



A Quality-Assurance Plan for Ground-Water Activities of the MD-DE-DC Water Science Center

Version 2007.01

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Contents

Contents.....	2
Introduction	3
Organization and Responsibilities	3
Orientation and Training	4
Project Planning.....	5
Proposals	6
Work Plans	6
Project Safety Planning	7
Project Reviews.....	8
Data Collection	8
Documentation of Technical Procedures.....	8
Documentation of Non-Routine Activities	9
Instrumentation	10
Data Processing, Review, Storage, and Archiving	11
WSC County Ground-Water Paper Files.....	12
Ground-Water Site Inventory (GWSI)	13
Continuous Ground-Water-Level Data	13
Real-Time Data	13
Traditional Recorder Data	14
Archival of Ground-Water Data	14
Data Analysis.....	15
Data Publication	17
References Cited.....	18

Introduction

The U.S. Geological Survey (USGS), Water Resources Discipline (WRD), investigates the occurrence, quantity, quality, distribution, and movement of the surface and ground water that compose the Nation's water resources. As the Nation's principal earth-science information agency, the USGS is depended upon to collect data of the highest quality. This Ground-Water Quality Assurance Plan (GWQAP) is a formal document describing the management policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan for ensuring quality in the ground-water products of the Maryland-Delaware-DC Water Science Center (WSC). The national guidelines for WSC ground-water quality assurance plans are entitled "A Quality-Assurance Plan for District Ground-Water Activities of the U.S. Geological Survey", Open-File Report 97-11 (Brunett and others, 1997), located online at <http://water.usgs.gov/ogw/pubs/OFR9711/>. This WSC GWQAP includes specific excerpts from OFR 97-11. The principles upon which the WSC quality assurance plan for ground-water activities is based include the following:

- Technical and scientific activities will be performed in accordance with applicable WRD practices and policies. This will ensure consistent work across projects, WSCs, and the WRD.
- These activities will be performed by technically qualified personnel performing at a level commensurate with their training and experience.
- All activities and studies will receive appropriate and timely review for completeness, reliability, and credibility.
- Remedial actions will be taken to remove technical deficiencies.

Organization and Responsibilities

Though quality assurance is a personal responsibility of all employees of the USGS, ultimate quality-assurance responsibility within each WSC lies with the Water Science Center Director. Clear statements of specific responsibilities promote an understanding of each person's role in the overall process of assuring quality and can help to prevent errors and deficiencies that may otherwise occur. Implementation and follow-up responsibilities lie with data-collection staff, Project Chiefs, Section Chiefs, discipline specialists, WSC Directors, regional specialists, and others. Even if quality-assurance responsibilities are ancillary duties for some employees, these functions are to be documented.

The following is a list of specific responsibilities of WSC personnel for implementing the GWQAP for MD-DE-DC WSC ground-water activities, as stated in OFR 97-11.

The WSC Director is responsible for:

- Managing and directing the WSC program, including all ground-water activities.
- Ensuring that ground-water activities in the WSC meet the needs of cooperating agencies, including state and local agencies; the general public; and the Federal Government.
- Ensuring that all aspects of this GWQAP are understood and followed by WSC personnel.
- Providing final resolution of any conflicts or disputes related to ground-water activities within the WSC.
- Keeping WSC staff briefed on procedural and technical communications from Region and Headquarters.
- Ensuring that technical reviews of all ground-water activities are conducted.
- Ensuring that all publications and other technical communications released by the WSC are accurate and are in accord with USGS policy.
- Ensuring that ground-water training is incorporated into each employee's training plan, where appropriate.

The Section Chief is responsible for:

- Managing and directing ground-water activities assigned to the section and ensuring that the stated objectives are met in a timely manner.
- Reviewing the work plans for ground-water programs and projects.
- Providing the Project Chief with technical and administrative support as needed.
- Creating, with ground-water personnel in the section, a training plan for each employee, where appropriate.
- Reviewing ground-water reports under his or her direction.
- Monitoring progress of ground-water Project Chiefs in implementing the GWQAP for their respective projects.

The Ground-Water Project Chief is responsible for:

- Directing and conducting the technical work of the project, including all phases of data collection, data review, data storage, data analysis, and report preparation according to appropriate procedures.
- Communicating project plans, progress, and problems to supervisors by providing written progress reports at periodic reviews.
- Preparing written work plans, documenting project activities, and ensuring that data are placed in the USGS National Water Information System (NWIS) database, as appropriate, prior to project termination.
- Maintaining a project file containing memoranda, personal communications, technical-procedure documents used, original data, and other documentation.
- Ensuring that project activities are carried out in a timely manner.
- Creating, with the supervisor, a personal training plan.
- Archiving of project files, at the completion of the project.

The WSC Ground-Water Specialist is responsible for:

- Maintaining current ground-water technical expertise for the WSC.
- Maintaining the ground-water technical-procedure documents file.
- Consulting with the WSC staff on ground-water technical matters.
- Advising on training needs for employees engaged in ground-water activities.
- Participating in technical reviews of ground-water activities.
- Reviewing ground-water related project proposals.
- Reviewing ground-water related project reports.

Orientation and Training

One of the benefits and strengths of working for the USGS is our depth and breadth of training available to both new and current employees. Because ground-water studies may include a large variety of both field data collection and analytical techniques applied in the office, ongoing training of personnel is essential to the successful completion of project work tasks. Employee training is an investment that has short-term and long-term benefits to the WSC's ground-water activities. The immediate benefits permit confidence that the work is being performed correctly and accurately. The long-term benefits provide for technically competent employees that are of great value to the organization. Because all work in the scientific arena is receiving increased scrutiny, the qualifications of ground-water personnel relative to the technical demands of the work to be performed must be well-documented. Training already received as well as current and planned training need to be incorporated into a documented training plan for each employee. Periodic reviews of these plans by WSC management will help determine additional training needs.

The following quality-assurance activities shall be performed by the WSC:

1. A written, reviewed, and approved training plan shall be prepared for each employee performing technical tasks relating to ground water.
 - A. Each training plan shall include an individual's short-term training needs, such as the knowledge and skills needed to perform currently assigned tasks as well as long-term training needs, such as skills needed to perform future tasks and for career development.
 - B. Training plans should be reviewed and updated at least annually.
2. Individuals shall receive appropriate training before assigned tasks are performed. Appropriate training includes new employee training, USGS National Training Center courses, mentoring, on-the-job training (OJT), vendor-provided training, and academic courses.
3. Each training activity shall be documented according to existing policy. The WSC shall establish a training file to facilitate cross-referencing by critical task and individual training. Qualifications contractors and of cooperators (Federal, State, and local agencies) performing tasks shall be to the satisfaction of the WSC Director.

Hydrologists new to the MD-DE-DC WSC ground-water program will be given a brief orientation arranged by their immediate supervisor. The entire orientation, which should take place within the first week of assignment to a ground-water study, will consist of reading or familiarization with a few reports and a visit and tour of libraries and file rooms. Suggested reading material should include, but not be limited to, the MD-DE-DC WSC internal web page online publications list (<http://md.water.usgs.gov/publications/online.html>) and the following publications and on-line resources:

- USGS Office of Ground Water (OGW) website: <http://water.usgs.gov/ogw/> - many online publications and descriptions of ground-water methods of investigation.
- USGS Office of Ground Water internal website: <http://water.usgs.gov/usgs/ogw/index.html> – conference and general information, directory of USGS ground-water programs, and technical topics.
- USGS WRD Northeastern Regional Hydrologist webpage: <http://water.usgs.gov/orh/nrwww/public.html>.
- USGS OGW Selected Publications: <http://water.usgs.gov/ogw/pubs.html>.

The WRD offers many training opportunities for technicians and hydrologists. Training needs and opportunities are discussed at least annually during performance evaluation interviews. Supervisors and Project Chiefs will offer or provide instruction in many of the elements needed on particular assignments. The Supervisor should consider assigning the workbook, "Study guide for a beginning course in ground-water hydrology; Part I, Course participants," USGS Open-File Report 90-183 (<http://pubs.usgs.gov/of/1990/ofr90-183/>), to all entry-level scientists. Many training courses are offered at the Regional level and at the National Training Center in Lakewood, Colorado. The hydrologist and his or her supervisor will discuss training needs.

Project Planning

Project preparation includes a proposal of work to be completed, estimation of project staffing needs, and preparation of a project workplan. The WSC Director has the responsibility for the selection of the Project Chief, but the choice will be made in consultation with the Section Chiefs and the Ground-Water Specialist. Aids in most phases of project preparation can be found.

Proposals

The development of a project begins with discussions with the cooperator regarding a ground-water problem or need, or in response to a national program. At this point, a project proposal is developed by the Project Chief and the supervisor, with technical assistance from the WSC discipline specialists. Proposals also may be prepared by Section Chiefs and discipline specialists. The proposal should summarize data needs and technical approaches, identify work elements, itemize specific costs, define total personnel needs, and provide deadlines for each work element. Requirements for work by various administrative subdivisions of the WSC, by the cooperator, or by contractors should be clearly identified and scheduled. Cost estimates for each of the project tasks should be estimated from budget worksheets obtained from the Administrative Services Unit. The proposal will be reviewed by the technical discipline specialists, as applicable. Approval of the project proposal at the Regional level is required.

Work Plans

The project workplan should contain a detailed outline and description of how and when project tasks will be completed. In general, if the project work tasks and procedures are carefully described in the workplan and reviewed by members of the WSC Leadership Team, these work elements can be implemented with greater ease and confidence. Guidelines for the content and quality assurance procedures of workplans are as follows:

As stated in OFR 97-11, to quality assure workplans, the following steps will be performed by the WSC:

1. Workplans for programs having ground-water activities should clearly state that the WSC GWQAP will be implemented.
2. To the extent practicable, workplans should state data-quality objectives and describe the strategies toward the collection of data to meet the intended use. When developing data-quality objectives, regional ground-water database and network needs should be considered as well as immediate objectives.
3. *Data-Quality Objectives* are those qualitative and quantitative statements developed by data users to specify the quality of data needed from a particular data-collection activity. For example, in order to describe land subsidence in an area, ground-water levels need to be measured using a particular method, at a particular frequency, and to a particular accuracy.
4. The workplan will specify the means for cataloging and archiving all ground-water activities and files according to WRD policy (<http://water.usgs.gov/osw/pubs/ofr92-56/ofr92-56.html>) and as described in the WSC GWQAP and the WSC archival memorandum (http://md-internal.er.usgs.gov/database/data_report_all.pdf).

Development of workplans might also include the following:

1. A bibliographic search of available reports, articles, data, and other pertinent information.
2. Retrieval of relevant data from existing databases in order to determine the availability of and the need for additional data. Errors or inconsistencies in the database should be identified and corrected at this time.
3. Review of other USGS file (paper) data, such as field sheets, water-level records, geophysical logs, lithologic logs, water-quality laboratory analytical data, or other original data.

A report plan will be developed either as an integral part of the workplan or as an attached document. The report plan identifies the type, scope, intended audience, and length of all reports; and provides a preliminary outline of each report, including a description of major illustrations, maps, and tables. Preparation of the work plan and report plan are to be accomplished in the first 10 percent of the project duration. To achieve this end, the project leader will confer with the Section Chief, the Ground-Water Specialist, and any other persons in or out of the USGS who may offer guidance or insight into the problem being addressed.

The qualifications of project personnel relative to the technical demands of the work will be determined by the Project Chief, Section Chief, and Ground-Water Specialist. Training to remedy deficiencies will be recommended. The Section Chief will develop and document a specific plan to provide the required training.

The entire project-planning process should be reviewed thoroughly in the initial project review, which should be held at a time representing 10 percent of the project duration.

Project Safety Planning

Because the collection of data in the field can be hazardous at times, the safety of field personnel is a primary concern. All personnel engaged in field or laboratory work in ground-water project activities must comply with applicable USGS safety and health standards, procedures, and guidelines as a condition of employment.

Field teams often work in areas of high traffic, remote locations, and under extreme environmental conditions. Field work involves the transportation and use of equipment and chemicals and can require working with heavy machinery. Additionally, field personnel may be exposed to waterborne and airborne chemicals and pathogens while sampling. Beyond the obvious concerns regarding unsafe conditions for field personnel, such as accidents and personal injuries, the quality of the data also may be compromised when sampling teams are exposed to dangerous conditions. So that personnel are aware of and follow established procedures and protocols that promote all aspects of safety, the WSC communicates information and directives related to safety to all personnel.

Training is provided by contract trainers (for example, Hazardous Waste Operation, 40-hour training) or by on-line or in-house training classes (for example, hazard communication and laboratory safety). In addition, periodic safety presentations are made on specific topics utilizing videotapes, memoranda, or guest speakers as appropriate. Specific required and mandatory training policies and procedures related to safety can be found in the USGS Manual, "Safety and Health for Field Operations Handbook - 445-3-H" at: (<http://www.usgs.gov/usgs-manual/handbook/hb/445-3-h.pdf>). Additional information is available on the WRD Safety web page at <http://1stop.usgs.gov/safety/>, and the Bureau Safety site at: <http://internal.usgs.gov/ops/safetynet/index.html>. Guidelines pertaining to safety in field activities are provided in Chapter 9 of the National Field Manual (<http://water.usgs.gov/owq/FieldManual/Chap9/content.html>).

A Job Hazard Analysis (JHA) (<http://internal.usgs.gov/ops/safetynet/jhamaster.html>) must be prepared by Project Chiefs for all projects. The purpose of a JHA is to ensure proper work assessment, funding, and assignment of responsibility with regard to all project safety elements. The information contained in the project JHA must be communicated to assigned personnel before project work begins.

An individual has been designated as the Safety Officer by the MD-DE-DC WSC Director. The duties of the Safety Officer include serving as a primary contact for all safety issues, coordinating and conducting training and inspections, identification and abatement of hazardous conditions, and promoting safety throughout the WSC. Personnel who have questions or concerns pertaining to safety,

or who have suggestions for improving safety, should direct those questions, concerns, and (or) suggestions to their immediate supervisor or the Safety Officer, as appropriate.

Project Reviews

Project reviews are conducted periodically by WSC Leadership Team members, technical advisors, or discipline specialists to ensure that project objectives are being met and to evaluate implementation of the GWQAP. Project reviews are used to maintain consistency in data collection, data analysis, and reporting. The WSC establishes project reviews schedules (<http://md-internal.er.usgs.gov/calendar/www/calendar.cfm>). These reviews consider the technical development and progress of the ground-water project. The WSC also schedules reviews at the 10-, 40-, and 70-percent (10/40/70) milestones of the project. Regularly planned reviews will ensure that the ground-water program or project is implemented and performed in a manner that results in a quality product done efficiently.

- In general, the 10-percent review ensures that the project begins properly, that no major technical item is overlooked in the planning, and that the objectives can be accomplished with the proposed approach. The 10-percent review is scheduled after initial reconnaissance, bibliographic and database searches, and before any systematic data collection. A topical outline and initial report writing are begun at this early stage. An annotated report outline, including draft illustrations, and a base map typically should be completed at this stage.
- At the 40-percent review, data collection is well underway, preliminary conclusions made, and any problems in achieving project objectives should be identified. The 40-percent review will confirm that all the tasks are on track to meet the planned objectives.
- The purpose of the 70-percent review is to ensure that all the data required to meet the objectives have been obtained, that the data-analysis process is on schedule and is yielding expected or reasonable results, and that the report is on schedule.

Data Collection

The types of data collected, the standards governing the precision and accuracy of the data, and the frequency with which data are collected may differ among the various WSC ground-water projects, according to the particular objectives of the studies. The Project Chief must clearly document and provide to the project personnel, in sufficient detail, instructions regarding data collection so that the project's data needs are satisfied. Routine and non-routine data-collection activities and procedures are documented by project or support personnel and are recorded in appropriate field notebooks. These notes are to be kept with project files and archived upon project completion.

Supervision of field procedures and activities is an essential responsibility of the Project Chief who must assure through personal observation that field personnel are fully qualified. The WSC Ground-Water Specialist will review the data collection activities of all ground-water projects. Training, including that on the job, will be used to ensure technique competence or to rectify inadequacies.

Documentation of Technical Procedures

Procedures used for the collection of ground-water data are derived from a series of technical procedures documents (http://water.usgs.gov/usgs/ogw/tech_proc/index.html), in technical memoranda (<http://water.usgs.gov/admin/memo/GW/index.html>), Techniques of Water-Resources Investigations (TWRI; <http://water.usgs.gov/pubs/twri/>) Reports, and a number of other publications. Where existing or standard procedures are not available for a project data collection activity, the Project Chief is

responsible for documenting procedures for that data collection activity and submitting them, through the WSC Ground-Water Specialist, to Regional or National Headquarters, for approval.

Techniques for the collection of ground-water samples are given in TWRIs and in memoranda issued by the Office of Water Quality and in publications with technical guidance provided by the WSC water-quality specialist. The WSC water-quality specialist will ensure that full coordination is arranged, and when applicable, that suitable cross-training in water-quality procedures is provided.

The following quality-assurance activities shall be performed by the WSC.

1. Technical-procedure documents shall be prepared or existing for documents used routine field data collection that is performed in support of ground-water activities. The water-quality aspects of ground-water activities that are addressed in the quality-assurance plan for water quality need not be duplicated.
2. The technical procedure used to collect data shall be indicated on the field form.
3. The MD-DE-DC WSC has established and maintains a file of technical-procedure documents.
 - A. Technical-procedure documents are cataloged and indexed in the WSC library.
 - B. The library contains all current and superseded versions of the technical-procedure documents.
4. Deviations from approved technical procedures shall be documented by the Project Chief and reviewed by the WSC Ground-Water Specialist to determine if a formal revision of the technical-procedure document is warranted.
5. New or revised technical-procedure documents shall be reviewed by an independent reviewer and approved by the WSC Ground-Water Specialist.
 - A. Reviews shall address the following:
 1. Applicability and appropriateness of the selected methods for the intended purpose.
 2. Correctness of facts, figures, tables, and equations.
 3. Completeness and clarity of step-by-step instructions and technical content.
 4. Evaluation of the stated accuracy of the procedure.
 - B. Approval of technical-procedure documents used within the WSC will be the responsibility of the Ground-Water Specialist. Upon approval, the technical-procedure the document shall be placed in the WSC file and a copy of it forwarded to the Regional Ground-Water Specialist.

Documentation of Non-Routine Activities

1. When data-collection methods are new, non-routine, or research oriented and involve a high degree of professional judgment or trial-and-error, an active record of the conduct, progress, and results of the data collection shall be maintained in a procedures notebook. These records shall be prepared and maintained in accordance with the following:
 - A. Prior to use of a procedures notebook, the Project Chief shall consult with the WSC Ground-Water Specialist concerning the appropriateness of a non-routine method for planned data collection.
 - B. Each procedures notebook entry shall include the names of the individuals performing the work, the date on which the work was performed, and the name of the individual making the entries.
 - C. At the conclusion of the method development, procedures notebooks shall be placed in the project file.

2. The results of the technique developed in the procedures notebook shall be reviewed by the WSC Ground-Water Specialist to ensure that work is proceeding in a technically appropriate and relevant manner.
3. If the technique that has been documented in the procedures notebook becomes a routine procedure for the WSC, then a technical-procedure document shall be developed.

Instrumentation

The majority of continuous data (water-levels and water-quality) are recorded by digital data recorders. The actual type/model of data recorder should be specified in project work plans or in separate data collection procedures for the project. Manuals for several data recorders are on file in the WSC office and are made available to appropriate field personnel; if a type/model of data recorder is used that has not been used in the MD-DE-DC WSC, it is the Project Chief's responsibility, in consultation with the WSC Ground-Water Specialist, to ensure that the instrument(s) meets the data-quality objectives of the project.

Unless logistically impossible (well bore too small, domestic well where homeowner doesn't agree to it) each recorder well site, an information card is located in an accessible place in the recorder shelter, or inside the recorder (or well) if possible, to provide information about the well and recorder, in order to assist anyone inspecting and/or servicing the recorder. Information listed includes well name, local number, county, water-level scale (if analog), land-surface datum, height and description of the measuring point above land-surface datum, and an example of the computation necessary for starting the data collection of the recorder. If logistically impossible (see above), the project quality assurance plan and field book should have detailed information, as above, to assist anyone visiting the site.

All instruments, devices, and equipment (including steel tapes) used to collect ground-water data are categorized as instruments. Because of the complexity of some instruments, their effect on the quality of the data may be unknown or unquantifiable. To ensure the consistency, comparability, and repeatability of collected data, instruments must be identified, maintained, calibrated, and operated in an appropriate manner. *Calibration is the comparison of the output from an instrument to a standard or to the output from another instrument or procedure of known accuracy in order to detect, correlate, report, or eliminate by adjustment variations in the accuracy of the instrument being evaluated.*

The following quality-assurance activities shall be performed by the WSC.

- Electronic instruments used to collect data shall be identified with a unique identifier (such as serial number) on the field form.
- Calibration procedures and schedules shall be established for each instrument based on the stability characteristics of the instrument, required accuracy, intended use, manufacturer's recommendation, and other conditions that may affect the quality of the data. The calibration procedure and schedule shall be documented in the technical-procedure document that requires use of the instrument, or in a stand-alone technical-procedure document if not satisfactorily documented in the user's manual for the instrument. Instruments shall be identified by type, manufacturer, and model. Calibration shall be performed whenever the accuracy of the instrument is suspect, regardless of the calibration schedule. Instruments consistently found to be out-of-calibration shall be repaired or replaced.
- A log shall be maintained for each instrument requiring calibration. The log shall contain all information pertinent to calibration, whether performed by WSC staff or by an outside organization or vendor. Calibration documentation recorded in the log shall include:
 - Name of organization and individual performing the calibration.
 - Identification of the instrument by type, manufacturer, model, serial number, or other unique and permanent identifier.

- Identification of calibration standard, including the range and accuracy.
- Identification of the document that describes the calibration process.
- Date of current calibration and date or milestone for next scheduled calibration.
- Records of instrument readings before and after any calibration.
- Data collected with instruments found to be out-of-calibration shall be evaluated to determine the effect on the intended use of the data. Affected data shall be discarded or their limitations documented in the database and in any application of the data.
- All instruments used to collect data shall be operated in accordance with the manufacturer's manual, unless otherwise documented. Modifications to the manufacturer's operating procedure shall be appended to the manufacturer's manual, which shall be kept with the equipment at all times. Duplicate manuals for all instruments shall also be kept on file. Operating procedures may be included in technical-procedure documents.
- Instrument maintenance shall be performed in accordance with the manufacturer's recommendations. A log shall be used to record maintenance performed.

Sample ground-water field forms can be found at <http://water.usgs.gov/usgs/ogw/FieldForms.htm>. This document can be modified for your own use on collecting ground-water levels in the field, with either a transducer site or a miscellaneous measurement site. Note that the field form should be used once—once a water level is measured and entered on the field form, it becomes “original” data—original data should be kept with the project files in the office and not taken back to the field.

Data Processing, Review, Storage, and Archiving

A data-management plan for the MD-DE-DC WSC (http://md-internal.er.usgs.gov/database/data_report_all.pdf) describes the procedures used for data processing, review, and storage, and archiving. After ground-water data are collected, they often are processed using one or more procedures, such as the application of time or datum corrections, and then are stored in computerized or physical files. Descriptive information on data-collection sites, such as well construction data and location, also should be stored. In general, data are most accessible and useful to the Project Chief and other WSC employees, as well as to those outside the WSC, if they are stored in a computerized database. Storage in a single database also enables interpretations to be more easily verified and repeated. All water data collected as part of the routine data collection of the WRD, which are all ground-water data collected by basic data programs and WSC projects must be stored in computer files of the USGS National Water Information System (NWIS) (OGW Technical Memorandum 93.03) (<http://water.usgs.gov/admin/memo/GW/gw93.03.html>). In addition, all data collected by others – such as cooperators, universities, or consultants – that are used to support published USGS documents and not published or archived elsewhere, shall be placed in NWIS. Exceptions to these requirements are spatial data coverages and other data for which appropriate database capabilities do not exist in NWIS. These should be archived with project files at the end of the project.

The database is maintained by:

- checking database files against original data files to ensure accuracy,
- performing internal cross-checks of the data in the database to identify anomalous data, and
- maintaining the original data in paper or electronic archives to ensure integrity.
- Original data** are those data – from automated data-collection sites, PDA data recording software (such as MONKES), laboratories, outside sources, and non-automated field observations – unmodified as collected or received, once put into conventional units

(engineering units, generally with a decimal) (<http://water.usgs.gov/osw/pubs/ofr92-56/ofr92-56.pdf>).

The following quality-assurance activities shall be performed by the individual Office that oversees the individual data project.

- All original data in paper form shall be placed in project or data-collection program files. Original data in electronic form (such as MONKES .xml files) shall be stored in a separate database. All original data shall be preserved unmodified as collected or received.
- All data collected as part of the routine data collection of the WRD, and all existing data collected by WRD and others that are used to support published USGS documents and not published or archived elsewhere, shall be placed in NWIS unless excluded under current WRD policy (<http://water.usgs.gov/osw/pubs/ofr92-56/ofr92-56.pdf>). Excluded data are spatial data coverages and other data that cannot be stored in NWIS.
- The WSC shall implement the WSC Data-Management Plan (http://md-internal.er.usgs.gov/database/data_report_all.pdf), which documents established policies, conventions, and responsibilities for data processing, data review, handling project and data-collection program files, and computerized databases.
- Data shall be reviewed promptly after any data-processing procedure is completed to ensure that the procedure was correctly applied and that the results are consistent both internally to the data set and with other data for the same site. This review shall be performed prior to publication or other dissemination to the general public and prior to the technical review of publications that contain the data or that use the data in interpretations. The WSC shall review ground-water data in addition to or in conjunction with other reviews on a semiannual basis. Reviews will be scheduled and implemented for data-collection programs as well as interpretive projects.

WSC County Ground-Water Paper Files

Original data, or copies of original data collected during ground-water studies should be made available for use by other WSC ground-water hydrologists and the general public, as part of the County ground-water files. Project chiefs are required to populate these files ongoing throughout the life of the project. If well folders or other information are withdrawn from the County files, a note stating where those data are temporarily stored must be emplaced.

Organization of the County Ground Water files is as follows:

- GWSI printout of well numbers and basic data: information includes station name, location coordinates, total depth, aquifer
- Well location map for the county and specific study areas
- Index of borehole geophysical logs per well number and station name
- Index of aquifer-test data per well number and station name
- Individual folders for all numbered wells
- Programs and plans--records of major activities in the county; historical and recent project folders
- Other pertinent local information including: newspaper articles, regulation of ground-water withdrawals, contaminant sites, etc.

Individual well folders should contain the following information as available:

- Original GWSI form - including all later modifications clearly marked
- GWSI printout of information in database - date stamped
- Well diagram - including measuring point height and configuration of well access

- Well location map - 1:24,000 topographic 7.5 ' X 7.5 ' quadrangle or appropriate local map and location sketch (including driving and walking directions)
- GWSI ground-water-level measurement form - tables of periodic measurements
- State MW-1 well forms
- Driller's and geologist's logs
- Water-level hydrographs -continuous and real-time recorders
- Graphical printouts of borehole geophysical logs
- Tables of aquifer-test data and associated analysis including overlay graphs of type-curve matching
- Printouts of laboratory analytical ground-water quality data
- Associated correspondence - especially regarding restrictions for well access and owner contact information
- Water-table or potentiometric surface maps
- Geologic maps - top of bedrock, structural data
- Copy of cover of associated reports

Ground-Water Site Inventory (GWSI)

All well information and data (unless proprietary) collected for a ground-water project should be entered in the Ground-Water Site Inventory (GWSI) database as early as possible. Generally, the paper GWSI form (<http://www.nwis.er.usgs.gov/forms/gwforms.html>) should be completed within 1 month of the well inventory. With the on-line search and retrieval capabilities provided by NWIS-Web, the importance of entering ground-water data into GWSI is obvious. WSC hydrologists who are writing proposals for new study areas or retrieving data as part of information request can now obtain information quickly by using NWIS-Web. These data generally will include original well, water-level borehole geophysical logs, and water-quality information, and data analyses that resulted from the study and which are not included in published reports resulting from the project. Data for wells constructed or inventoried for the study will be coded onto GWSI forms and entered into computer storage. Instructions for the GWSI system have been distributed and are available from the WSC Ground-Water Specialist or GWSI Database Administrator.

The WSC procedure for GWSI data entry is summarized as follows:

1. Project chief or designee completes GWSI form.
2. GWSI forms given to Ground-Water Specialist or GWSI database administrator for approval.
3. Ground-water specialist either (a) returns deficient forms to the Project Chief, or (b) forwards approved forms to WSC Database Administrator (DBA).
4. DBA or designee enters the data into GWSI.
5. Project chief retrieves and verifies new entries.

Continuous Ground-Water-Level Data

Another leading role of the USGS in the field of ground-water hydrology is the collection of continuous ground-water-level data. The equipment used, however, has changed dramatically within the past few years, with the availability of near real-time satellite telemetry data transmissions.

Real-Time Data

As of April 2007, data from 11 wells in MD-DE-DC were transmitted using Data Collection Platforms (DCPs) every 4 hours, and served to the general public online at

<http://waterdata.usgs.gov/nwis/current/?type=gw>. Because of availability of data from real-time technology, quality assurance procedures can proceed daily. Along with the transmission of real-time ground-water-level data, other data, including battery voltage and DCP transmitted power, are available to monitor. Ground-water hydrologists and technicians generally review the data daily and note problems regarding "zero" values, large and rapid fluctuations in water levels, battery power drainage, transmission errors, and similar uncharacteristic responses of the ground-water-level recorder. These problems can be repaired within 1 day because of the availability of near real-time transmissions. Although the initial cost of equipment start-up is higher with DCPs if the equipment is purchased, rental is also available from the USGS Hydrologic Instrumentation Facility (HIF), the long-term field trip time is most likely largely reduced, compared with traditional continuous recorders. If no problems with ground-water-level data are noted, a well need only be serviced every 4 to 6 months. Traditional continuous recorders and data loggers generally require a field visit every 6 to 8 weeks. With the daily QA procedures in place, preparation of data for the Annual Report becomes much more efficient.

Updates for ground-water-level data presented through the NWISWeb software occur nightly. However, corrections and edits to real-time data older than 5 days must be pushed to NWISWeb after edits within ADAPS. Ground-water personnel must notify the Webmaster when corrections are needed for this older data. Notification by e-mail is the preferred method, with copies to the DBA, Data Section Chief, Supervisor, and the Ground-Water Specialist.

Traditional Recorder Data

Although the MD-DE-DC WSC seeks to become entirely real-time in the transmission of ground-water-level data from wells, often project budgets may not allow the purchase or rental of DCP equipment. In general, these recorders include either a float/tape or pressure transducer monitoring device connected to a data recorder. As data are not available for QA procedures on a daily basis, as with real-time transmissions, field visits must occur every 6-8 weeks to ensure the proper operation of the equipment. Common problems include battery voltage drainage and floats becoming unresponsive or within the well casing. Quality assurance of this data must be kept current for processing in the Annual Data Report.

Field data corrections, including adjustment of the encoder on a float/tape monitoring system, are subjective, but generally should occur when abnormal deviation from the field verification measurement is observed. Notes should be recorded to reflect the adjustment, including the date and time. A field notebook for each well is suggested.

Archival of Ground-Water Data

Subsequent to project completion, Project Chiefs should consider the archival of ground-water data. The WSC Data Management Plan, located online at http://md-internal.er.usgs.gov/database/data_report_all.pdf, outlines procedures, responsibilities of personnel, and directed outlets for various types of data and other project-related information. Archiving of data and project information is a systematic process by which we protect that information from change or loss, by providing the necessary organization and security.

The WSC Data Management Plan discusses requirements for both ground-water network records and project data/information with regard to timelines and content. Data and project information are considered "active" if the records are 5 years old or less. For records more than 5 years old and up to 10 years old, storage is provided in the WSC Archives. For records more than 10 years old, the information is boxed and forwarded to the Federal Records Center (Atlanta, Ga.).

As stated in OFR 97-11, archiving is the final step in the processes of data collection, analysis, and interpretation. Although the report represents the summary of the current work, the data and its interpretation should be available for further analysis.

To quality assure the archiving process, the following steps will be performed by the WSC:

- All data will be archived as specified by current WRD policy.
- All model related computer files and appropriate simulation results will be archived as outlined in OGW Technical Memorandum 93.01 (<http://water.usgs.gov/usgs/ogw/techmemo/memos/gw93.01>) and updated in OGW Technical Memorandum 00.02 (<http://water.usgs.gov/admin/memo/GW/gw00.02.html>). Archived model data and descriptive files are located on the WSCs local-area network (LAN) in the \\igsacnewusdodec\projects\gwmarchive folder.
- All aquifer-test data and results will be archived as outlined in OGW Technical Memorandum 94.02 (<http://water.usgs.gov/usgs/ogw/techmemo/memos/gw94.02>).
- All borehole geophysical logs collected subsequent to October 30, 2000, will be archived as outlined in OGW Technical Memorandum 00.03 (http://water.usgs.gov/usgs/ogw/bgag/log_archive/logarchive_ogwmemo.html).
- All WSC borehole geophysical logs collected subsequent to October 30, 2000, must be archived according to procedures outline in OGW memorandum 00.03, located online at http://water.usgs.gov/usgs/ogw/bgag/log_archive/logarchive_ogwmemo.html. The WSC borehole geophysical archive is located on the LAN in the XX folder. Log archival instructions also are located in the folder.

Data Analysis

Data collection and data analysis are parallel and mutually supportive activities for interpretive projects; weakness in data can sometimes be revealed by concurrent analysis (e.g., plotting and contouring water-level or water-quality data will immediately show data anomalies), and the absence of needed data can be recognized during the analysis of the ground-water system under study. Analysis of data should begin in the field, as data are being collected. Reviews of data-analysis procedures ensure that selected analysis techniques are appropriate for meeting project objectives. Data-analysis techniques are identified, at least preliminarily, during development of the project work plan.

The analysis of ground-water data covers a very broad range of activities, from the interpretation of ground-water-level contours, to the entire field of numerical simulation. Standards against which these activities can be measured are accordingly distributed across a very wide segment of the hydrologic literature. To the extent practical, without placing undue restraint on the freedom of the project staff to employ or develop innovative technology, the methods of data analysis and synthesis should be detailed in the project work plan, and standards should be set by reference to specific descriptions of those methods in the literature. The methods by which data, or the results of data analyses, are "interpreted," such as the insight involved in the interpolation of water-level data to produce a potentiometric-surface map or the interpretation of the results of model simulations, cannot be completely documented. However, such interpretations must be appropriately qualified, including descriptions of the limitations of the methods used and data uncertainty.

The Project Chief is responsible for the daily conduct of project activities and the supervision, guidance, and instruction of other personnel assigned to the project. Quality assurance is provided by the Section Chief through continuous informal consultation and review of progress. The Section Chief will assure that the elements of the work plan are properly addressed and completed on time. In those

instances where it becomes evident that the work plan should be modified, the Section Chief will approve and document the changes, in consultation with the project staff and the WSC Director.

As noted previously, formal project review will be scheduled at least three times over the term of the project, at the 10-, 40-, and 70-percent points of the project duration. At the 10-percent review, after a better understanding of the project is developed, data-analysis procedures should be reviewed for suitability in meeting the project's objectives. At the 40-percent review, some data collection efforts and associated technical analysis should be available for review. At this point, data-analysis techniques should be reviewed to ensure that preliminary analyses produce valid results. For complex or technically innovative projects, more frequent review may be scheduled. The intent of these reviews is to verify the progress of the project, to assure that appropriate analytical techniques are being used, and to verify that conclusions drawn from the study are sound and well documented. When problems are identified, the WSC Leadership team and specialists should agree on appropriate remedial actions and, if necessary, modify the work plan accordingly. When substantial changes in the work plan are necessary or desirable, a justification must be prepared and approval obtained from the WSC Director. All significant findings of the project reviews should be documented for the project file and all changes in the project work plan should be dated and made part of the work plan and the BASIS+ project description. At a point when data analysis is complete, at approximately 70 percent of project completion, all data that were collected for a project, and the results of intermediate and final data analyses, are assembled and reviewed. Original data, data analyses, and data that were collected but not used in analysis, along with reasons for the exclusion, are documented as a part of the project review and placed in the project file.

From OFR 97-11, the following quality assurance activities will be performed by the WSC.

1. Data-analysis procedures will be referenced and new data-analysis procedures, including those implemented by software, will be documented in a report released prior to, or as part of, the report giving the results of that technique. Documentation might include:
 - a description of the theoretical basis and computational procedure in sufficient detail to perform the analysis,
 - all data requirements or options for the data-analysis procedure, and
 - comparisons of the technique with known or accepted solutions.
- Office of Ground Water Technical Memorandums 79.04, 91.04, and 96.04 (see online at <http://water.usgs.gov/admin/memo/GW/auto.html>) have outlined documentation requirements for data-analysis procedures implemented by software.
2. The results of data analysis will not be presented at a finer spatial or temporal resolution than supported by the input data. The results will not be displayed with an accuracy that exceeds the capability of the analysis or the accuracy of the data-collection methods. Interpretations and data analysis will be appropriately qualified, including descriptions of limitations and data uncertainty.
3. WSCs will establish a written policy for reviewing data-analysis procedures and documenting the review. The results of any data analysis will be reviewed, prior to release, to ensure that the analysis is valid. The reviewer will be provided with any necessary background information to adequately perform the review. The WSC will establish a procedure for resolving the reviewers' concerns that ensures that the review comments are carefully considered and revisions made, if appropriate, and that direct interaction occurs between the Project Chief and the reviewer. The WSC also will establish and implement an archiving process for the review documents.

USGS ground-water software is available online at http://water.usgs.gov/software/ground_water.html.

Data Publication

Unless designated and approved as "proprietary", data collected as part of any ground-water project must be published as outlined in the USGS guidelines at <http://water.usgs.gov/usgs/publishing/index.html>. Standard publication outlets for WSC ground-water records are:

1. Annual water-resources data report--this will include records from the observation-well network and from interpretive studies: WSC approval authority.
2. Interpretive-study data reports: WSC approval authority.
3. Interpretive-study interpretive reports: Scientific Investigations Reports (SIRs) or Open-File reports (OFRs); Regional approval required.

Additional publication outlets include:

1. Short abstracts for technical meetings.
2. Proceedings papers - technical meetings.
3. Technical journal articles.

The selection of the appropriate publication outlet for ground-water data will be the primary responsibility of the Project Chief and the Section Chief with advice from the WSC Reports Specialist and Ground-Water Specialist. Consideration of the publication ground-water level data from interpretive studies in the annual data report will be determined during the first year of data collection.

Processing of the WSC's annual data report for ground-water records is as follows:

1. Field personnel download data during October, as data collection has been completed for the previous water year.
2. All raw data from data-collection-platforms, continuous recorders, and periodic tape downs are processed using DECODES and entered into ADAPS.
3. Data are quality assured. Corrections are made, and reprocessed through ADAPS.
4. Hydrographs, station summaries (monthly tables having minimum/maximum and mean daily water levels), and are printed and forwarded to the Ground-Water Specialist for approval.
5. Station report headers and GWSI printouts of well information are forwarded to the Ground-Water Specialist for cross-verification and approval.
6. Paper copies of hydrographs, data tables, and report headers are either returned to field personnel for corrections, or forwarded to the DBA for inclusion in the report.
7. Report figure updates are completed by the Senior Ground-Water Technician/report author and forwarded to the Publications Section for modification.
8. Introductory report text is updated and edited by Senior Ground-Water Technician/report author and the Ground-Water Specialist.
9. The DBA, Ground-Water Specialist, and Senior Ground-Water Technician/report author review the entire draft copy of the annual data report.
10. A draft copy of the report is forwarded to the Publication Section editor. Corrections are made by the report authors.
11. The draft copy of the report is forwarded to the Reports Specialist and WSC Chief approval.

Subsequent to the first completed report draft, the Ground-Water Specialist or DBA will pull all associated data from GWSI and QWDATA to verify review procedures and assure inclusion of project data within the databases.

As a public service agency, disseminating information to the general public, our cooperators, and Congress, has been required of the USGS since its creation in the Organic Act of 1875. As stated in OFR 97-11, the report review process ensures the quality of the written report, which is the culmination and final result of the training, planning, data collection, and data analysis. To satisfy national responsibilities and to produce accurate and timely reports, the WSC will perform the following quality-assurance activities.

1. All ground-water data collected in USGS data-collection programs and interpretive and research projects will be published in a timely manner. Data in NWIS that have been reviewed and approved are available to the general public and can be considered published.
2. The WSC Chief, in consultation with the Office of Ground Water, will approve, in writing, any exceptions to the requirement to publish all data, including data collected under an agreement of confidentiality.
3. Data furnished by sources other than WRD may be used for analysis and published if the source of the information approves and if (1) the data have been appropriately quality assured, or (2) the data have not been thoroughly quality-assured but are described in terms of appropriate qualifications and limitations. In either case, the source of the data must be acknowledged. Care should be taken to assure that data are published with the correct number of significant figures.
4. Reports will be reviewed and approved according to current WSC and WRD policy.

Interim reports, or reports on particular aspects of the technical program, will be written soon after the particular work element is completed and will not be deferred until late in the project. Review of these reports by the Project Chief and colleagues within the WSC will give an early indication of possible problems or technical deficiencies. Report progress will be an element of the Ground-Water Specialist's formal review. Colleague reviewers should be selected when the report is submitted for supervisory review. After the author has replied to review comments, the Project Chief, Section Chief, and Ground-Water Specialist will jointly go over the report to assure that the comments have been adequately addressed or that the reasons for rejecting criticism are sound. All reports transmitted to the Region for processing will be technically correct and editorially sound.

References Cited

Brunett, J.O., Barber, N.L., Burns, A.W., Fogelman, R.P., Gillies, D.C., Lidwin, R.A., and Mack, T.J., 1997, A quality-assurance plan for District ground-water activities of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 97-11, 44 p.