, current stage, crest-stage gage reading, and outside high-water mark, if found.

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 SWS 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 that are communicated by the SWS to the responsible field person, and that person is responsible for ensuring that the corrective actions are taken and that the actions actually correct the deficiencies. A corrected CSG analysis form is kept in folder and reviewed by the SWS before publication in the Annual Data Report.

Policies and procedures for computation of peak discharges at crest-stage gages and associated documentation are presented in this report 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 GWSC. In situations where artificial controls are installed as permanent structures, it is GWSC 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 means cannot be used, then theoretical methods are used and verified by some means of direct measurement, if possible. Portable weir plates and flumes are not currently used by GWSC personnel. These portable device applications, if used, would be 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 GWSC. When installing an artificial control, GWSC personnel take into account the criteria for selecting the various types of controls, principles governing their design, and the attributes considered to be desirable in such structures (Carter and Davidian, 1968, p. 3; Rantz and others, 1982, p. 15 and 348; and Kilpatrick and Schneider, 1983, p. 2 and 44).

When field inspections of artificial controls are performed, specific information pertaining to control conditions are written on the field note sheets for the purpose of assisting in 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 would 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 when attempting to solve a nonroutine problem.

Flood Conditions

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

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

The Flood Coordinator is responsible for ensuring that the Flood Plan includes all appropriate information, including updated information. Currently, the Data Chief is the designated Flood Coordinator. The Data Chief and SWS review the Flood Plan every 3 years or after a major flood 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 GWSC who assist in surface-water activities. Individuals who receive a copy of the plan will keep copies in their office and/or in their field truck. 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 coordinates flood activities for the GWSC. For personnel who are not already in the field, their first responsibility during flood conditions is to come to office with the intent of going in the field for an extended period of time. The Flood Coordinator makes field assignments. For personnel who are already in the field, their first responsibility during flood conditions is to proceed to make measurement at the previously selected streamflow site 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 in information about flood stage and making a discharge measurement then proceeding to find and document high-water marks. GWSC personnel apply methods discussed in Rantz and others (1982, p. 60) for determining peak stage at gaging stations.

GWSC 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 personnel with questions about particular policies or procedures related to flood activities, or who recognize their need for further training in any aspect of flood-data collection, should address their questions to the Data Chief and SWUC.

The Data Chief and SWS are responsible for reviewing GWSC activities related to floods. This review includes seeing that guidelines and priorities spelled out in the Flood Plan are followed and that the guidelines appropriately address GWSC 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 encountered by GWSC personnel during periods of low flow are typically quite different from those encountered 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 that 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 narrow spaces between cobbles. When natural conditions are in the range 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). The channel modification should not be performed when it may affect the recorded stage at the gage, if possible. After modification of the cross section, the flow is allowed to stabilize before the discharge measurement is initiated.

GWSC policy requires that point-of-zero-flow (PZF) measurements be made by field personnel during periods of low flow at all gages where the low-flow control is recognizable in order to make the PZF determinations. A channel control is an example of where a point-of-zero flow measurement generally is not made.

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

Cold-Weather Conditions

Surface-water activities in this GWSC 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 to field personnel. The highest priority in collecting streamflow data during winter periods is employee safety.

For gaging stations where the stream is subject to freezing during the winter, discharge measurements under ice cover and during periods of partial ice cover are useful for analysis and determination of flow throughout winter periods. GWSC personnel are required to follow 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. GWSC personnel also follow procedures to collect winter streamflow data as presented in Rantz and others (1982, p. 124). Additionally, guidelines on equipment for measurement of flow under ice are provided in OSW Technical Memorandum 84.05.

Presently, OSW views the preferred metering equipment for discharge measurements for slush-free conditions under ice cover to be a type Price AA current meter built with the Water Survey of Canada winter-style yoke with a conventional metal-cup rotor. For conditions where slush ice 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 slush ice and retard freezing in ice-covered streams is considered to be more important than the turbulent-flow-related inaccuracies associated with the rotor (OSW Technical Memorandum 92.04). The OSW also views the regular AA meters with conventional metal-bucket 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 periods of 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-note sheets when station records are reviewed annually.

Processing and Analysis of Stage and Streamflow Data

The computation of streamflow records involves the analysis of field observations and field measurements, the determination of stage-discharge relations, adjustment and application of those relations, and systematic documentation of the methods and decisions that were 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 GWSC coincide with those described in Rantz and others (1982) and in Kennedy (1983).

Processing of 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. The GWSC's policy is that rating analyses and shift applications will be performed using the following procedures for data disseminated on the GWSC's public Web page *http://ga.water.usgs.gov/*.

It is the policy of the GWSC that real-time data presented on the GWSC Web pages are considered to be provisional and subject to revision. Web-site users are warned of the inherent limitations of provisional data by providing them with prominent clickable headings that link to a page that provides a detailed explanation of the meaning of the term *provisional* *data*. It is a goal of the GWSC to process, check, and finalize all surface-water records by April 1 of the following water year. Additionally, records for a large part of the Georgia streamflow 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.

During times of flooding, the use of real-time data is an integral part of improving and maintaining the stage-discharge ratings used for computing streamflow records. The GWSC 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 provide definition for the upper portion of the station ratings. The list specifies above what gage height measurements are needed for each site. The real-time data on the Web, along with projected crest estimates provided by the National Weather Service, are used to help determine to which stations and at what 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 make those updates the same day that the measurement information is called into the office.

Web-Page Presentation Format

Georgia real-time data are served from computers, which are located in the Atlanta office, and are maintained by the GWSC. The National Water Information System Web (NWISWeb) software is used to conform to National USGS standards. Links to real-time streamflow data are displayed prominently on the GWSC home page (*http://ga.water.usgs.gov/*). By clicking on the phrase "Map of current streamflow conditions," one accesses a map of Georgia showing color-coded dots that identify the location of streamflow-gaging stations equipped with telemetry and the current flow conditions at each site. Also from the GWSC home page, by clicking on the word, "Streamflow," one accesses a list of Georgia real-time streamflow-gaging stations grouped by river basin. The GWSC home page also contains a direct link to a National map showing color-coded dots that indicate the location of gages around the country and the current flow conditions. The GWSC webmaster approves and executes any modifications to the GWSC 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 all GWSC Web pages conform to all USGS Web and publication policies. The GWSC Director holds the ultimate responsibility to approve the content of all pages posted on the GWSC Web site.

Review of Real-Time Streamflow Data

Real-time streamflow data that are disseminated on the public Web pages must be reviewed frequently to ensure their quality and to prevent the distribution of erroneous information. The GWSC utilizes both automated and manual review procedures to meet this objective.

The GWSC implements automated procedures that include the setting of minimum and maximum threshold values for stage and discharge and their rates of change. If exceeded, these settings will initiate warnings of potential errors that will be displayed on the Georgia real-time streamflow Web page.

In addition to the automated procedures, WRD Technical Memorandum 99.34 requires frequent and ongoing screening and review of Web data, including the daily review of hydrographs during normal hours of operation. The GWSC also requires that all Web pages containing real-time streamflow data be reviewed regularly for accuracy and/or missing data. The SWUC and the field person responsible for the gage real-time visually scan streamflow data each work day. The primary goal of the visual check is to identify stations that have failed to transmit the real-time data and to identify real-time data that appear to be in some way erroneous. Each week, a person within the surface water unit is assigned the duty of repairing malfunctioning gages. This person is referred to as the "rover." When problems are identified with a gage, Data Chief or SWUC then notifies the rover. The rover is counseled on the course of action needed to fix the problem and is responsible for repairing the malfunctioning gage. Another goal of the visual check is to identify high-water, backwater, or other pertinent conditions so that special measurements can be made to improve the overall records-computation process for the streamflow network.

Error Handling

There are two general types of errors associated with streamflow data that are delivered by the real-time system and disseminated on the Internet. The first are persistent-type problems usually associated with some type of equipment failure whether in data collection or transmission, but also could be related to ice effects. Because of the nature of the problems they generally occur on a continuing basis for more than a single recording interval. The second are the intermittent-type problems, which are often the result of a data transmission error. These often show up as either a zero or an unreasonably large value. It is the policy of the GWSC that intermittent-type errors, such as extremely large gage-height data transmission errors, are identified as soon as is reasonably possible, and the erroneous data are 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, that individual takes actions immediately to delete or correct the value and update the real-time Web site to reflect the corrected data. In regard to persistent-type problems, it is GWSC 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 shown on the Web for a particular station are clearly in error—resulting from the malfunction of 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 data for the site are removed from the Web page. After repairs have been made to the gaging station and the data are determined to be accurate, the Data Chief is responsible for deciding when posting of the real-time data on the Web is to resume.

Data-Qualification Statements

WRD Technical Memorandum 95.19 requires that streamflow data made available on the Web should be considered provisional until the formal review process has been completed. To ensure that everyone who accesses data from the Web are aware of this, data qualification statements must be included at key locations with a clickable heading Provisional Data Subject to Revision on all real-time data pages. It is the policy of the GWSC that all GWSC Web pages that contain real-time data, or contain data that have not been formally approved as final, present a prominent clickable heading that links to the following explanation:

> 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

The gage-height information, discharge information, control conditions, and other field observations written by personnel on the measurement note sheets and other field note sheets form the basis for records computation for each gaging station. Measurements and field notes that contain original data are required to be stored indefinitely (Hubbard, 1992).

Measurements and other field notes for the water year that are currently being computed are filed in the primary station folder or in the current water year measurement file drawer. Measurements and notes for previous water years are filed in the historical files. Most of the historical discharge measurements obtained prior to 1950 has been archived at the Federal Record Center in Atlanta, Georgia.

It is GWSC policy that all measurements are checked. For conventional measurements, that check includes a check of computations and the procedure, such as stationing, number of sections, use of proper meter, correct gage height, and proper transcription of numbers. For measurements computed using an automated discharge-measurement calculator, only the procedural check will be 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 National Water Information System (NWIS) database. A printout of the measurement list (Kennedy, 1983, p. 12), grouped by year, is included in the technical file in the station-records filing cabinet.

The person who works the records for each station is responsible for ensuring that the measurement note sheets are correct, that the information stored in the computer files agrees with the measurement note sheets, and that 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 (60-, 30-, or 15-minute values) in the form of electronic transmissions by telephone, electronic transmissions by satellite, or values stored in electronic data recorders. Streamflow records are computed by converting gage-height record to discharge record through 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 for the period of analysis in as complete a manner as possible. Periods of inaccurate gage-height data are identified then 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 procedures for processing the data are discussed in Kennedy (1983, p. 6), and Rantz and others (1982, p. 560 and 587).

Immediately following a data-collection field trip, all surface-water data on computer medium are transferred into ADAPS using DECODES. Data transmitted by telephone line or by satellite are entered into the computer by automated computer programs. Raw data are maintained unaltered for future reference on a file on the data-entry personal computer (PC) and on backup tapes created by the GWSC computer system. 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 the correct data are inserted. Any such modification of data should be quality controlled, using graphical methods. 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 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 is normally computed each year by the field person who is responsible for the data collection activities at that site. Other field personnel check all records for each station by using a records computation checklist. Similar procedures are incorporated for each field office. Each field office is responsible for setting up necessary office files for storing collected data.

Procedures for Working 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 discharge measurement, accuracy of 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 crest-stage gages, and confirmation or updating of gage datum by levels.

Records computation includes examination of 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 for those inaccuracies. When possible and appropriate, inaccurate gage-height data are corrected. When corrections are not possible, the erroneous gage-height data are documented in writing (station analysis) and are removed from the set of data used for streamflow records computation. All missing gage-height records should be documented. Specifically, the period and the reason for the missing record should be listed in the station analysis.

In general, data that accurately reflect the stream level should be kept. Examples could include backwater from leaves, ice, or beaver dams. Stage record that does not reflect the stream level—such as stuck float, plugged intakes, and buried orifice—should be removed. Periods of mildly lagging intakes may be retained in the unit-value record.

In the GWSC, the primary computer printouts (referred to in this report as “primaries”) are considered work sheets. All discharge measurements and field inspections are noted on the primaries. All periods of ice effect, backwater, faulty record, and the like are noted on the primaries by marking a line through the original daily mean discharge and are annotated by the appropriate estimation symbol.

It is not necessary to hand list estimated discharges on the primary sheet, but they should be machine labeled with an “e” on an attached daily-value (DV) table printout. The person working the record is responsible for clearly identifying periods of bad gage-height record; the checker, if in agreement, is responsible for deleting that bad gage-height record from the computer file. For periods when data from the primary recorder are replaced by data from a backup recorder, that change is thoroughly documented on the primary sheet and 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 (Kennedy, 1983, p. 6) and TWRI 3-A19 (Kennedy, 1990).

Procedures for computing records and completing level information for each station include ensuring that the level-notes front sheet is 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 or fall in slope reach (complex ratings) (Kennedy, 1983, p. 14).

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

For each gaging station, the most recent digital rating table can be obtained by producing 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 filing cabinet with the station files. In the event that a rating is superseded, a copy of the rating being replaced (older rating) is stored in the rating backfile section of the paper file. A graphical plot of the most recent rating can be obtained by generating the graph, using the plotter with the standard USGS software. The current master copy of the plotted rating is maintained in alphabetical order in the rating file drawer. 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 technicians 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 TWRI 3-A8 (Buchanan and Somers, 1969) and TWRI 3-A10 (Kennedy, 1984) pertaining 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 GWSC 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

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 12 or 13). 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 12 and 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 working 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 working 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 of introducing 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 worker. 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 Corrections, 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 in terms of when the datum change occurred. In the absence of any 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 0.02 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 are made to agree with reference gage data. These corrections are applied when the difference between the recording gage and the base 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 the GWSC database applications software. Generally shifts are applied if the discharge measurements plot more than their rated accuracy from the rating. Although, there are factors that 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 works the station records documents the shifts by describing the shift magnitude and time of application in the station analysis and by including the shift-analysis printout and the shift-bar-diagram plot with the station analysis. Station records should also 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 that 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 GWSC's records-working process. The person who works the station records 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 discharges versus 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, station 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, the name of the streamflow stations with which the hydrograph was compared, 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-size form and standard log cycles so that the dimensions of the graphs are uniform for all gaging stations.

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

Hydrograph comparisons assist the GWSC 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 stations on 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 there are questions concerning hydrographs.

Station Analysis

A complete analysis of data collected, procedures used in processing the data, and the logic on which the computations were based is documented for each year of record for each station to provide a basis for review and to serve as a reference in case 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. 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 the records. The person who works the records writes the station analysis.

The person writing the station analysis should use a standard word-processing software package. Regardless of whether or not the analysis is complete or incomplete, a hard copy of the station analysis is kept in the primary folder for the water year currently being computed. Completed and checked analyses for previous years are grouped in a separate folder in the station backfile. 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 computer-generated year-end summary, and printouts of the datum and shift applications. The hard copy of the analysis, signed and dated by the original records worker and the checker, is considered the permanent document for the station file. Electronic files of the station analysis are stored on the GWSC computer network.

The person who works the station record is responsible for ensuring that the computation process 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 worked the station records. If a consensus cannot be reached between the two parties, it is their responsibility to present the problem to the Data Chief or SWUC who will make the final determination.

Winter Records

The GWSC rarely has ice-affected streamflow data. However, on those few occasions, the formation of ice in stream channels or on section controls affects the stage-discharge relation by causing backwater; 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.

Furnished Records

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

If the GWSC receives furnished data by 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 the data and assure that the data are in conformance with WRD standards. If errors in the data are suspected, the furnishing agency is contacted to determine if an error has been made. The Data Chief, SWUC, or SWS is responsible for contacting the furnishing agency. Data published from another agency are not normally retained as permanent record in the GWSC database.

Daily Values Table

With few exceptions, for each gaging station operated by the WRD a discharge value is determined and stored for each day. The daily values table generated by use of the NWIS software represents what discharge values 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 works the records is responsible for determining that the calculated daily mean discharges accurately represent the actual streamflow conditions. That person is responsible for ensuring that the daily-values table, which includes those values stored in the daily-values computer file, 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 primaries, 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 analyses. The person who works the records updates the progress board upon completion of the station records. The checker then updates the progress board 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 GWSC personnel have been determined to be correct and finalized, the surface-water data for that water year are published along with other data in the GWSC's annual data report. The annual data report is part of the series entitled "U.S. Geological Survey Water-Data Reports." Information presented in the annual data report includes daily discharge values during the year, extremes for the year and period of record, and various statistics. Additionally, manuscript station descriptions are presented in the annual data report. Information contained in the manuscript includes physical descriptions of the gage and basin, history of the station and data, and statements of cooperation.

In preparing the annual data report for publication, the GWSC follows the relevant guidelines presented in the report, "WRD Data Reports Preparation Guide," by Charles E. Novak, 1985 edition and OSW Technical Memorandum 92.07 (summary statistics memo). Someone other than the person who computed and wrote the station analysis checks each station. The Data Chief does the final review of each station manuscript before inclusion in the annual data report. The SWUC or SWS does the final review of the data and publication. The Data Chief or SWS checks proof copy of the report.

Manuscripts for publication in the annual data report are produced using a standard word-processor program. The table of daily values and streamflow statistics presented in the report is loaded directly into the manuscript files from the computer data files. Each information statement and data value presented on each page of the draft is checked and rechecked, followed by a detailed review of the entire report.

The Data Chief reviews a copy of the final report. It is the Data Chief who oversees all facets of the data collection, data analysis, and report-production process. Therefore, he Data Chief plays the primary role in ensuring the quality of the information contained in the annual data report.

Records Checkoff List

The status of progress on records computation for each gaging station in the State is posted in a single, highly visible location in the Hydrologic Monitoring and Analysis Section. Each gaging-station name is followed by a series of blank squares. The persons computing or checking gaging-station records place their initials in the blanks to indicate the completion of specific phases of the records-computation process. Checkers, because they are not predesignated, must list their first initial in the checked record square while in the process of checking. When the checker completes the record, the full initials of the checker are placed in the square.

Review of Records

After streamflow records for each station have been computed and checked, senior personnel who are chosen by the Data Chief review records for all of the GWSC's gaging stations. The SWS will review 10 percent of the gaging stations, which include complex or nontraditional sites. The goal of the review is to ensure that proper methods were applied throughout the process of obtaining the surface-water data and computing the record. Another goal of the review is to ensure that proper methods were applied throughout the process of obtaining the surface-water data and computing the record. Another goal is 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 redocumenting the station data, as necessary. If questions arise concerning the validity of the identified deficiencies, the Data Chief or SWS resolves those questions.

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

Crest-Stage Gages

Records for crest-stage gages are computed with goals and procedures similar to those for other gaging stations. The field notes are examined for correctness and accuracy. Peak stages recorded by crest-stage gages 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 for field aspects of collecting data at crest-stage gages is included 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 crest-stage gages installed solely for the purpose of confirming peak stages at sites where bubbler systems are used.

At sites where crest-stage gages 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 or indirect high-water measurements.

For each 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 each 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 GWSC computer database. Current station descriptions and a summary of levels are maintained in the station folders and in electronic form on the computer. A brief station analysis is written each year describing computation of the annual peak, identifying which rating was used and the type of flow condition, describing how the dates of the peaks were determined.

The CSG coordinator, Data Chief, SWUC, or SWS are responsible for ensuring the correct computation of annual peaks at crest-stage gages. Senior personnel, who are chosen by the Data Chief, review of the crest-stage gage 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 SWS is responsibility 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 on computer 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 data 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 the assistance and approval of 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 eight weeks. Workload is based on experience and knowledge of the field personnel, but is normally distributed equally as possible. Beyond normal data-collection activities, it is very important that plans be formulated to cover extreme hydrologic events. The GWSC Flood Plan provides basic guidance for coverage of flood events.

The Data Chief, assisted by the SWS, supervises 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 chief for each field office, with assistance by 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 makeup of hard-copy files associated with surface-water data. Information pertaining to files maintained in computer storage can be found in the "Database Management" section of this report.

For each gaging station, a separate set of file folders are maintained for current and historical data. Current files are organized by station number, and historical files are organized alphabetically. Current files are filed in the data section filing area, and historical files are kept in the record section filing area for each field office. The set of current files for each 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. No historical file folders are allowed to be removed from the office. Historical file folders from the past 5 to 10 years for sites assigned to the remote field offices are filed alphabetically in those offices and are periodically (about every 5 years) transferred to the GWSC historical files.

Field-Trip Folders

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

Level Notes

Recent or current level notes are included in current station office folders. When new levels are run the old level notes are moved to the historical measurement and field-note files. The level summaries are filed in the current station office folder. A copy of the most recent level notes is kept 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 compiled and maintained on the GWSC computer network by station and water year. Field personnel are responsible for updating and maintaining the station description for their areas. The SWUC or Data Chief is responsible for ensuring that folders or files are updated.

Discontinued Stations

Discontinued station file folders are maintained in the historical files by downstream station number. These station folders contain station descriptions, old analyses, old ratings, daily discharge data, and other pertinent information for each water year.

Map Files

The GWSC maintains separate map file areas: drainage area maps, general topographic maps, and county maps for the State. All the maps are organized in alphabetical order. Topographic maps are available in scales of 1:24,000, and 1:100,000; county maps are at various scales. All maps must stay in the office since these are original informational maps (official) used in our operations. There are other topographic maps that are available for general use or field use. These maps are filed separately from the official maps. The Data Chief is responsible for updating any information on the official office maps.

Archiving

All WRD personnel are directed to safeguard all original field records containing geologic and hydrogeologic measurements and observations. Selected material not maintained in field offices are placed in archival storage. Detailed information on what records have been removed to archival centers should be retained in the GWSC or project office (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 data and edited data, observer's notes and readings, station descriptions, analyses, and other supporting information (WRD Technical Memorandum 92.59 and Hubbard, 1992, p. 12). At this time there is an agreement between WRD and the Federal Records Centers (FRC) of the National Archives and Records Administration to archive original-data records (memorandum from the Chief, Branch of Operational Support, May 7, 1993).

Surface-water information is sent to the FRC from the GWSC, as determined by the Data Chief. The Data Chief is responsible for deciding what information is sent to the FRC, for ensuring that the information is properly packed and logged, and for ascertaining that the information is received by the FRC. The Data Chief maintains records in the surface-water section of exactly what has been archived. Personnel who have questions concerning archiving procedures should address their questions to the Data Chief. Personnel who receive requests for information that require accessing archived records should contact the Data Chief for assistance.

Communication of New Methods and Current Procedures

Personnel who receive training or encounter new methods or procedures are required to pass that information along to all persons directly involved in tasks that can make use of the information. Sometimes the Data Chief, SWUC, or SWS conduct informal training to pass along 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 the memorandums are posted as continuous reminder to section personnel. The Data Chief, SWUC, and SWS are available for anyone to ask questions and discuss procedures.

Collection of Precipitation Data

Surface-water activities in the GWSC include the collection, analysis, and publication of precipitation data. At the time this GWSC QA Plan was developed, OSW was in the process of developing a technical memorandum for the collection, quality assurance, and presentation of precipitation data. Some of the draft guidelines in that memorandum were taken from existing GWSC guidelines for the collection, analysis, and publication of precipitation data.

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. There should be a 45-degree cone of clearance above the top of the rain gage. 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 analysis of terrain with the use of topographic maps, field reconnaissance, and evaluation of types of installation. The GWSC uses Design Analysis H-340 self-calibrating tipping bucket rain gages for the collection of precipitation data. The cumulative (running total) values from the rain gage are logged in 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 GWSC 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 datalogger or field computer is recorded on the inspection sheet. If the number of recorded tips is not equal to 30, then the test is rerun. If the rain gage fails a second time, then the rain gage is replaced. The rain gage cover should be replaced carefully so that erroneous typing of the bucket does not occur. The test tips must then be deleted from the datalogger.

Each rain gage is calibrated every year using a constant head bottle with a nozzle representing an intensity of 2 inches per hour. The calibration bottle is filled with a known volume of water, which corresponds to a certain number of inches of rain or number of bucket tips. The permissible error range in the number of tips in subsequent calibrations test for that site must be no more than 5 percent. If the computed correction factor is between 0.95 and 1.05, then the precipitation data produced by the rain gage is considered good. However, if the rain gage calibration test is not within 5 percent, then the rain gage is replaced. The rain gage that was 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 in a log book, which contains a log of all the calibration tests for each rain gage.

Station Descriptions

A station description is prepared for each rain gage station and becomes part of the permanent record for each station. It is GWSC policy that the station description is written by the time the first year's record is computed and analyzed. The field person, the Data Chief, or the SWUC are 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 GWSC computer network by year and station. The station descriptions are located in the Archive Station Descriptions folder.

Processing and Analysis of Precipitation Data

Processing of Real-Time Precipitation Data

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

Web-Page Presentation Format

Georgia real-time data are served from computers, located in the Atlanta office, maintained by the GWSC. The National Water Information System Web (NWISWeb) software is used to conform to National USGS standards. Links to real-time precipitation data are displayed prominently on the GWSC home page (*http://ga.water.usgs.gov/*). By clicking on the word "Precipitation," one accesses a list of Georgia real-time rain gage stations grouped by county. All data from real-time rain gages on the public Web page will be published. Any modifications to the GWSC 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 USGS webmaster. The webmaster is responsible for ensuring that all GWSC Web pages conform to all USGS Web and publication policies. The GWSC Director holds the ultimate responsibility for approving the content of all pages posted on the GWSC Web site.

Review of Real-Time Precipitation Data

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

The GWSC has implemented automated procedures that include the setting of minimum and maximum threshold values and rates of change threshold values. If exceeded, these settings will initiate warnings of potential errors that will be displayed on the Georgia real-time precipitation Web page.

In addition to the automated procedures, WRD Technical Memorandum 99.34 requires frequent and ongoing screening and review of Web data. The GWSC also requires that all Web pages containing real-time precipitation data be reviewed regularly for accuracy and/or missing data. The SWUC and the 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 have failed to transmit the real-time data and to identify real-time data that appear to be in some way erroneous, including a clog in the rain gage funnel. When problems are identified with a rain gage, the Data Chief or the SWUC then notifies the "rover." The rover is counseled on the course of action needed to fix the problem and is responsible for repairing the malfunctioning rain gage.

Error Handling

There are two general types of errors associated with precipitation data that are delivered by the real-time system and disseminated on the Internet. The first are persistent-type problems usually associated with some type of equipment failure whether in data collection or transmission. Because of the nature of the problem they generally occur on a continuing basis for more than a single recording interval. The second are the intermittent-type problems, which are often the result of a data transmission error. These often show up as either a zero or an unreasonably large value. It is the policy of the GWSC that intermittent-type errors, such as extremely large precipitation data transmission errors, are identified as soon as is reasonably possible, and the erroneous data are 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—resulting from the malfunction of equipment, vandalism at the site, or other similar problems—the Data Chief is responsible for deciding when data for the site are removed from the Web page. After repairs have been made to the rain gage station and the data are determined to be accurate, the Data Chief is responsible for deciding when posting of the real-time data on the Web is to resume.

Continuous Record

Cumulative (running total) precipitation data are collected as continuous record (15-minute values) in electronic transmissions by satellite. Precipitation record is assembled for the period of analysis in as complete a manner as possible. The Data Chief or SWS determines, and deletes as appropriate, periods of inaccurate precipitation data.

Immediately following a data-collection field trip, all precipitation data on computer medium are transferred into ADAPS using DECODES. Data transmitted by satellite are entered into the computer by automated computer programs. Raw data are maintained unaltered for future reference on a file on the data-entry PC and on backup tapes created by the GWSC computer system. Precipitation data from the primary recorder that is 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 the 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 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 that site normally computes precipitation data for each station. Other field personnel check all records for each station are using a records computation checklist. Similar procedures are incorporated for each field office. Each field office is responsible for setting up necessary office files for storing collected data.

Procedures for Working 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 included in the records-computation process.

Data Corrections

The GWSC does not apply data corrections to the precipitation data. If a calibration test indicates that a rain gage is in error by more than 5 percent, then the precipitation data produced by that rain gage are removed from the record.

Estimation of Missing Record

The GWSC does not estimate missing precipitation record. If the rain gage is affected by a plugged funnel or snow/ice effects, then the data during this period are deleted and classified as missing. If precipitation data are missing for a portion of a day, the daily sum value for that day can be accurately computed as long as there are consecutive values at the 00:00:00 time stamp and the rain gage accumulator is not reset during this period. However, if consecutive 00:00:00 values are missing, then the daily sum value for that day can be accurately computed as long as no precipitation occurred during the missing gap in data.

Station Analysis

A complete analysis of data collected, procedures used in processing the data, and the logic on which the computations were based is documented for each year of record for each station to provide a basis for review and to serve as a reference in case 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 works the records writes the station analysis, which is usually incorporated with station analysis for stage and discharge.

The person writing the station analysis should use a standard word-processing software package, which is available on USGS computers. 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 records worker and the checker, is considered the permanent document for the station file. Electronic files of the station analysis are stored on the GWSC computer network by station and water year.

The person who works the station record is responsible for ensuring that the computation process 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 worked the station records. If a consensus cannot be reached between the two parties, it is their responsibility to present the problem 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 working the record is responsible for ensuring that the daily sum values table, which includes those values stored in the daily-values computer file, contains the 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 analyses. The person who works the records updates the progress board on completion of the station records. The checker then updates the progress board 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 GWSC personnel have been determined to be correct and finalized, the precipitation data for that water year are published along with other data in the GWSC's annual data report. Information contained in the manuscript includes physical descriptions of the gage and basin, history of the station and data, and statements of cooperation.

Review of Records

After precipitation records for each station have been computed and checked, senior personnel, who are chosen by the Data Chief, reviews records for all of the GWSC's raingage stations. The goal of the review is to ensure that proper methods were applied throughout the process of obtaining the precipitation data and computing the record. If deficiencies are identified during the record review, the individual responsible for compiling the station analysis data are notified in writing or verbally. The individuals are responsible for correcting identified deficiencies, and to redocument the station data as necessary. If questions arise concerning the validity of the identified deficiencies, the Data Chief or SWS resolve those questions.

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

Collection of Sediment Data

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

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

Book 3, chap. C1—"Fluvial Sediment Concepts" by Guy (1970),

Book 3, chap. C2—"Field Methods for Measurement of Fluvial Sediment" by Guy and Norman (1970),

Book 3, chap. C3—"Computation of Fluvial-Sediment Discharge" by Porterfield (1972).

Although no additional TWRI chapters have been written to supersede the above-mentioned reports, Open-File Report 86-531 "Field Methods for Measurement of Fluvial Sediment" by Edwards and Glysson (1988) essentially replaces book 3, chap. C2 (WRD Technical Memorandum 71.73, OSW Technical Memorandum 88.17, and OSW Technical Memorandum 93.01).

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

GWSC personnel collect suspended-sediment data 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 GWSC follows the criteria described in Edwards and Glysson (1988, p. 32).

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 (OSW Technical Memorandum 93.01 and OWQ Technical Memorandum 76.17). For samples that are split, the cone splitter is used (OWQ Technical Memorandum 80.17).

Guidelines for the collection and publication of bedload data are provided in OSW Technical Memorandum 90.08. This memorandum supersedes policy and guidelines provided in previous OWQ Technical Memorandums 76.04, 77.07, 79.17, and 80.07, as well as WRD Technical Memorandum 77.60. Among the policies stated in OSW Technical Memorandum 90.08, which are followed by the GWSC, is one stating that three cross-sectional procedures 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 in some situations are analyzed individually and in other situations are analyzed as a composite. Until sampling variability for a particular site is understood by those analyzing the data, all samples are required to be analyzed individually.

The supervisor's project personnel involved in sediment related hydrologic investigations are responsible for scheduling sediment-collection activities at specific sites. The GWSC Water Quality Specialist has the individual responsibility for ensuring that GWSC personnel use correct procedures to collect sediment data. This individual 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. The GWSC Water-Quality Specialist or other qualified personnel who have proper training in sediment-related disciplines answer questions from GWSC personnel concerning sediment-sampling techniques.

Field Notes

GWSC personnel are required to fill out note sheets each time a site is visited for the purpose of sediment sampling. The employee completes 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 field notes.

Equipment

The field personnel who use the sampling equipment is responsible for care and maintenance of the sediment-data-collection equipment. Major parts replacement and repair of damaged equipment are accomplished through contract with the Federal Interagency Sedimentation Program (FISP) in Vicksburg, Mississippi. Minor repairs are done in-house by qualified personnel. The GWSC Water-Quality Specialist and project personnel are responsible for ensuring that appropriate equipment is used at all sampling sites. Sampling equipment is selected based on the constituents that are being investigated, the type of analyses that are to be performed, and site conditions, including velocity and maximum depth of water. The GWSC 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, 1992, p. 2). GWSC personnel are required to prepare sample labels, analysis instructions, and sample documentation according to guidelines presented in Knott and others (1992).

Sediment-sample containers and sediment samples are stored in the GWSC 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 in foam-filled plastic crates for shipment 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 GWSC. 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 the proper sampling equipment and methods are used during high-flow conditions The GWSC Water-Quality Specialist and qualified project personnel are responsible for providing answers to GWSC personnel who have questions concerning high-flow sampling equipment or sampling procedures.

Cold-Weather Conditions

Sediment-sampling activities in the GWSC 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 the danger of damaging sampling equipment, such as during spring breakup, field personnel may manage only to obtain surface samples between the floating slabs of ice (Edwards and Glysson, 1988, p. 86). The 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. A list of elements included in each station description, along with an explanation of what items are included with each element, is presented in the attachment to OSW Technical Memorandum 91.15. At sites where sediment samples are collected but other streamflow data are not 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 for the purpose of providing 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 site samples are to be taken and what method is to be used. Recent station analyses contain pertinent information about the sampling conditions and problems that may have been recently encountered.

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 field personnel corrects and documents the deficiency.

At sampling sites with a gage houses, a log of sampling activities is kept. Information recorded in this log includes the names of the individuals who conducted the sampling, dates and times of the 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 GWSC follows the considerations and guidelines presented in Porterfield (1972), Guy (1969), and OSW Technical Memorandum 91.15 in carrying out these four steps.

The GWSC Water Quality Specialist and qualified project personnel are jointly responsible for ensuring that appropriate procedures are correctly applied 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 GWSC has a sediment laboratory, which runs limited sediment analysis. If a more detailed sediment analysis is needed, then the samples are shipped to the appropriate laboratory for analysis.

Sediment Station Analysis

A sediment station analysis is written for each sediment station operated by the GWSC each water year. The sediment station analysis is a summary of the sediment activities at the station for a given year. The analysis describes the coverage of sampling, the types of samples and sampling, 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, such that the checker and the reviewer can determine from the analysis the adequacy of the activities in defining the record and in 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 along with 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 annual data report series and additionally in open-file and interpretive project reports, where appropriate.

Sediment Data Storage

Sediment data are stored both in paper files in the GWSC and in computer data base files, which is part of the USGS NWIS. People responsible for ensuring that the data are properly processed and maintained include the GWSC Water-Quality Specialist, project personnel, and database administrators. Paper and computer-file records are reviewed on an annual basis, and any discrepancies are resolved between these people.

Database Management

The overall process of storing surface-water data collected at continuous-record gaging stations includes entering the unit-value stage data into computer files, using NWIS, the standard USGS database; computing corresponding discharge values; computing daily mean discharges based on those unit discharges; and storing those daily means in the NWIS database.

In addition, instantaneous annual peak discharges and the associated peak gage heights as well as 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 that the data are correct. The Data Chief also oversees all aspects of data entry and data management, except in situations pertaining to water-quality files and specific project files.

The field person who collects the unit-value stage data is responsible for entering the data into the computer system. Depending on the equipment that is used at each site, generally the data are entered manually, automatically by satellite, by downloading electronic signals through a personal computer or data card, or by interrogation and retrieval of electronic signal through telephone lines.

The Data Chief can delegate the task of entering the unit values into the computer 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 to a specific individual the responsibilities of maintaining the local computer programs and files and updating the National database.

The SWS is responsible for updating the Peak Flow File and ensuring that the data contained in the Peak Flow File 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 most recent year. Following the computer-update procedure, that individual ensures the correctness of the data by comparing all stored values for that updated year against 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 the interpretive information derived from the analyses of surface-water data.

Publication Policy

The USGS and WRD have created specific policies pertaining to publication of data and interpretation of those data. All WRD personnel, including those of the GWSC, are required to abide by those policies. A brief summary of goals, procedures, and policies are 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 others until the information is made available to all, impartially and simultaneously, through Director- or Regional-approved 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 the approval by the Region or of the Director, hydrologic measurements resulting from observations and laboratory analyses, after they have been reviewed for accuracy by designated WRD personnel, have been 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 Director before release for publication. The objectives of the approved 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. Director's or Regional's report approval ensures that each publication or writing (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, 1991, p. 10).

Types of Publications

Various types of book publications released by the USGS are available in which surface-water data and data analyses are presented. Publications of the formal series include Water-Supply Papers, Professional Papers, Bulletins, Circulars, Techniques of Water-Resources Investigations, Special Reports, and Selected Papers in the Hydrologic Sciences (U.S. Geological Survey, 1986, p. 42). Publications in the informal series include Water-Resources Investigations Reports, Open-File Reports, and Administrative Report (U.S. Geological Survey, 1986, p. 52). Surface-water data collected by this GWSC are published each year in a hydrologic data report that belongs to the annual series entitled "U.S. Geological Survey Water-Data Reports." Factors considered by the GWSC when deciding which form of publication should be used in presenting various types of information are presented in Green (1991, p. 14).

Review Process

Procedures for publication and requirements for manuscript review by WRD are summarized in U.S. Geological Survey (1991, p. 36–41). The GWSC fulfills those requirements for review and approval of reports prior to printing and distribution. All reports written by USGS personnel in connection with their official duties must be approved by the originating Discipline or the Director. At least two technical reviews of each report are required by WRD (U.S. Geological Survey, 1991, p. 36). Competent and thorough editorial and technical review is the most certain way to improve and assure the high quality of the final report (Moore and others, 1990, p. 24). Principles of editorial review and responsibilities of reviewers and authors are presented in Moore and others (1990, p. 24–49).

Several steps are taken to ensure the quality of the annual data report. The main emphasis is to ensure the quality of the original copy of manuscripts and checking the original copy, and by checking the final printed report before it is distributed. Approval of the annual data report for publication is done at the Water Science Center level and distribution of the annual report via mailing lists is handled by the Data Chief. The Data Chief is responsible for ensuring quality in the annual data report by detecting deficiencies, and by correcting those deficiencies.

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 GWSC. Beyond the obvious negative impact unsafe conditions can have on personnel, such as accidents and personal injuries, they also can have a direct effect on the quality of surface-water data and data analysis. For example, errors may be made when an individual's attention to detail is compromised when dangerous conditions create distractions. So that personnel are aware of and follow established procedures and policies that promote all aspects of safety, the GWSC communicates information and directives related to safety to all personnel by in-house training classes, memorandums, and showing videotapes. Specific policies and procedures related to safety can be found in the GWSC Safety Plan. The Safety Officer is responsible for ensuring that each employee reads and familiarizes themselves with specific safety memorandums or manuals, attend training classes as required. Personnel who have questions or concerns pertaining to safety, or who have suggestions for improving some aspects of safety, direct those questions, concerns, and suggestions to the Safety Officer.

Training

Ensuring that personnel obtain knowledge of correct methods and procedures is a vital aspect of maintaining the quality of surface-water data and data analysis. By providing appropriate training to personnel, the GWSC increases the quality of work and eliminates the source of many potential errors. Most of the training is provided for personnel by the GWSC as on-the-job type training. Other types of training pertaining to data collection and analysis procedures are accomplished by in-house training by supervisors or specialists, regional training courses, or training courses through the USGS National Training Center. The goal of this type as well as all types of training are to ensure that field and office activities are performed in accordance with specified 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 GWSC Training Officer determines and requests formal training. Regional and National training courses for each year are made available to each employee. Training for employees are documented in their Career Development Plan and personnel files.

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Appendix A. Memorandums Cited

Office of Surface Water (OSW)

OSW Technical Memorandum 2005.04
OSW Technical Memorandum 2004.04
OSW Technical Memorandum 2002.02
OSW Technical Memorandum 2002.01
OSW Technical Memorandum 2000.07
OSW Technical Memorandum 2000.03
OSW Technical Memorandum 99.06
OSW Technical Memorandum 97.01
OSW Technical Memorandum 96.04
OSW Technical Memorandum 96.02
OSW Technical Memorandum 93.12
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 92.07
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 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 B. Hydrologic Monitoring and Analysis Section—Surface-Water Electronic Archiving

This addendum to the GWSC 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 GWSC computer network.

The directory structure for Station Description Files is:

*Groups**sw**Station_Archive**station#**station_description*\

Where:

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

EXAMPLE*:* *Groups**sw**Station_Archive**02335450**station_description*\

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

sdstation#_YYYY.doc

Where:

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

YYYY is the water year of the station description.

EXAMPLE: The station description for 02335000 Chattahoochee River near Norcross for the 2004 water year will have the file name sd02335000_2004.doc.

The directory structure for Station Manuscript Files is:

*Groups**sw**Station_Archive**station#**station_manuscript*\

Where:

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

EXAMPLE: *Groups**sw**Station_Archive**02335450**station_manuscript*\

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

smstation#_YYYY.doc

Where:

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

YYYY is the water year of the station manuscript.

EXAMPLE: The station manuscript for 02335000 Chattahoochee River near Norcross for the 2004 water year will have the file name sm02335000_2004.doc.

The directory structure for Station Analysis Files is:

*Groups**sw**Station_Archive**station#**station_analysis*\

Where:

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

EXAMPLE*:* *Groups**sw**Station_Archive**02335450**station_analysis*\\

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

sastation#_YYYY.doc

Where:

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

YYYY is the water year of the station analysis.

EXAMPLE: The station analysis for 02335000 Chattahoochee River near Norcross for the 2004 water year will have the file name sa02335000_2004.doc.

The directory structure for Station Photos Files is:

\Groups\sw\Station_Archive\station#\station_Photos

Where:

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

EXAMPLE*: \Groups\sw\Station_Archive\ 02335450\station_photos*

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

station#_##.jpg

Where:

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

is the photo number.

EXAMPLE: A station photo for 02335000 Chattahoochee River near Norcross will have the file name s02335000_01.jpg.

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

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

/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*: /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 */sw/edldata/02335450/555/WY2004/* folder on the GWSC computer network.

Archive Directory Structure for ADCP Files

ADCP Transect Files are stored on the GWSC computer network, and the directory structure for ADCP Transect Files is:

/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.

The prefix of the transects is the first four letters of the stream and the first three letters of the nearest location.

EXAMPLE: The transect prefix for Chattahoochee River near Norcross, GA (02335000) is ChatNor.

All the transect files (r, w, and n) will be placed in the measurement folder. These transect files include the transect used to determine bed movement. All the transect files should be locked before being archived. Also, the .dmv summary file created using the Q measurement wizard will also be placed in the measurement folder.

The .dmv Files have the following format:

station#_measurement#.dmv

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, # 575, made at Chattahoochee River near Norcross has a total of five transects, which includes one transect for the moving bed test. All of the transect files go in the */sw/ADCP/02335000/575/* folder. The 02335000_575.dmv that was created using the Q measurement wizard is also placed in the */sw/ADCP/02335000/575/* folder.

ADCP RGTest Files are stored on the GWSC computer network, and the directory structure for ADCP RGTest Files is:

/sw/ADCP/ADCP_RGTest/fieldoffice_serial#/

Where:

fieldoffice_serial# is the field office where the ADCP is kept and the serial number of the ADCP.

EXAMPLE*:* A RGTest was run on May 19, 2004, at 09:12:31 using the ADCP with a serial number of 1640. The file 1640.040519091231.txt file goes in the */sw/ADCP/ADCP_RGTest/Atlanta_1640/* folder.

The output file created from the RGTest is automatically saved in the following format:

serial#.YYMMDDHHMMSS.txt

Where:

serial# is the serial number of the ADCP.

YYMMDDHHMMSS is the year, month, day, hour, minute, and second the RGTest was run.

EXAMPLE: A RGTest that was run on May 19, 2004 at 09:12:31 using the ADCP with a serial number of 1640 has the file name 1640.040519091231.txt.

ADCP Compass Calibration Files are stored on the GWSC computer network, and the directory structure for ADCP Compass Calibration Files is:

/sw/ADCP/ADCP_Compass_Calibration/ fieldoffice_serial#/

Where:

fieldoffice_serial# is the field office where the ADCP is kept and the serial number of the ADCP

EXAMPLE*:* A compass calibration was run on May 19, 2004 at 09:12:31 using the ADCP with a serial number of 1640. The file CompCal.1640.051904.txt file goes in the */sw/ADCP/ADCP_Compass_ Calibration/Atlanta_1640/* folder.

The output file created from the Compass Calibration is automatically saved in the following format:

CompCal.serial#.YYMMDDHHMMSS.txt

Where:

serial# is the serial number of the ADCP.

YYMMDDHHMMSS is the year, month, day, hour, minute, and second the RGTest was run.

EXAMPLE: A compass calibration that was run on May 19, 2004, at 09:12:31 using the ADCP with a serial number of 1640 has the file name CompCal.1640.040519091231.txt.

ADCP Magnetic Variation Files are stored on the GWSC computer network, and the directory structure for ADCP Magnetic Variation Files is:

/sw/ADCP/station#/Magnetic_Variation/YYMMDD/

Where:

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

YYMMDD is the year, month, and day the magnetic variation files were collected.

All four transects, which include the r, w, and n files, should be place in the magnetic variation folder.

EXAMPLE*:* Four transects used to determine the magnetic variation at Chattahoochee River near Norcross were collected on May 19, 2004. All of the transect files for these four transects are placed in the */sw/ ADCP/02335000/Magnetic_Variation/040519/* folder.

Archive Directory Structure for ADV Files

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

/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 */sw/ADV/02335350/65/* folder.

ADVCHECK Files are stored on the GWSC computer network, and the directory structure for ADVCHECK Files is:

/sw/ADV/ADVCHECK/serial#/

Where:

serial# is the serial number of the ADV.

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

serial#.YYMMDDHHMM.ckg

Where:

serial# is the serial number of the ADCP.

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

EXAMPLE: An ADVCHECK 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.ckg. This file is placed in the */sw/ADV/ADVCHECK/P589/* folder.

Archive Directory Structure for Index Velocity Files

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

/sw/Index_Velocity_Meter/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, 051904_02338500_CONFIG.txt, is placed in the */sw/Index_Velocity_Meter/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 GWSC computer network, and the directory structure for Index Velocity Beam Check Files is:

/sw/Index_Velocity_Meter/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 */sw/Index_Velocity_Meter/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 GWSC computer network, and the directory structure for Index Velocity Data Files is:

/sw/Index_Velocity_Meter/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 */sw/Index_Velocity_Meter/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 C. Hydroacoustic Instrumentation—Standards, Policies, and Procedures

This addendum to the GWSC Surface Water Quality-Assurance Plan presents standards, policies, and procedures used by the GWSC 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 GWSC. 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 GWSC 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:

- USGS Open-File Report 95-701, Quality Assurance Plan for Discharge Measurements Using Broadband Acoustic Doppler Current Profiles (Lipscomb, 1995)
- USGS Open-File Report 01-01, Discharge Measurements Using a Broad-Band Acoustic Doppler Current Profiler (Simpson, 2001)
- OSW Technical Memorandum 96.02, Interim Policy and Technical Guidance on Broadband ADCPs
- OSW Technical Memorandum 2000.03, Software for Computing Streamflow from Acoustic Profiler Data
- OSW Technical Memorandum 2000.07, National Coordination and Support for Hydroacoustic Activities
- OWS Technical Memorandum 2002.01, Configuration of Acoustic Profilers (RD Instruments) for Measurement of Streamflow
- OSW Technical Memorandum 2002.02, Policy and Technical Guidance on Discharge Measurements using Acoustic Doppler Current Profilers
- OSW Technical Memorandum 2005.04, Release of WinRiver Software (version 10.06) for Computing Streamflow from Acoustic Profile Data

ADCP Quality-Assurance Folder

An ADCP Quality-Assurance Folder is maintained by the designated GWSC 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 GWSC
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 holding the position of the ADCP in the part of the river thought most likely to have the largest sediment load (usually near the zone of largest flow). The moving-bottom check is recorded and archived with the rest of the measurement-data files. The test should last at least 10 minutes. If the position of the ADCP cannot be held precisely, a moving-bottom check of 15 minutes or more might be needed to differentiate actual boat movement from apparent upstream movement caused by a moving-bottom condition.

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

5. 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.

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

7. 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.

8. 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 GWSC 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

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 an ADVCheck, 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 ADVCheck 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), an ADVCheck 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 handheld 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.
   - Battery data—the 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. Backscatter 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:

.CTL file—an ASCII file containing the Flowtracker configuration.

.DAT file—an ASCII file containing 1-second velocity component and signal-to-noise ratios.

.SUM file—an ASCII file containing station information and summary statistics from each measurement.

.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 downrate 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 GWSC 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.

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 four 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 GWSC 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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