Chapter 4 Appendices

This page intentionally left blank.

Chapter 4
Appendix A

Monitoring Protocols
for Groundwater Level Monitoring Network

This page intentionally left blank.

California Statewide Groundwater Elevation Monitoring (CASGEM) Program

Procedures for Monitoring Entity Reporting

December 2010

Department of Water Resources (DWR) will use the internet as the primary communication tool to notify interested parties and groundwater Monitoring Entities of the status of the CASGEM program on an ongoing basis. Information will be posted at the following website: http://www.water.ca.gov/groundwater/casgem

In addition to the above-referenced website, DWR will distribute information via email. In order to be placed on the CASGEM contact list, please register your contact information at the following website: http://www.water.ca.gov/groundwater/casgem/register/

For questions about the Reporting Procedures, or other technical issues, please contact:

DWR Headquarters
Mary Scruggs
901 P Street
Sacramento, CA 95814
(916) 654-1324
mscruggs@water.ca.gov

Northern Region Office
Kelly Staton
2440 Main Street
Red Bluff, CA 96080
530-529-7344
staton@water.ca.gov

North Central Region Office
Chris Bonds
3500 Industrial Avenue
West Sacramento, CA 95691
(916) 376-9657
cbonds@water.ca.gov

South Central Region Office
Dane Mathis
3374 Shields Avenue
Fresno, CA 93726
(559) 230-3354
dmathis@water.ca.gov

Southern Region Office
Tim Ross
770 Fairmont Avenue
Suite 102
Glendale, CA 91203
(818) 500-1645 x278
tross@water.ca.gov

TABLE OF CONTENTS

INTRODUCTION TO CASGEM PROGRAM

In November 2009 Part 2.11 (Groundwater Monitoring) was added to Division 6 of the Water Code by Senate Bill 6 (7th Extraordinary Session) (SB 6), a copy of which is included in the Appendix. (All statutory references in this document are to the Water Code.) The new law directs that groundwater elevations in all basins and subbasins in California be regularly and systematically monitored, preferably by local entities, with the goal of demonstrating seasonal and long-term trends in groundwater elevations. The Department of Water Resources (DWR) is directed to make the resulting information readily and widely available.

DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program in accordance with SB 6 to establish a permanent, locally-managed system to monitor groundwater elevation in California's alluvial groundwater basins and subbasins identified in DWR Bulletin 118. The CASGEM program will rely and build on the many, established local long-term groundwater monitoring and management programs. DWR's role is to coordinate information collected locally through the CASGEM program and to maintain the collected groundwater elevation data in a readily and widely available public database. DWR will also continue measuring its current network of groundwater monitoring wells as funding allows.

The goals of the CASGEM program are to:

- Establish procedures for notification and data reporting by prospective Monitoring Entities (this document)
- Verify local Monitoring Entities in accordance with the Water Code
- Develop an interface for local entities to enter data into a database compatible with DWR's Water Data Library
- Maintain the database and make it easily accessible to the public and local entities for use in water supply planning and management

If no local entities volunteer to monitor groundwater elevations in a basin or part of a basin, DWR may be required to develop a monitoring program for that part. If DWR takes over monitoring of a basin, certain entities in the basin may not be eligible for water grants or loans administered by the state.

During August and September 2010, DWR held 10 workshops throughout the state in cooperation with Association of California Water Agencies (ACWA) to introduce the CASGEM program and explain the purpose and process of the program to local agencies and stakeholders. A copy of the DWR presentation is available on the CASGEM website (http://www.water.ca.gov/groundwater/casgem). A summary of

Frequently Asked Questions (FAQs), primarily from the workshops, is provided in on the CASGEM website.

DWR's main role is to administer the CASGEM program through providing public outreach; creating and maintaining the CASGEM website and online data submittal system; and, supporting local entities through the process of becoming a Monitoring Entity and preparing Monitoring Plans. DWR will use the CASGEM website to provide up-to-date information on the program. The website will also be the access point for the online notification and data submittal systems.

Staff from the DWR regional offices will be available to assist potential Monitoring Entities with the online notification submittal process. After receiving notification from prospective Monitoring Entities, DWR will review them for completeness, verify the authority of the applying entity under Section 10927, and check for overlapping monitoring areas. DWR will advise each party on the status of their notification within three months of submittal and will work with entities to address any deficiencies in their submittals.

DWR encourages local agencies and groups to collaborate to determine who will serve as the Monitoring Entity for the area. However, if more than one party seeks to become the Monitoring Entity for the same area and overlapping monitoring area issues cannot be resolved locally, DWR will make a final determination of the Monitoring Entity for the area. DWR's determinations will consider the order in which entities are identified in Section 10927 and other factors as described in the Water Code.

DWR will post the selection of each Monitoring Entity and its monitoring area on the CASGEM website and will notify each Monitoring Entity in writing. A map-based interface will be available for users to identify the Monitoring Entity for each basin in the state.

DWR will prepare the first status report on the CASGEM program for the Governor and Legislature by January 1, 2012. In this initial report, DWR will report on the extent of groundwater elevation monitoring within each basin. This report will include a statewide prioritization of basins based on water supply, water demand, and other factors identified in Section 10933. DWR will explore options for basins without identified monitoring, with a focus on identifying options for local monitoring. Future status reports on the CASGEM program will be prepared by DWR in years ending in 5 or 0.

PURPOSE OF MONITORING ENTITY REPORTING PROCEDURES

The purpose of these procedures is to introduce the CASGEM program and its components as the framework for implementing SB 6, with particular emphasis on the initial step of establishing Monitoring Entities for each Bulletin 118 basin in the state.

A summary of the requirements of local entities to comply with the CASGEM program is presented in Table 1.

Table 1. Quick Guide for Local Entities

- Determine whether you qualify as a potential Monitoring Entity (see "Requirements to become Monitoring Entity" on pages 9-13)
- Identify the basins within your area (see Bulletin 118)
- Collaborate with other local entities to identify and choose the prospective Monitoring Entity (or Entities) for your area
- Submit Monitoring Entity notification to DWR through CASGEM website (http://www.water.ca.gov/groundwater/casgem) on or before January 1, 2011
- DWR will review the notification and advise the prospective Monitoring Entity of the status of the notification within 3 months of submittal
- Work with staff of the DWR regional office to address any deficiencies in the submittal
- If more than one party seeks to become the Monitoring Entity for the same area, work with staff of the DWR regional office to resolve
- Check the CASGEM website for a listing of the selected Monitoring Entities
- Develop and submit a Monitoring Plan to DWR through the CASGEM website
- Staff from the DWR regional office are available to assist with the Monitoring Plan and to recommend changes
- Submit monitoring data to DWR through the CASGEM website on or before January 1, 2012

CASGEM Schedule

<table>
<tr><th colspan="2">CASGEM Schedule</th><th colspan="2">DWR Activities</th><th>Local Entity Activities</th></tr>
<tr><td rowspan="3">2010</td><td>July-September</td><td colspan="2">ACWA/DWR Workshops</td><td rowspan="2">Collaborate to identify prospective Monitoring Entities</td></tr>
<tr><td rowspan="2">October-December</td><td colspan="2">•Draft Procedures and Guidelines
•Solicit Comments
•Finalize Procedures and Guidelines</td></tr>
<tr><td colspan="2">Notification System ready online</td><td>Prospective Monitoring Entities submit notifications to DWR</td></tr>
<tr><td rowspan="5">2011</td><td>January 1, 2011</td><td rowspan="4">Review and designation of Monitoring Entities</td><td rowspan="4">Review Monitoring Plans and provide recommendations</td><td>Monitoring Entity notifications due to DWR on or before 1/1/2011</td></tr>
<tr><td>January-March</td><td rowspan="2">Monitoring Entities develop and submit Monitoring Plans to DWR</td></tr>
<tr><td>April-June</td></tr>
<tr><td>July-September</td><td rowspan="2">Groundwater elevation monitoring begins and continues</td></tr>
<tr><td>October-December</td><td colspan="2">Preparation of first CASGEM status report</td></tr>
<tr><td>2012</td><td>January 1, 2012</td><td colspan="2">DWR submits first CASGEM status report to Governor and Legislature</td><td>First CASGEM data submittals due to DWR on or before 1/1/2012</td></tr>
</table>

A timetable for implementing the CASGEM schedule is shown above.

MONITORING ENTITIES

The CASGEM program establishes the framework for collaboration between local monitoring parties and DWR to collect groundwater elevation data throughout the state's 515 basins as defined in Bulletin 118. A Monitoring Entity is a local agency or group that voluntarily takes responsibility for conducting or coordinating groundwater elevation monitoring and reporting for all or part of a groundwater basin.

To determine if you are within a Bulletin 118 basin, please refer to maps and descriptions in Bulletin 118, available online at: http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm. Geographic Information System (GIS) shapefiles of the basins are also available at this website. DWR can assist in identifying other potential local monitoring parties in each basin.

ROLES AND RESPONSIBILITIES OF MONITORING ENTITIES

Through the CASGEM program, local entities with appropriate authority may notify DWR of their intent to be a Monitoring Entity. Monitoring Entities will have specific responsibilities, including:

- Coordinate with DWR to establish a Monitoring Plan
- Conduct or coordinate the regular and systematic monitoring of groundwater elevations as specified in the Monitoring Plan
- Submit monitoring data to DWR in a timely manner

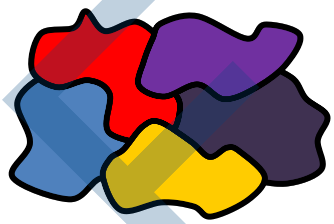
A Monitoring Entity can perform monitoring for any number of basins or portions thereof, but no area can have more than one Monitoring Entity. While the Monitoring Entity is responsible for compiling the data and submitting it to DWR for a particular area, the actual measurements can be taken by any number of agencies that would work under the direction of the Monitoring Entity. (Cooperating agencies would submit data to the Monitoring Entity, not to DWR.) Thus, assuming there are no overlapping areas or gaps in basin coverage for a given area, there are three possible basic scenarios, illustrated in Figure 1:

- A single Monitoring Entity that collects and reports groundwater elevation data for the entire basin (Scenario A);
- Multiple Monitoring Entities that collect and report groundwater elevation data for their portion of the basin (Scenario B); or

- An umbrella Monitoring Entity that coordinates and reports groundwater elevation data collected by multiple agencies within the basin (Scenario C).

Scenario A. One Monitoring Entity collects and reports data for entire basin

**Scenario B.
One basin, several Monitoring Entities collecting and submitting data**



**Scenario C.
One basin, one Monitoring Entity coordinating and submitting data collected by several agencies**

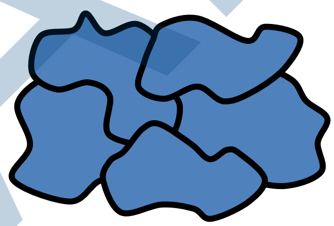


Figure 1. Illustration of possible Monitoring Entity scenarios for a monitored basin.

DWR currently monitors water elevations in about 4,000 wells statewide and cooperates with local and federal agencies to monitor roughly an additional 6,000 wells. DWR plans to continue monitoring groundwater elevations, contingent upon available funding. In some basins DWR currently does most, if not all, of the water-elevation monitoring. In these basins, a local entity still needs to notify DWR of their intent to become the Monitoring Entity. The Monitoring Entity must determine which DWR wells will be included in their CASGEM monitoring network. As long as DWR continues its monitoring program, the department will transmit its groundwater elevation data to the CASGEM system. However, if DWR is unable to continue monitoring for any reason, the Monitoring Entity will be required to re-evaluate its monitoring network to determine which wells to retain in its monitoring network.

REQUIREMENTS TO BECOME MONITORING ENTITY

Section 10927 of the Water Code defines the types of entities that may assume responsibility for monitoring and reporting groundwater elevations as part of the CASGEM program.

A summary list of eligible entities, in order of priority, and notification requirements for each entity is provided below:

1. A **watermaster or water management engineer** appointed by a court or pursuant to statute to administer a final judgment determining rights to groundwater [Section 10927(a)].
   Notification Requirements:
   - Name of Agency
   - Agency Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)
   - Name and number of basin to be monitored (from Bulletin 118)
   - Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
   - Statement that the entity will comply with the requirements of Water Code Part 2.11
   - Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

2. A **groundwater management agency** with statutory authority to manage groundwater pursuant to its principal act that is monitoring groundwater elevations in all or a part of a groundwater basin on or before January 1, 2010 [Section 10927(b)(1)].
   Notification Requirements:
   - Name of Agency
   - Agency Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)

- Name and number of basin to be monitored (from Bulletin 118)
- Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
- Statement that the entity will comply with the requirements of Water Code Part 2.11
- Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

3. A **water replenishment district** established pursuant to Water Code Division 18 (commencing with Section 60000). This part does not expand or otherwise affect the authority of a water replenishment district relating to monitoring elevations [Section 10927(b)(2)].

   Notification Requirements:

   - Name of Agency
   - Agency Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)
   - Name and number of basin to be monitored (from Bulletin 118)
   - Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
   - Statement that the entity will comply with the requirements of Water Code Part 2.11
   - Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

4. A **local agency that is managing all or part of a groundwater basin pursuant to Water Code Part 2.75** (commencing with Section 10750) and that was monitoring groundwater elevations in all or part of a groundwater basin on or before January 1, 2010, or a local agency or county that is managing all or part of a groundwater basin pursuant to any other legally enforceable groundwater management plan with provisions that are substantively similar to those described in that part and that was monitoring groundwater elevations in all or a part of a groundwater basin on or before January 1, 2010 [Section 10927(c)].

Notification Requirements:

- Name of Agency
- Agency Contact Name
- Address
- Telephone Number
- Email Address
- Any other relevant contact information
- Authority (as listed in Section 10927)
- Name and number of basin to be monitored (from Bulletin 118)
- Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
- Statement that the entity will comply with the requirements of Water Code Part 2.11
- Copy of current groundwater management plan
- Statement describing the ability or qualifications of the entity to conduct the groundwater monitoring functions required
- Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

5. A **local agency that is managing all or part of a groundwater basin pursuant to an integrated regional water management plan** prepared pursuant to Water Code Part 2.2 (commencing with Section 10530) that includes a groundwater management component that complies with the requirements of Section 10753.7 [Section 10927(d)].

   Notification Requirements:

   - Name of Agency
   - Agency Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)
   - Name and number of basin to be monitored (from Bulletin 118)
   - Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
   - Statement that the entity will comply with the requirements of Water Code Part 2.11
   - Copy of current groundwater component of integrated regional water management plan
   - Statement describing the ability or qualifications of the entity to conduct the groundwater monitoring functions required

- Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

6. A **county** that is not managing all or a part of a groundwater basin pursuant to a legally enforceable groundwater management plan with provisions that are substantively similar to those described in Water Code Part 2.75 (commencing with Section 10750) [Section 10927(e)].
   Notification Requirements:
   - Name of County
   - County Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)
   - Name and number of basin to be monitored (from Bulletin 118)
   - Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
   - Statement that the entity will comply with the requirements of Water Code Part 2.11
   - Statement describing the ability or qualifications of the entity to conduct the groundwater monitoring functions required
   - Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

7. A **voluntary cooperative groundwater monitoring association** formed pursuant to Section 10935 [Section 10927(f)]. As described in the Water Code Section 10935, the voluntary associations may be established by contract, a joint powers agreement, a memorandum of agreement, or other form of agreement deemed acceptable by DWR, so long as it contains: the names of the participants; the boundaries of the area covered by the agreement; the name or names of the parties responsible for meeting the requirements; the method of recovering the costs associated with meeting the requirements; and other provisions that may be required by DWR. Entities seeking to form a voluntary association should notify DWR, which will work cooperatively with the interested parties to facilitate the formation of the association.

Notification Requirements:

- Name of Association
- Association Contact Name
- Address
- Telephone Number
- Email Address
- Any other relevant contact information
- Authority (as listed in Section 10927)
- Name and number of basin to be monitored (from Bulletin 118)
- Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
- Statement that the entity will comply with the requirements of Water Code Part 2.11
- Statement describing the ability or qualifications of the entity to conduct the groundwater monitoring functions required
- Statement of intent to meet the association formation requirements described in Section 10935
- Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

Local agencies are encouraged to coordinate among themselves to determine the proposed Monitoring Entity or Entities that best suits their area. The resulting interested entity (or entities) should notify DWR of its intent to become a groundwater Monitoring Entity for one or more basins, or portions thereof by the January 1, 2011 deadline. Certain basic information is required for notification, including contact information and additional details depending on the authority of the entity desiring to monitor groundwater (Section 10928), as listed above. This notification information will be submitted to DWR using an online system that will be available by mid-December 2010.

MONITORING PLANS

Monitoring Entities will each develop a Monitoring Plan that includes the following sections: Monitoring Sites and Timing, Field Methods, and Data Reporting. Monitoring Plans should be completed and submitted to DWR by summer 2011. Staff from the DWR regional offices will be available to assist Monitoring Entities with the development of Monitoring Plans, if needed. In determining what information should be reported to DWR, the department will defer to existing monitoring programs if those programs result in information that demonstrates seasonal (annual high and low groundwater elevations) and long-term trends in groundwater elevations. Staff from the DWR regional offices will assist Monitoring Entities to address any gaps in basin coverage (see below) and other monitoring issues and may make recommendations for the location of additional wells. However, the department has no authority to require a Monitoring Entity to install additional wells unless funds are provided for that purpose. Once a Monitoring Plan is established with DWR, Monitoring Entities should notify DWR of any changes to the plan.

Key Components of Monitoring Plans

Submit to DWR by summer 2011

- Monitoring Sites and Timing
  - Well Network Design
  - Selected wells (current)
  - Planned (future) wells
  - Frequency to capture seasonal highs and lows
  - Map and shapefile of monitoring area and well locations

Field Methods for groundwater monitoring

- Methods for measuring
  - Reference Point
  - Static water level
  - Depth to water
  - Standardized form for data collection

Data Reporting

- Online data submittal, minimum July & January each year

DATA GAPS

A data gap refers to a basin or portion of a basin that is not included in any of the Monitoring Plans submitted to DWR. This is essentially an area that lacks the density of monitoring wells that would allow seasonal and long-term trends in groundwater elevations to be determined for the basin, subbasin, or a portion thereof. Among the 515 basins defined by Bulletin 118, data gaps may exist for a variety of reasons, including a lack of suitable monitoring wells, lack of groundwater use, access issues, and jurisdictional issues, among others.

If no local entity is able and/or willing to fill a data gap, the department may be required to perform groundwater monitoring functions. If DWR performs this monitoring, local agencies and the county that have the authority under Section 10927 to monitor the area of the data gap would be potentially ineligible for a water grant or loan awarded or administered by the state. The Monitoring Entity or entities with the authority to monitor the area of the data gap should provide detailed information regarding the nature of and reason for the data gap so that DWR may include such information in the prioritization of groundwater basins and subbasins as appropriate.

Agencies and counties that are eligible to be designated Monitoring Entities but choose not participate in the CASGEM program will not lose their state water grant and loan eligibility if their entire service area qualifies as a disadvantaged community (Water Code Section 10933.7(b)). It will be the responsibility of the local agency or county applying for a state water grant or loan to demonstrate their disadvantaged community status at the time they are applying for the grant or loan.

MONITORING SITES AND TIMING

The Monitoring Plan will identify the wells to be monitored and the frequency with which they will be monitored. The Monitoring Plan should explain how proposed monitoring will be sufficient to demonstrate the seasonal and long-term groundwater elevation trends in the monitored area. The density of monitoring locations will depend on the complexity of the basin.

Because of security concerns, the California Department of Public Health (DPH) routinely limits the disclosure of detailed public water supply well location information. Pursuant to Water Code Section 10931, the DWR is required to collaborate with DPH to ensure that the information reported to the CASGEM program will not result in the inappropriate disclosure of information of concern to DPH. At this time, DWR has reached no agreement with DPH regarding the appropriate treatment of public water supply well data. As a result, CASGEM does not currently plan to use such well information in its database.

The Monitoring Plan should contain a table identifying the wells to be monitored and the timing of that monitoring. Because the law specifies that information should demonstrate seasonal and long-term trends in groundwater elevations, at a minimum monitoring should be conducted at each location for the yearly high and low for the basin. The yearly high and low groundwater elevations typically occur in spring and fall, but this may vary from basin to basin. It is very important that the timing of all the measurements in the basin is coordinated. Rationale for selection of the timing (seasonal highs and lows) should be included in the Monitoring Plan.

The information on the monitoring sites and timing to be submitted in the online system should include:

- Well identification number
- State well number
- Location (decimal latitude and longitude, North American Datum (NAD) 83)
- Reference point elevation (feet, North American Vertical Datum (NAVD) 88)
- Land surface datum (feet, NAVD88)
- Map and shapefile with monitoring locations, Bulletin 118 groundwater basin boundary, and boundary of monitoring area
- Frequency and timing of measurements

FIELD METHODS

The consistent and documented collection of groundwater elevation data is important for ensuring that the data can be used across the state, regardless of the Monitoring Entity. The field methods should meet a common set of basic requirements; however, the methods do not have to be exactly the same. Many entities already have in place monitoring efforts that are successful in meeting local needs and that can meet the needs for this program, either as-is or with the incorporation of individual components. The CASGEM program wishes to maintain, to the greatest extent possible, the procedures of high-quality local groundwater elevation monitoring programs, so long as they meet the overall program goals and policies. Of particular concern are the following basic requirements:

- Method(s) to establish the Reference Point, including step-by-step instructions
- Method(s) to ensure static groundwater elevation
- Method(s) to measure depth to water, including step-by-step instructions
- Method(s) and form(s) for recording measurements

It is the responsibility of each Monitoring Entity to develop and implement monitoring protocols that are appropriate to local groundwater basin conditions, protect the water quality of its monitoring wells, and maintain the quality of the data that it submits to the CASGEM Program. DWR has developed field guidelines (Department of Water Resources Groundwater Elevation Monitoring Guidelines) based on a review of existing field methods from DWR and other organizations, which is available on the CASGEM website. Monitoring Entities are welcome to refer to these guidelines when developing field methods for their own Monitoring Plans. However, the DWR guidelines are for internal use in the event that the Department is required to perform groundwater monitoring functions pursuant to Section 10933.5 and are not binding on any other agency. The core of the CASGEM program will rely and build on the many, established local long-term groundwater monitoring and management programs. The department will defer to existing monitoring programs that result in information that demonstrates seasonal and long-term trends in groundwater elevations.

DATA REPORTING

DWR will develop an online data submittal system for Monitoring Entities to submit their groundwater elevation data. Several methods of submitting data will be available, such as direct online data entry, or upload of data files for batch entry. Initial groundwater elevation data should be submitted to DWR by January 1, 2012. Thereafter, data should be submitted as soon as possible after collection, but no later than January 1st and July 1st of each year, at the minimum. Historical data can also be submitted via the DWR data system to aid in data interpretation. All submitted data will be available to the public, except for confidential data.

Each groundwater elevation data measurement submitted to the online system should include:

- Well identification number
- Measurement date
- Reference point and land surface elevation
- Depth to water
- Method of measuring water depth
- Measurement quality codes

The Monitoring Entity information, well information, and groundwater elevation information is to be provided by the Monitoring Entity. Items labeled as required must be submitted to DWR to report groundwater elevations. Items labeled as recommended should be submitted to DWR if they are available, as they assist in fully evaluating the quality of measurements. DWR will provide standard form(s) for Monitoring Entities to submit groundwater elevation data online. However, if Monitoring Entities cannot use the standard form(s) or provide the data elements listed below, DWR will work cooperatively with Monitoring Entities to develop alternate methods of submitting data.

Entity Information

All entities assuming groundwater monitoring functions as delineated in Section 10927 (a)-(f) are required to submit the following information:

- Monitoring Entity's name, address, telephone number, contact person name and email address, and any other relevant contact information (Section 10928 (a) (1), 10928 (b) (1))
- Name, address, telephone number, email address and any other relevant contact information for entities collecting data that is submitted by a designated submitting entity (Monitoring Entity)
- Groundwater basins being monitored
    - Identify entire basins monitored
    - Identify partial basins monitored

Well Information

The following information about each well is required for the CASGEM online system:

- Unique well identification number. Agencies may use an existing State Well Number, an existing local well designation, or develop their own identification name, using the following protocol:
    - Agency name, abbreviation, or acronym followed by a sequential number (e.g., SGA 01)
    - Groundwater basin – followed by a sequential number (e.g., Llagas 03)
    - Geographic name – followed by a sequential number (e.g., Yolo 12)
    - Well names should be 15 characters long or less
    - Avoid using owner/business names or specific locational information for privacy and security
- Decimal latitude/longitude coordinates of well, using horizontal datum NAD83, and the method of determining coordinates (Actual coordinates are preferred; however, Monitoring Entities may submit approximate locations, as needed, to protect the privacy of well owners. For example, to protect the privacy of a well owner, a Monitoring Entity may submit well coordinate locations that are only within 1000-feet of the actual well location.)
- Groundwater basin or sub-basin
- Reference point elevation of the well (feet) using NAVD88 vertical datum
- Elevation of land surface datum at the well (feet) using NAVD88 vertical datum
- Use of well (e.g., dedicated monitoring, irrigation, domestic, etc)
- Well completion type (e.g. single well, nested, or multi-completion wells)
- Depth of screened interval(s) and total well depth of well, if available (feet)
- Well Completion Report number (DWR Form 188), if available

The following information about each well is recommended for the CASGEM online system:

- State Well Number – assigned by DWR in most cases
- Method by which land surface elevation was determined (for example, topographic map, GPS, etc.)
- Written description of location of well, including distance from nearby landmarks and location of reference point in relation to well appurtenances (DWR Form 429)
- Well information comments

Groundwater Elevation Information

The following information for each groundwater elevation measurement is required for the CASGEM online system:

- Well identification number (see Well Information, above)
- Measurement date
- Reference point elevation of the well (feet) using NAVD88 vertical datum
- Elevation of land surface datum at the well (feet) using NAVD88 vertical datum
- Depth to water below reference point (feet) (unless no measurement was taken)
- Method of measuring water depth
- Measurement Quality Codes

- If no measurement is taken, a specified "no measurement" code, must be recorded. Standard codes will be provided by the online system. If a measurement is taken, a "no measurement" code is not recorded.)
- If the quality of a measurement is uncertain, a "questionable measurement" code can be recorded. Standard codes will be provided by the online system. If no measurement is taken, a "questionable measurement" code is not recorded.)

- Measuring agency identification

The following information for each groundwater elevation measurement is recommended for the CASGEM online system:

- Measurement time (PST/PDT with military time/24 hour format)
- Comments about measurement, if applicable

Groundwater elevation data shall be submitted electronically to DWR's online system. DWR will develop electronic data transmittal (EDT) alternatives and data standards to permit bulk data transfer and assist Monitoring Entities in EDT reporting to DWR. As stated above, if Monitoring Entities cannot use the standard form(s) or provide the necessary groundwater elevation data elements, DWR will work cooperatively with Monitoring Entities to develop alternate methods of submitting data.

The CASGEM online data submittal system will be compatible with the Water Data Library (WDL) (http://www.water.ca.gov/waterdatalibrary/), DWR's existing groundwater elevation database. The CASGEM system will include data reporting options similar to those in WDL, such as hydrographs, seasonal contour data, and data downloads. The combined accessibility of the WDL and the CASGEM system will be a significant resource for local agencies in making sound groundwater management decisions.

REFERENCES

California Departement of Water Resources. (2003). *California's Groundwater, Bulletin 118-03.*

California Department of Water Resources. (2009). *California Water Plan Update 2009, Bulletin 160-09.*

APPENDIX – SENATE BILL 6 (7TH EXTRAORDINARY SESSION) - GROUNDWATER MONITORING

Senate Bill No. 6

CHAPTER 1

An act to add Part 2.11 (commencing with Section 10920) to Division 6 of, and to repeal and add Section 12924 of, the Water Code, relating to groundwater.

[Approved by Governor November 6, 2009. Filed with Secretary of State November 6, 2009.]

Legislative Counsel's Digest

SB 6, Steinberg. Groundwater.

(1) Existing law authorizes a local agency whose service area includes a groundwater basin that is not subject to groundwater management to adopt and implement a groundwater management plan pursuant to certain provisions of law. Existing law requires a groundwater management plan to include certain components to qualify as a plan for the purposes of those provisions, including a provision that establishes funding requirements for the construction of certain groundwater projects.

This bill would establish a groundwater monitoring program pursuant to which specified entities, in accordance with prescribed procedures, may propose to be designated by the Department of Water Resources as groundwater monitoring entities, as defined, for the purposes of monitoring and reporting with regard to groundwater elevations in all or part of a basin or subbasin, as defined. The bill would require the department to work cooperatively with each monitoring entity to determine the manner in which groundwater elevation information should be reported to the department. The bill would authorize the department to make recommendations for improving an existing monitoring program, and to require additional monitoring wells under certain circumstances. Under certain circumstances, the department would be required to perform groundwater monitoring functions. In that event, prescribed entities with authority to assume groundwater monitoring functions with regard to a basin or subbasin for which the department has assumed those functions would not be eligible for a water grant or loan awarded or administered by the state.

(2) Existing law requires the department to conduct an investigation of the state's groundwater basins and to report its findings to the Governor and the Legislature not later than January 1, 1980.

This bill would repeal that provision. The department would be required to conduct an investigation of the state's groundwater basins and to report its findings to the Governor and the Legislature not later than January 1, 2012, and thereafter in years ending in 5 or 0.

(3) The bill would take effect only if SB 1 and SB 7 of the 2009–10 7th Extraordinary Session of the Legislature are enacted and become effective.

The people of the State of California do enact as follows:

SECTION 1. Part 2.11 (commencing with Section 10920) is added to Division 6 of the Water Code, to read:

PART 2.11. GROUNDWATER MONITORING

Chapter 1. General Provisions

10920. (a) It is the intent of the Legislature that on or before January 1, 2012, groundwater elevations in all groundwater basins and subbasins be regularly and systematically monitored locally and that the resulting groundwater information be made readily and widely available.

(b) It is further the intent of the Legislature that the department continue to maintain its current network of monitoring wells, including groundwater elevation and groundwater quality monitoring wells, and that the department continue to coordinate monitoring with local entities.

10921. This part does not require the monitoring of groundwater elevations in an area that is not within a basin or subbasin.

10922. This part does not expand or otherwise affect the powers or duties of the department relating to groundwater beyond those expressly granted by this part.

Chapter 2. Definitions

10925. Unless the context otherwise requires, the definitions set forth in this section govern the construction of this part.

(a) “Basin” or “subbasin” means a groundwater basin or subbasin identified and defined in the department’s Bulletin No. 118.

(b) “Bulletin No. 118” means the department’s report entitled “California’s Groundwater: Bulletin 118” updated in 2003, or as it may be subsequently updated or revised in accordance with Section 12924.

(c) “Monitoring entity” means a party conducting or coordinating the monitoring of groundwater elevations pursuant to this part.

(d) “Monitoring functions” and “groundwater monitoring functions” means the monitoring of groundwater elevations, the reporting of those elevations to the department, and other related actions required by this part.

(e) “Monitoring groundwater elevations” means monitoring groundwater elevations, coordinating the monitoring of groundwater elevations, or both.

(f) “Voluntary cooperative groundwater monitoring association” means an association formed for the purposes of monitoring groundwater elevations pursuant to Section 10935.

Chapter 3. Groundwater Monitoring Program

10927. Any of the following entities may assume responsibility for monitoring and reporting groundwater elevations in all or a part of a basin or subbasin in accordance with this part:

(a) A watermaster or water management engineer appointed by a court or pursuant to statute to administer a final judgment determining rights to groundwater.

(b) (1) A groundwater management agency with statutory authority to manage groundwater pursuant to its principal act that is monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010.

(2) A water replenishment district established pursuant to Division 18 (commencing with Section 60000). This part does not expand or otherwise affect the authority of a water replenishment district relating to monitoring groundwater elevations.

(c) A local agency that is managing all or part of a groundwater basin or subbasin pursuant to Part 2.75 (commencing with Section 10750) and that was monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010, or a local agency or county that is managing all or part of a groundwater basin or subbasin pursuant to any other legally enforceable groundwater management plan with provisions that are substantively similar to those described in that part and that was monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010.

(d) A local agency that is managing all or part of a groundwater basin or subbasin pursuant to an integrated regional water management plan prepared pursuant to Part 2.2 (commencing with Section 10530) that includes a groundwater management component that complies with the requirements of Section 10753.7.

(e) A county that is not managing all or a part of a groundwater basin or subbasin pursuant to a legally enforceable groundwater management plan with provisions that are substantively similar to those described in Part 2.75 (commencing with Section 10750).

(f) A voluntary cooperative groundwater monitoring association formed pursuant to Section 10935.

10928. (a) Any entity described in subdivision (a) or (b) of Section 10927 that seeks to assume groundwater monitoring functions in accordance with this part shall notify the department, in writing, on or before January 1, 2011. The notification shall include all of the following information:

(1) The entity's name, address, telephone number, and any other relevant contact information.

(2) The specific authority described in Section 10927 pursuant to which the entity qualifies to assume the groundwater monitoring functions.

(3) A map showing the area for which the entity is requesting to perform the groundwater monitoring functions.

(4) A statement that the entity will comply with all of the requirements of this part.

(b) Any entity described in subdivision (c), (d), (e), or (f) of Section 10927 that seeks to assume groundwater monitoring functions in accordance with this part shall notify the department, in writing, by January 1, 2011. The information provided in the notification shall include all of the following:

(1) The entity's name, address, telephone number, and any other relevant contact information.

(2) The specific authority described in Section 10927 pursuant to which the entity qualifies to assume the groundwater monitoring functions.

(3) For entities that seek to qualify pursuant to subdivision (c) or (d) of Section 10927, the notification shall also include a copy of the current groundwater management plan or the groundwater component of the integrated regional water management plan, as appropriate.

(4) For entities that seek to qualify pursuant to subdivision (f) of Section 10927, the notification shall include a statement of intention to meet the requirements of Section 10935.

(5) A map showing the area for which the entity is proposing to perform the groundwater monitoring functions.

(6) A statement that the entity will comply with all of the requirements of this part.

(7) A statement describing the ability and qualifications of the entity to conduct the groundwater monitoring functions required by this part.
(c) The department may request additional information that it deems necessary for the purposes of determining the area that is proposed to be monitored or the qualifications of the entity to perform the groundwater monitoring functions.

10929. (a) (1) The department shall review all notifications received pursuant to Section 10928.

(2) Upon the receipt of a notification pursuant to subdivision (a) of Section 10928, the department shall verify that the notifying entity has the appropriate authority under subdivision (a) or (b) of Section 10927.

(3) Upon the receipt of a notification pursuant to subdivision (b) of Section 10928, the department shall do both of the following:

(A) Verify that each notification is complete.

(B) Assess the qualifications of the notifying party.

(b) If the department has questions about the completeness or accuracy of a notification, or the qualifications of a party, the department shall contact the party to resolve any deficiencies. If the department is unable to resolve the deficiencies, the department shall notify the party in writing that the notification will not be considered further until the deficiencies are corrected.

(c) If the department determines that more than one party seeks to become the monitoring entity for the same portion of a basin or subbasin, the department shall consult with the interested parties to determine which party will perform the monitoring functions. In determining which party will perform the monitoring functions under this part, the department shall follow the order in which entities are identified in Section 10927.

(d) The department shall advise each party on the status of its notification within three months of receiving the notification.

10930. Upon completion of each review pursuant to Section 10929, the department shall do both of the following if it determines that a party will perform monitoring functions under this part:

(a) Notify the party in writing that it is a monitoring entity and the specific portion of the basin or subbasin for which it shall assume groundwater monitoring functions.

(b) Post on the department's Internet Web site information that identifies the monitoring entity and the portion of the basin or subbasin for which the monitoring entity will be responsible.

10931. (a) The department shall work cooperatively with each monitoring entity to determine the manner in which groundwater elevation information should be reported to the department pursuant to this part. In determining what information should be reported to the department, the department shall defer to existing monitoring programs if those programs result in information that demonstrates seasonal and long-term trends in groundwater elevations. The department shall collaborate with the State Department of Public Health to ensure that the information reported to the department will not result in the inappropriate disclosure of the physical address or geographical location of drinking water sources, storage facilities, pumping operational data, or treatment facilities.

(b) (1) For the purposes of this part, the department may recommend improvements to an existing monitoring program, including recommendations for additional monitoring wells.

(2) The department may not require additional monitoring wells unless funds are provided for that purpose.

10932. Monitoring entities shall commence monitoring and reporting groundwater elevations pursuant to this part on or before January 1, 2012.

10933. (a) On or before January 1, 2012, the department shall commence to identify the extent of monitoring of groundwater elevations that is being undertaken within each basin and subbasin.

(b) The department shall prioritize groundwater basins and subbasins for the purpose of implementing this section. In prioritizing the basins and subbasins, the department shall, to the extent data are available, consider all of the following:

(1) The population overlying the basin or subbasin.

(2) The rate of current and projected growth of the population overlying the basin or subbasin.

(3) The number of public supply wells that draw from the basin or subbasin.

(4) The total number of wells that draw from the basin or subbasin.

(5) The irrigated acreage overlying the basin or subbasin.

(6) The degree to which persons overlying the basin or subbasin rely on groundwater as their primary source of water.

(7) Any documented impacts on the groundwater within the basin or subbasin, including overdraft, subsidence, saline intrusion, and other water quality degradation.

(8) Any other information determined to be relevant by the department.

(c) If the department determines that all or part of a basin or subbasin is not being monitored pursuant to this part, the department shall do all of the following:

(1) Attempt to contact all well owners within the area not being monitored.

(2) Determine if there is an interest in establishing any of the following:

(A) A groundwater management plan pursuant to Part 2.75 (commencing with Section 10750).

(B) An integrated regional water management plan pursuant to Part 2.2 (commencing with Section 10530) that includes a groundwater management component that complies with the requirements of Section 10753.7.

(C) A voluntary groundwater monitoring association pursuant to Section 10935.

(d) If the department determines that there is sufficient interest in establishing a plan or association described in paragraph (2) of subdivision (c), or if the county agrees to perform the groundwater monitoring functions in accordance with this part, the department shall work cooperatively with the interested parties to comply with the requirements of this part within two years.

(e) If the department determines, with regard to a basin or subbasin, that there is insufficient interest in establishing a plan or association described in paragraph (2) of subdivision (c), and if the county decides not to perform the groundwater monitoring and reporting functions of this part, the department shall do all of the following:

(1) Identify any existing monitoring wells that overlie the basin or subbasin that are owned or operated by the department or any other state or federal agency.

(2) Determine whether the monitoring wells identified pursuant to paragraph (1) provide sufficient information to demonstrate seasonal and long-term trends in groundwater elevations.

(3) If the department determines that the monitoring wells identified pursuant to paragraph (1) provide sufficient information to demonstrate seasonal and long-term trends in groundwater elevations, the department shall not perform groundwater monitoring functions pursuant to Section 10934.

(4) If the department determines that the monitoring wells identified pursuant to paragraph (1) provide insufficient information to demonstrate seasonal and long-term trends in groundwater elevations, and the State Mining and Geology Board concurs with

that determination, the department shall perform groundwater monitoring functions pursuant to Section 10934.[1]

10933.5. (a) Consistent with Section 10933, the department shall perform the groundwater monitoring functions for those portions of a basin or subbasin for which no monitoring entity has agreed to perform the groundwater monitoring functions.

(b) Upon determining that it is required to perform groundwater monitoring functions, the department shall notify both of the following entities that it is forming the groundwater monitoring district:

(1) Each well owner within the affected area.

(2) Each county that contains all or a part of the affected area.

(c) The department shall not assess a fee or charge to recover the costs for carrying out its power and duties under this part.

(d) The department may establish regulations to implement this section.

10933.7. (a) If the department is required to perform groundwater monitoring functions pursuant to Section 10933.5, the county and the entities described in subdivisions (a) to (d), inclusive, of Section 10927 shall not be eligible for a water grant or loan awarded or administered by the state.

(b) Notwithstanding subdivision (a), the department shall determine that an entity described in subdivision (a) is eligible for a water grant or loan under the circumstances described in subdivision (a) if the entity has submitted to the department for approval documentation demonstrating that its entire service area qualifies as a disadvantaged community.

10934. (a) For purposes of this part, neither any entity described in Section 10927, nor the department, shall have the authority to do either of the following:

(1) To enter private property without the consent of the property owner.

[1] The reference in Section 10933(e)(4) to Section 10934 has been amended by Stats. 2010, Ch. 328, sec. 237 (S.B. 1330). The new reference will be to Section 10933.5.

(2) To require a private property owner to submit groundwater monitoring information to the entity.

(b) This section does not apply to a county or an entity described in subdivisions (a) to (d), inclusive, of Section 10927 that assumed responsibility for monitoring and reporting groundwater elevations prior to the effective date of this part.

10935. (a) A voluntary cooperative groundwater monitoring association may be formed for the purposes of monitoring groundwater elevations in accordance with this part. The association may be established by contract, a joint powers agreement, a memorandum of agreement, or other form of agreement deemed acceptable by the department.

(b) Upon notification to the department by one or more entities that seek to form a voluntary cooperative groundwater monitoring association, the department shall work cooperatively with the interested parties to facilitate the formation of the association.

(c) The contract or agreement shall include all of the following:

(1) The names of the participants.

(2) The boundaries of the area covered by the agreement.

(3) The name or names of the parties responsible for meeting the requirements of this part.

(4) The method of recovering the costs associated with meeting the requirements of this part.

(5) Other provisions that may be required by the department.

10936. Costs incurred by the department pursuant to this chapter may be funded from unallocated bond revenues pursuant to paragraph (12) of subdivision (a) of Section 75027 of the Public Resources Code, to the extent those funds are available for those purposes.

SEC. 2. Section 12924 of the Water Code is repealed.

SEC. 3. Section 12924 is added to the Water Code, to read:

12924. (a) The department, in conjunction with other public agencies, shall conduct an investigation of the state's groundwater basins. The department shall identify the state's groundwater basins on the basis of geological and hydrological conditions and consideration of political boundary lines whenever practical. The department shall also investigate existing general patterns of groundwater pumping and groundwater recharge within those basins to the extent necessary to identify basins that are subject to critical conditions of overdraft.

(b) The department shall report its findings to the Governor and the Legislature not later than January 1, 2012, and thereafter in years ending in 5 or 0.

SEC. 4. This act shall take effect only if Senate Bill 1 and Senate Bill 7 of the 2009–10 Seventh Extraordinary Session of the Legislature are enacted and become effective.

Chapter 4
Appendix B

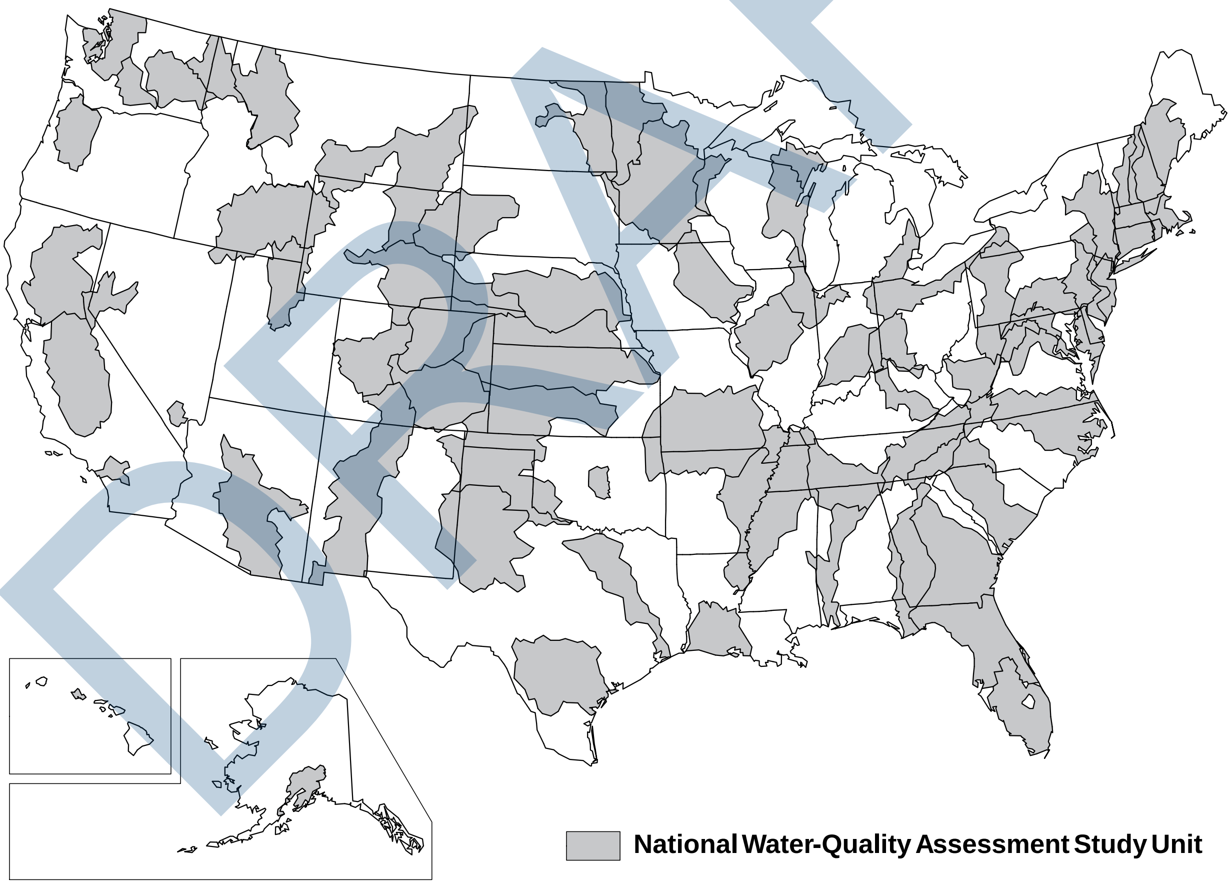
USGS Groundwater Data Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water-Quality Samples and Related Data

This page intentionally left blank.

GROUND-WATER DATA-COLLECTION PROTOCOLS AND PROCEDURES FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM: COLLECTION AND DOCUMENTATION OF WATER-QUALITY SAMPLES AND RELATED DATA

U.S. GEOLOGICAL SURVEY

Open-File Report 95-399



NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

GROUND-WATER DATA-COLLECTION PROTOCOLS AND PROCEDURES FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM: COLLECTION AND DOCUMENTATION OF WATER-QUALITY SAMPLES AND RELATED DATA

By Michael T. Koterba, Franceska D. Wilde, and Wayne W. Lapham

---

U.S. Geological Survey

Open-File Report 95-399

Reston, Virginia
1995

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary *Seal*

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For additional information, write to:

NAWQA - Mail Stop 413
U.S. Geological Survey
12201 Sunrise Valley Drive
Reston, Virginia 22092

Copies of this report can be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Denver Federal Center
Denver, Colorado 80225

FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the NationÕs freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

(signed)

Robert M. Hirsch
Chief Hydrologist

CONTENTS

ILLUSTRATIONS

TABLES

TABLES--Continued

CONVERSION FACTORS AND ABBREVIATIONS

Multiply	**By**	**To obtain**
	Length	
inch (in)	25.4	millimeter
	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square kilometer
	Volume	
gallon (gal)	3.785	liter
	3785	milliliter
	Flow	
gallon per minute (gal/min)	0.06308	liter per second

Physical and Chemical Water-Quality Units

Temperature: Water and air temperature are given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by use of the following equation:

$$°F = 1.8(°C) + 32$$

Specific electrical conductance of water is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). This unit is equivalent to micromhos per centimeter at 25 degrees Celsius.

method detection limit (MDL): The minimum concentration of a substance that can be identified, measured, and reported with 99-percent confidence that the analyte concentration is greater than zero; determined from analysis of a sample in a given matrix containing analtye.

minimum reporting level (MRL): The smallest measured concentration of a constituent that may be reliably reported using a given analytical method. In many cases, the MRL is used when documentation for the method detection limit is not available.

micrometer (µm), or "micron": The millionth part of the meter--the pore diameter of filter membranes is given in micrometer units.

milligrams per liter (mg/L) or micrograms per liter (µg/L): Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) or water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

millivolt (mV): A unit of electromotive force equal to one thousandth of a volt.

nephelometric turbidity unit (NTU): A measure of turbidity in a water sample, roughly equivalent to Formazin turbidity unit (FTU) and Jackson turbidity unit (JTU).

normality, *N* (equivalents/L): The number of equivalents of acid, base, or redox-active species per liter of solution. Examples: a solution that is 0.01 formal in HCl is 0.01 *N* in H^+. A solution that is 0.01 formal in H_2SO_4 is 0.02 *N* in H^+.

GROUND-WATER DATA-COLLECTION PROTOCOLS AND PROCEDURES FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM: COLLECTION AND DOCUMENTATION OF WATER-QUALITY SAMPLES AND RELATED DATA

By Michael T. Koterba, Franceska D. Wilde, and Wayne W. Lapham

ABSTRACT

Protocols for ground-water sampling are described in a report written in 1989 as part of the pilot program for the National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS). These protocols have been reviewed and revised to address the needs of the full-scale implementation of the NAWQA Program that began in 1991. This report, which is a collaborative effort between the NAWQA Program and the USGS Office of Water Quality, is the result of that review and revision.

This report describes protocols and recommended procedures for the collection of water-quality samples and related data from wells for the NAWQA Program. Protocols and recommended procedures discussed include (1) equipment setup and other preparations for data collection; (2) well purging and field measurements; (3) collecting and processing ground-water-quality samples; (4) equipment decontamination; (5) quality-control sampling; and (6) sample handling and shipping.

INTRODUCTION

The full-scale implementation of the National Water-Quality Assessment (NAWQA) Program in 1991 required updating the ground-water protocols prepared for the NAWQA pilot program (Hardy and others, 1989) and more detailed information for collecting ground-water-quality data in the NAWQA Program. That effort has resulted in this report and a companion report by Lapham and others (in press). Broader based reports that establish and document ground-water data-collection protocols and procedures for all U.S. Geological Survey (USGS) programs include Radtke and Wilde (in press) and two planned companion reports.[1]

This report describes protocols and recommended procedures for collecting ground-water-quality samples and related data (hereafter referred to as ground-water-quality data) specifically for the Occurrence and Distribution Assessment component of the full-scale NAWQA Program. In addition to updating and expanding the report by Hardy and others (1989), this report complements other reports prepared for the NAWQA Program, including those that describe NAWQA well installation, selection, and documentation (Lapham and others, in press), design of the NAWQA Program (Gilliom and others, 1995; Alley and Cohen, 1991), the conceptual

---

[1]For further information about the status of these planned reports contact the Office of Water Quality, U.S. Geological Survey, 412 National Center, Reston, VA 22092.

framework of the NAWQA Program (Leahy and Wilber, 1991; Hirsch and others, 1988; Cohen and others, 1988), an implementation plan for the NAWQA Program (Leahy and others, 1990), and a description of a quality-assurance (administrative) plan for the NAWQA pilot program (Mattraw and others, 1989).

For the purposes of this report, a protocol identifies a course of action that is mandatory under most circumstances as a consequence of USGS and NAWQA policies. For example, the routine collection of quality-control samples throughout the period during which ground-water-quality data are being collected is a protocol, and the requirement that equipment be decontaminated between uses according to prescribed methods to avoid cross-contamination of water-quality samples and the wells being sampled is a protocol. A recommended procedure is one that generally is preferred over other procedures that are available or commonly used. A procedure generally is recommended for the purpose of conforming to rules for good field practices and is expected to result in reproducible data of a desired and defined quality. Recommended procedures are not protocols because they are either too restrictive or possibly inappropriate in some situations. For example, one recommended procedure is to measure the water level in the well before ground-water-quality data are collected; this is not possible for some water-supply wells. Another recommended procedure is that equipment decontamination, which is required, be conducted in the field immediately after use; this, however, is not possible for some field-site conditions.

Although modifications are likely as new technologies evolve, the protocols and recommended procedures for data collection and documentation described in this report are considered capable of producing representative data of known quality that are suitable for assessment, while also being feasible to employ, given limitations of time and funds. Their use promotes consistency and comparability of ground-water data among Study Units in the NAWQA Program.

Background

The USGS began full-scale implementation of the NAWQA Program in 1991. The goals of the NAWQA Program are to (1) provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources; (2) define long-term trends in water quality; and (3) identify, describe, and explain major factors that could affect observed water-quality conditions and trends (Hirsch and others, 1988).

The design concepts of the NAWQA Program are based in part on a pilot program that began in 1986. The NAWQA pilot program consisted of seven Study Units conducting water-quality assessment in separate study areas. These study areas were distributed geographically throughout the continental United States and represented diverse hydrologic environments and water-quality conditions. Four of the pilot assessments focused on surface water and three focused on ground water. The ground-water pilot study areas were the Carson River Basin in Nevada and California (Welch and Plume, 1987); the Central Oklahoma Aquifer in Oklahoma (Christenson and Parkhurst, 1987); and the Delmarva Peninsula in Delaware, Maryland, and Virginia (Bachman and others, 1987).

The NAWQA Program design that has evolved from the pilot program consists of two major components: (1) Study-Unit Investigations of both surface and ground water, and (2) National Assessment activities, which combine results of individual Study Units for selected topics. This design provides information on water quality for policymakers and managers at local, State, regional, and national scales.

Components and attributes of the current ground-water-sampling design for a Study Unit are described in Lapham and others (in press) and Gilliom and others (1995). In brief, for the full-scale NAWQA Program, investigations of 60 Study Units, ranging in area from 1,200 to more than 60,000 square miles, are ongoing or planned. The 60 Study Units include parts of most of the major river basins and aquifer systems in the Nation, and incorporate about 60 to 70 percent of the Nation's water use and population served by public water supply. Investigations in each Study Unit are being conducted on a rotational rather than a continuous basis. One-third of the Study Units are being studied intensively at any given time. For each Study Unit, a 3- to 4-year intensive period of data collection and analysis will be alternated with a 6- to 7-year period of low-intensity assessment activities. The first intensive period of study for 20 of the 60 Study Units, which is referred to as the Occurrence and Distribution Assessment, began in 1993.

Data from each Occurrence and Distribution Assessment will be aggregated and compared for selected topics from all Study Units, as well as from other programs, to obtain regional and national perspectives on water quality. Consistent methods of data collection by the Study Units are needed for comparability of data. The protocols and recommended procedures described in this report are intended to ensure that consistency.

Purpose and Scope

This report describes protocols and recommended procedures to be used by the NAWQA Program for the collection of ground-water-quality data from wells. Protocols and recommended procedures discussed relate to the plans and preparations for ground-water sampling, and the collecting, processing, and handling of ground-water samples, including well purging, field measurements taken during purging, equipment decontamination, quality-control sampling, and sample documentation, handling, and shipping. Quality-assurance protocols and procedures are incorporated for each data-collection activity.

Quality Assurance and Quality Control

In this report, quality assurance refers to activities that control or guide data-collection methods, such as protocols, recommended procedures, and work plans and schedules. Quality control refers to the data or measurements generated to quantify measurement bias and variability associated with the data-collection process. The quality assurance (QA) activities and quality control (QC) data associated with NAWQA protocols and recommended procedures described in this report are best carried out as an integral part of the plans, preparations, implementation, and documentation used to obtain ground-water-quality data (Shampine and others, 1992). To emphasize the importance of an integrated approach, and the need for all NAWQA ground-water staff to participate, the protocols and recommended procedures that relate to QA and QC appear throughout this report in relation to a variety of responsibilities and activities, rather than being segregated in a separate section.

An integrated approach to QA and QC helps to clarify what needs to be done, when, and by whom through QA activities that are logically and efficiently coordinated with other activities and through the collection of data to assess that the ground-water data collected are of a quality suitable for Study-Unit and National Assessments. In order of discussion, the data-quality requirements for NAWQA ground-water sampling and the role of QC sampling are described in "Data-Quality Requirements." Equipment and supplies specific to QC sampling are described, along with those generally required to obtain water-quality data, in "Selection and Purchase of Equipment and Supplies." The QA requirements for field instruments and water-quality vehicles are incorporated under the respective topics (see "Field Instruments" and "Water-Quality Vehicles"). The design for selecting QC sample types and scheduling their collection are described immediately following the discussion of the design of water-quality sampling schedules.

Protocols and recommended procedures to be followed in collecting QC samples are incorporated as part of a number of activities that occur in chronological order and that define the overall data-collection process at a well. For example, the collection of replicate ground-water samples is described after well purging, and as part of the discussion on the collection of water-quality samples (see "Sample Collection and Processing"), whereas the collection of field blanks is described after equipment decontamination (see "Preparation of Blank Samples"). Preparing special types of samples, including QC samples such as field spikes, is described after the section on field blanks because that is when field-spiked samples for pesticides and volatile organic compounds will be prepared (see "Preparation of Other Routine Quality-Control Samples and Field Extracts of Pesticide Samples"). Finally, documentation activities relating directly to QA and QC are described throughout this report.

Although this report includes many QA-QC protocols and recommended procedures, it does not replace the need for individual Study Units to assess, review, and possibly expand on those described. Study Units are encouraged to publish their QA-QC plans and results independent of any work performed at the national level of the NAWQA Program, and as appropriate for their particular needs.

Acknowledgments

The authors gratefully acknowledge the contributions and assistance of many colleagues within the USGS in producing this document. In particular, thorough and thoughtful reviews and discussions were provided by Mark A. Hardy, William H. Werkheiser, and Neil M. Dubrovsky of the USGS on preliminary drafts, and by David W. Clark, Dorinda J. Gellenbeck, and W. Brian Hughes of the USGS National Water-Quality Assessment Program on subsequent drafts of this report. Editorial assistance was provided by Iris M. Collies.

COLLECTION AND DOCUMENTATION OF WATER-QUALITY SAMPLES AND RELATED DATA

Ground-water-quality data for the Occurrence and Distribution Assessment of the NAWQA Program are to be collected and documented in accordance with the specific protocols and recommended procedures described in this report and in Lapham and others (in press). Protocols and recommended procedures are provided that cover plans and preparations, collection methods, and the documentation of activities before, during, and after water-quality data are collected. The principles underlying these protocols and recommended procedures have been shown to produce data suitable for the Occurrence and Distribution Assessments of NAWQA in selected pilot areas (Christenson and Rea, 1993; Hamilton and others, 1993; Koterba and others, 1993; and Rea, in press).

The NAWQA ground-water protocols and recommended procedures are applicable for data commonly collected for all three ground-water components (Study-Unit Surveys, Land-Use Studies, and Flowpath Studies) of the NAWQA Program (table 1). Although they are consistent with general guidelines for USGS ground-water data collection (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1), these protocols and recommended procedures reflect NAWQA Program objectives, and could differ in some aspects from those of other USGS programs. In particular, because of the perennial nature of the NAWQA Program, methods used by individual Study Units are constrained by the need for national consistency in the quality of data collected and by the degree and type of documentation required.

Data-Quality Requirements

The importance of national consistency in data collection cannot be overstated. Inconsistent methods can lead to variable and biased data measurements.[2] Modifications to collection and analytical methods potentially result in data whose measurements vary or are biased in relation to previously collected data. If not quantified and documented, such modifications complicate trend analysis (Smith and Alexander, 1989).

The protocols and recommended procedures for NAWQA are designed to reduce inconsistencies and enhance the quality of data used in spatial and trend analysis. The purpose of data-quality requirements is to ensure that data-collection methods are consistent, and that the data obtained meet study needs. The NAWQA Program has three requirements related to sample collection: (1) document the methods used to collect ground-water-quality data and all quality-assurance and quality-control measures, (2) ensure that the quality of data collected is known, and (3) demonstrate that the quality of data obtained is suitable for assessment objectives. In meeting these requirements, it is necessary that data-collection and analytical methods be designed, planned, and executed as consistently as possible. This will help reduce bias and variability among the data collected within a single Study Unit and among Study Units.

---

[2]The term “bias” is defined in this report as a systematic error that is manifested as a consistent positive or negative deviation from the known or true value. “Variability” is defined as measurement reproducibility or the degree of similarity among independent measurements of the same quantity, often measured as a variance or relative standard deviation and without reference to the known probable or true value.

Table 1. Summary of current (1995) required, recommended, and optional water-quality constituents to be measured in the three ground-water components of the Occurrence and Distribution Assessment**,** National Water-Quality Assessment Program (from Lapham and others, in press)

[Required water-quality constituents to be measured for the Occurrence and Distribution Assessment are determined partly by the water-quality topics of national interest selected for National Assessment. Topics selected for National Assessment (1994) are nutrients, pesticides, and volatile organic compounds. The topics selected can change over time. Quality-control samples also are required - types of quality-control samples depend on study component. Req, Required; Rec, Recommended; Opt, Optional; NWQL, National Water Quality Laboratory; SC, Schedule; LC, Laboratory Code]

Water-quality constituent or constituent class	Study-Unit Survey	Land-Use Studies	Flowpath Studies[1]	Method[2]
Field measurements				
- Temperature	Req	Req	Req	Field
- Specific electrical conductance	Req	Req	Req	Field
- pH	Req	Req	Req	Field
- Dissolved oxygen	Req	Req	Req	Field
- Acid neutralizing capacity (ANC) (unfiltered sample)[3]	Rec	Rec	Rec	Field incremental
- Alkalinity (filtered sample)[3]	Req	Req	Req	Field incremental
- Turbidity[4]	Rec	Rec	Rec	Field
Major inorganics	Req	Req	Req	NWQL SC2750
Nutrients	Req	Req	Req	NWQL SC2752
Filtered organic carbon	Req	Req	Opt	NWQL SC2085
Pesticides	Req	Req	Opt	NWQL SC2001/2010 NWQL SC2050/2051
Volatile organic compounds (VOCs)	Req	Req or Opt[5]	Req or Opt[6]	NWQL SC 2090
Radon	Req	Req or Rec[7]	Req or Rec[6]	NWQL LC 1369
Trace elements[4]	Opt	Opt	Opt	NWQL SC 2703
Radium	Opt	Opt	Opt	NWQL-Opt
Uranium	Opt	Opt	Opt	NWQL-Opt
Tritium, tritium-helium, chlorofluorocarbons (CFCs)[8]	Rec	Rec	Rec	NWQL LC1565 (tritium)
Environmental isotopes[9]	Rec	Rec	Rec	NWQL-Opt

Table 1. Summary of current (1995) required, recommended, and optional water-quality constituents to be measured in the three ground-water components of the Occurrence and Distribution Assessment, National Water-Quality Assessment Program (from Lapham and others, in press)--Continued

---

[1]Selection of constituents for measurement in Flowpath Studies is determined by Flowpath-Study objectives. During at least the first round of sampling, however, the broad range of constituents measured in Study-Unit Surveys and Land-Use Studies will be measured.

[2]Schedules and laboratory codes listed are required for Study Units that began their intensive phase in 1991 or 1994, and apply until changed by National Program directive. Schedules for radium and uranium can be selected by the Study Unit, but require NAWQA Quality-Assurance Specialist approval. A detailed discussion is found in the “Sample Collection and Processing” section of this report.

[3]ANC (formerly referred to as unfiltered alkalinity) is measured on an unfiltered sample. Alkalinity is measured on a filtered sample. A Study Unit could have collected ANC, alkalinity, or both to date.

[4]Turbidity measurements are required whenever trace-element samples are collected to evaluate potential colloidal contributions to measured concentrations of iron, manganese, and other elements.

[5]VOCs are required at all urban Land-Use Study wells, but are optional in agricultural Land-Use Studies. If VOCs are chosen as part of an agricultural Land-Use Study, then they should be measured in at least 20 of the Land-Use Study wells.

[6]VOCs are required at all urban flowpath wells for at least the first round of sampling. If VOCs are measured in an agricultural Land-Use Study, then they should be measured at all Flowpath-Study wells within that Land-Use Study for at least the first round of sampling.

[7]Radon is required at any Land-Use or Flowpath Study well if that well also is part of a Study-Unit Survey; otherwise radon collection is recommended for Land-Use or Flowpath-Study wells located in likely source areas.

[8]Collection of tritium, tritium-helium, chlorofluorocarbons (CFCs), and (or) other samples for dating ground water is recommended, depending on the hydrogeologic setting. For tritium methods, see NWQL catalog; for CFCs, see Office of Water Quality Technical Memorandum No. 95.02 (unpublished document located in the USGS Office of Water Quality, MS 412, Reston, VA 22092).

[9]For a general discussion of the use of environmental isotopes in ground-water studies, see Alley (1993).

This report comprises a substantial part of the documentation requirement. Because of diverse site conditions, well types, equipment requirements, and staff experience, situations could arise where NAWQA protocols and recommended procedures described in this report need to be modified. Modifications at the program level will be made in a systematic manner and initially documented through internal, regional, or national memorandums. For modifications internal to Study Units, the chief of the Study Unit is responsible for ensuring that the proposed modification is discussed with the NAWQA Program Quality-Assurance (QA) Specialist before implementation, and that any modifications used are clearly documented in Study-Unit publications. It also is necessary for the NAWQA Program or individual Study Units to provide evidence of the effect, or lack thereof, of modifications on data quality.

To ensure data quality and suitability (the second and third data-quality requirements) each Study Unit will routinely follow protocols and recommended procedures that are described in detail in the following sections. The QA-QC measures include (1) the collection of selected QC samples in the field to test equipment and methods before data collection begins, and (2) the routine collection of selected QC samples (such as blanks, replicates, and spiked replicate samples) during ground-water-quality sampling. Additional QC samples and QA measures will be taken if modifications in methods of sample and data collection occur that require quantification.

Individual NAWQA Study Units or National Synthesis teams may find it necessary to expand QC data collection to identify specific sources of measurement bias or variability. In addition, it has been necessary in some cases to enhance collection of QC data in order to interpret the corresponding ground-water-quality data (Koterba and others, 1991; Ferree and others, 1992; and Koterba and others, 1994). Study-Unit and National-Synthesis-Team budgets, plans, and preparations need to remain flexible to allow for the possibility that additional QC data could be needed.

Plans and Preparations

Plans and preparations for ground-water sampling are completed well in advance of data-collection activities, yet must remain flexible enough to be modified if circumstances dictate. Preparations include becoming familiar with the protocols and recommended procedures described in this document. Sampling equipment and supplies need to be obtained in time for sampling and for the staff to be trained in their use. The ground-water staff also needs to become familiar with and develop the documentation and management of samples and data, including that for QC samples. Finally, the ground-water staff should make detailed plans and preparations for the first field season, which for most Study Units commonly will begin early in the first year of the Occurrence and Distribution Assessment.

As the Study-Unit Investigation progresses, subsequent plans and preparations for each field season are required annually, and are developed as part of the general workplan. Study Units commonly will complete preparations for sampling several weeks in advance of each field season. Documenting site conditions, water-quality data collection, and reviewing collected data are processes that begin before each field season, continue during data collection, and often extend months beyond each field season.

Five key elements to consider in the initial and (in some cases) annual plans and preparations include (1) site visits to assess conditions that could affect sample and data collection; (2) selecting and obtaining sampling equipment and supplies early, to ensure that those eventually used best meet field conditions and fall within NAWQA Program requirements or recommendations; (3) training, to prepare field teams; (4) conducting a field evaluation, to determine that the equipment and procedures will provide high-quality data and that planned documentation and management activities are adequate; and (5) developing detailed schedules that clearly describe staff responsibilities before, during, and after each field season. Each of these planning and preparation elements is described below in detail.

Site Visits

Wells selected or installed for each ground-water component are visited at least once before sampling. During this or any other visit, site data are reviewed to determine if information is needed to (1) complete documentation requirements (Lapham and others, in press), and (2) plan water-quality sampling activities (table 2). In addition, plans currently (1995) are being developed for screening wells for high concentrations (10 µg/L or greater) of volatile-organic-compound (VOC) contamination (John Zogorski, VOC National Synthesis Team, U.S. Geological Survey, written commun., 1995). This could add to the information that needs to be collected during these site visits for selected wells sampled after 1995.

Selection and Purchase of Equipment and Supplies

Because of the need to obtain nationally consistent data over many years on a wide variety of chemical constituents (table 1), most equipment and supplies not provided by the Study Unit generally should be obtained from one of three USGS suppliers: the Hydrologic Instrumentation Facility, Quality Water Service Unit, and National Water Quality Laboratory (table 3). Each of these suppliers offers the advantage of stocking equipment that otherwise would have to be obtained from multiple sources. These suppliers also conduct QC checks and provide QC data for selected supplies and equipment distributed to USGS personnel. For these reasons, these suppliers are designated as the required or sole-source supplier for such items (table 3, USGS supplier with “S” designation). The USGS suppliers also are recommended as sources for other equipment (table 3, USGS supplier with “R” designation) in order to reduce the time, effort, paperwork, and cost to the Study Unit to locate and obtain equipment. Should the need arise, each supplier also can provide equipment not previously available.

Table 2. Information to obtain when planning water-quality data-collection activities

1. **Type of Well Hookup for Sampling:** Determine if a hookup to a garden-hose-threaded flow valve (common for water-supply wells) or to a portable, submersible pump (common for monitoring wells) is needed for sample collection.

2. **Depth Measurements**: Measure the depth of the well and depth to the water level in the well to check well-construction integrity and to determine pump lift, height of water column, volume of standing water held in the well, and purge volume.[1]

3. **Site Conditions and Restrictions:** Note road or access conditions to the well, areas of low clearance, limits on arrival and departure times, or presence of roaming animals (for example, livestock or pets) that could create problems for a field team.

4. **Contact Person**: Obtain land- or well-owner name and telephone numbers (business and home) and contact owner before or upon arrival, and perhaps upon departure.

5. **Local Maps and Photographs**: Locate well on maps, site sketches, or photographs, and indicate the measuring point for well-depth measurements, as well as areas for equipment setup and waste discharge.

6. **Travel Maps and Travel Times**: Identify route and travel times from District office or previous site, and possible tunnel or bridge restrictions on the transport of gasoline, bottled gas, or methanol (or other organic cleaning agent).

---

[1]Measurements are made in accordance with National Water-Quality Assessment Program and U.S. Geological Survey protocols (Lapham and others, in press). Purge volume is defined as three times the volume of standing water in the well casing or, in absence of a casing, the borehole.

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program

[OM, open market; HIF, U.S. Geological Survey Hydrologic Instrument Facility, Stennis Space Center, Miss.; R, recommended supplier; QWSU, Quality Water Service Unit, Ocala, Fla,; SU, Study Unit; µm, micrometer; mm, millimeter; S, sole (required) source of supplies indicated; NWQL, National Water Quality Laboratory, Arvada, Colo.; mL, milliliter; L, liter; ASTM, American Society for Testing and Materials; SC, NWQL analytical schedule; FA, filtered and acidified sample; FU, filtered (unacidified) sample; RU, raw (unfiltered) sample; FCC, filtered, chilled (no preservative added) sample; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; DIW, deionized water; BTD&QS, Branch of Technical Development and Quality Systems, Arvada, Colo.]

Equipment and supplies	**Suppliers**
1. Well-head setup or connection	
• Monitoring well: submersible pump and reel system	OM[1]
• Water-supply well: hook-up segment with garden-hose thread	HIF[2], R
2. Sample-flow transfer system from pump reel to collection point	
• Antibacksiphon device, Teflon, connected in line	HIF, R[3]
• Extension lines for sample flow, Teflon, with connectors	HIF, R
• Manifold, with connectors and Teflon valves, for routing sample flow	HIF, R
• Sample-collection equipment that has connectors to manifold:	
Radon collector with septa, and connectors to manifold	HIF, R
Glass syringe with leur-locked stainless-steel needles	QWSU, R
Teflon, line with connector to manifold, either open ended for turbidity sample collection, or with connector to flowthrough turbidimeter	HIF, R
• Sample-collection and processing chamber frame, PVC or inert material with sample-flow-transfer port	HIF, R
• Preservation-chamber frame, PVC or inert material	HIF, R
• Transparent disposable covers and plastic clips to hold covers inside frames for sample and preservation chamber frames	SU, HIF, R[4]
• Flowthrough chamber with field-instrument ports, manifold connections, and waste line	OM[5]
3. Sample-filtration equipment	
Organic carbon, filtered fractions	
• Stainless-steel cylinder unit with nitrogen-gas deso-quick connect, gas scrubber, and gas line with connector to secondary regulator	HIF, R
• Nitrogen gas tank, with primary and secondary regulators	OM
• Filter membranes, 0.45-µm, 47-mm diameter, silver	QWSU, S
• Safety belts, to secure gas tank	OM
• Container, to collect spent silver nitrate membranes	SU
Pesticides	
• Aluminum or stainless-steel unit	OM, NWQL[6]
• Filter membranes, 0.7-µm, 142-mm diameter, baked, GF/F grade glass microfiber	QWSU, S
• Connector from filter unit to sample-chamber outflow tube	SU[6]

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program--Continued

Equipment and supplies	**Suppliers**
Inorganic (major ions, nutrients, and trace elements)	
• Filter units, capsule with self-contained 0.45-µm[7], pleated, Supor capsule	QWSU, S
• Convoluted (spiral configuration) Teflon sample-flow lines from filter unit to sample-chamber outflow tube[8]	OM
4. Sample Bottles (sample containers, caps, and protective foam sleeves)	
Organic samples	
• Volatile organic sample (SC2090), 40-mL amber vial, baked (Teflon-lined cap)--three vials per sample (Also includes trip blanks.)	NWQL, S
• Pesticides (SC2001 or 2010) sample: 1-L amber bottle, baked (Teflon-lined cap)	QWSU, S
• Pesticides (SC2050 or 2051) sample: 1-L amber bottle, baked (Teflon-lined cap)	QWSU, S
• Organic carbon (SC2085) samples (filtered): 125-mL, amber bottle, baked (Teflon-lined cap)	QWSU, S
• Sleeves, foam, for 40-mL, 1-L, and 125-mL containers	QWSU, S
Inorganic samples	
• Radon (LC1369) sample: scintillation vial (one per transport tube)	NWQL, S
• Major cations (SC2750): filtered, acid-rinsed, 250-mL clear polyethylene bottle (with clear cap), FA--two per sample (one archived by SU)	QWSU, S
• Trace elements (SC2703, SC172, LC112 for arsenic and LC87 for selenium for field blanks): acid-rinsed, 250-mL clear polyethylene bottle (with clear cap), FA--one per sample	QWSU, S
• Major anions (SC2750): 500-mL, clear polyethylene bottle labeled FU, clear 28-mm neck (with black cap)--one per sample	QWSU, S[9]
• Nutrients (SC2752): 125-mL amber polyethylene bottle (with black cap), FCC--one per sample	QWSU, S
• Unfiltered sample (SC2750) RU for laboratory measurements: 250-mL clear polyethylene bottle (with black cap)--one per sample	QWSU, S
(Order black caps for 28-mm bottle neck separately)	QWSU, S
5. Sample and Shipping Forms and Shipping Supplies	
• Field form (standard National Water Quality Field Form or District analog)[10]	SU
• Analytical Services Request (ASR) forms for NWQL	NWQL, S
• Sample Reply Form (Study Unit to NWQL) and return envelope, self-addressed, stamped (see appendix, fig. A20, for example)	SU
• Overnight shipping labels	Contract Carrier
• Surface-mail shipping labels (supplied and prepared at District Office)	SU

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program--Continued

Equipment and supplies	**Suppliers**
• Coolers, with latch lid and drain port, maximum loaded weight of 50-60 lbs. (for overnight sample delivery)	OM
• Heavy cardboard boxes, maximum loaded weight, 20 lbs. (surface delivery)	OM
• Plastic bags, heavy, 4-mil (for holding ice and overnight samples in cooler)	OM
• Plastic bags, resealable (for holding ASR and other forms mailed with samples)	OM
• Filament tape (to secure lid and drain cap of cooler, and surface-delivery boxes)	OM
6. Field-titration equipment[11]	
• Digital or other titrator meeting USGS specifications	QWSU, R
• Acid cartridges (for digital titrator)--0.16 and 1.6 Normal sulfuric acid	QWSU, S
• Extra acid-delivery tubes for digital titrator, clear plastic	QWSU, R
• Glass beakers (250 mL)	OM
• Volumetric pipets, glass, Class A (for preparing filtered samples)	OM
• Magnetic stirrer and small Teflon-coated stir bars	OM
7. Field instruments[11]	
• pH (electrometric) meter	OM
• pH electrodes and refill solutions (specify type of electrode)	QWSU, R
• Specific electrical conductance meter	OM
• Dissolved-oxygen (amperometric) meter and associated equipment (sensor cable, membrane and solution kit)	OM or QWSU
• Pocket barometer (used for pressure correction to dissolved-oxygen meter)	HIF, R
• Calibration wand and cup (for dissolved oxygen)	HIF, R[12]
• Turbidity (nephelometric) meter (turbidity measurement generally is recommended, but required for trace-element sampling)	OM
• Temperature measurement: thermistor thermometer (recommended), possibly part of other field meters. Also need a liquid-in-glass thermometer, ASTM certified, 0.1°C-graduated range of -5 to 45°C (for calibrating thermistor thermometer)	QWSU, R OM, R
8. Miscellaneous equipment and supplies	
• Parafilm	HIF, R
• Forceps (tweezers), Teflon-tipped stainless steel (to handle filter membranes for organic and inorganic samples); or steel forceps (for flat glass-fiber and silver membranes) and plastic forceps (for cellulose nitrate or other inorganic-sample membranes)	OM
• Plastic beakers and small cups, used to hold solutions for calibrating or checking field-instrument sensors	OM, R

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program---Continued

Equipment and supplies	Suppliers
9. Decontamination equipment and supplies	
• District deionized water (DIW) (conductivity ≤1 µS/cm), quality controlled	SU
• Inorganic-free blank water (IBW) (quality controlled for major ions and trace elements)	QWSU, S[13]
• Pesticide-free blank water (PBW) or volatile and pesticide-free blank water (VPBW) (for pesticides or volatile organics)	NWQL, S[13]
• Methanol, pesticide-grade high purity (organic-sampling equipment)	OM
• Laboratory detergent, phosphate free, concentrated: diluted to a 0.1 percent decontamination solution, by volume, with DIW	QWSU, R
• Wash bottles, polyethylene, 250 mL or 500 mL (for DIW and IBW)	QWSU, R
• Wash bottles, Teflon, 500 mL (for PBW and VPBW)	QWSU, R
• Wash bottle, for methanol or other organic solvent, 250 mL	OM
• Laboratory gloves, powderless (latex or vinyl) (for decontamination and sample collection)	QWSU, R
• Plastic trays (3)	HIF, R
• Pump standpipes (glass graduated cylinders or pipette jars are preferred)	HIF, R[14]
• Forced-hot-air dryer, portable, vehicle-powered (for evaporating methanol residues)	OM
• Teflon bags, small (for small organic-sampling equipment and pump intake)	HIF, R
• Heavy aluminum foil (for wrapping organic-carbon and pesticide-filter-unit inlets and outlets	OM
• Plastic bags, resealable (for small inorganic sampling equipment)	OM
• Plastic bags, large, for enclosing cleaned pump reel, extension lines, and other large equipment	HIF, R
• Paper tissues, lint free, soft, disposable, large and small sizes (for example, Kimwipes)	OM
10. Safety equipment	OM[15]
• Fire extinguishers (A-B-C type) with mounts	
• Safety goggles or glasses	
• Eye-wash bottle	
• Emergency spill kits for any chemicals being used	
• Approved containers for transporting pure and used methanol	
• Safety cones, large	
• Material Safety Data Sheets	
11. Chemical reagents (kits include equipment for dispensing reagent)	
Preservatives	
• VOC samples (SC2090) -- 1:1 hydrochloric acid (kit)	NWQL, S
• Acrolein and acrylonitrile samples (SC1401) -- 1:1 hydrochloric acid	NWQL, S[16]
• VOC samples in chlorinated water matrix--ascorbic acid (with scoop)	NWQL, S[17]
• Inorganic (FA) samples for major cations (SC2750) and trace elements (SC2703)--nitric acid, 1-mL glass ampoule, one per sample	QWSU, S[18]

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program--Continued

Equipment and supplies	**Suppliers**
Standards	
• pH standard buffers (pH 4, 7, and 10)	QWSU, S
• Specific electrical conductance standards (50 to 50,000 μS/cm; for low-conductivity waters of $\leq$20 μS/cm, use pH 4.31 buffer)	QWSU, S[19]
• Turbidity standards--Formazin	OM
• Dissolved-oxygen "zero" standard dilutions, freshly prepared with reagent grade sodium sulfite and cobalt chloride	OM[20]
Spike and other solutions	
• VOCs (SC2090, SC2091, SC2092): standard NAWQA spike solution and spike-solution kit	NWQL, S
• Pesticides (SC2050 or 2051 and SC2001 or 2010): standard NAWQA spike solution and spike-solution kits	NWQL, S
• Mixtures, required for trace elements (SC2703)	BTD&QS, S
• IBW, PBW, VPBW (see no. 9, "Decontamination equipment and supplies")	NWQL and QWSU, S
12. Optional Equipment[21]	
• Equipment for isotope, radiochemical, and other special samples--for example, deuterium-oxygen, tritium, uranium, radium, mercury, chlorofluorocarbons	OM
• Field solid-phase-extraction equipment for pesticide samples	NWQL, S

[1] That meets NAWQA Program requirements; see text.

[2] To remove oils and other manufacturing or shipping residues, and before assembling HIF or other equipment that includes Teflon tubing (without metal fittings), soak tubing for 30 minutes in a 5 percent hydrochloric acid solution rinsed with tap water until rinsate has pH similar to tap water, then final rinse three times with DIW. For a 5-percent acid solution, add 5 milliliters of 12 normal (concentrated) acid (specific gravity 1.19 and trace-element free) to each 100 milliliters of DIW (specific conductance not to exceed 1.0 microsiemens at 25 degrees Celsius).

[3] Required for each portable pump system (monitoring wells) or hook-up setup (water-supply wells). Purchase separately from pump system; a single unit can be interchanged between portable-pump and hook-up systems.

[4] Recommended design that allows cover to be attached inside frame with small, plastic clips.

[5] Flowthrough chamber from HIF meets design criteria for use with individual field instruments--pH, dissolved oxygen, specific electrical conductance, and temperature--required for ground-water-quality sample collection.

[6] For aluminum filter unit purchased through NWQL that is set up for solid-phase extraction, SU supplies a short Teflon tube (1/2-inch outer diameter, 3/8-inch inner diameter) that slips over standard nipple connection on filter unit and is connected by a 5/8-inch outer diameter by 1/2-inch inner diameter Teflon sleeve to the tube extending from the sample chamber frame to the filter unit.

[7] For ground water that contains colloidal material, filter membranes with a pore size less than 0.45 μm are required if the filtrate data must represent ion concentrations in solution. The filter pore size in general should not exceed 0.2 μm.

[8] Commonly sold in 5-foot lengths and can be cut into small lengths. Convoluted is preferred over corrugated type because latter is prone to trapping sediment, and must be replaced frequently (Johnson and Swanson, 1994).

[9] RU sample is not needed with trace-element schedule SC2703 if field conductivity is recorded on trace-element ASR form, along with a notation (in comment line to laboratory) that there is "no RU sample."

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program--Continued

---

[10]To be filed with ASR Forms (SU copy) every time samples are collected at well (see appendix, fig. A8, for example).

[11]Refer to table 5 and Radtke and Wilde (in press) for descriptions of equipment and equipment specifications.

[12]Use air-calibration-chamber-in-water method (Radtke and Wilde, in press, Sec. 6.2).

[13]IBW, PBW and VPBW are laboratory-produced waters quality-controlled for specified analyses. The primary use of these waters is for blank samples, but they also can be used in small quantities for ultraclean decontamination procedures. PBW and VPBW contain about 0.1 mg/L of organic carbon (NWQL Technical Memorandum 92.01--unpublished document available from NWQL, 5293 Ward Road, Arvada, CO 80002), but analyses could differ among lots.

[14]Glass is the preferred standpipe material for decontaminating pump equipment because it does not readily absorb contaminants (Reynolds and others, 1990), especially if used repeatedly after equipment exposure to volatile organic compounds.

[15]Contact District Safety Officer for suppliers and specifications.

[16]Acrolein requires careful acidification to pH between 4 and 5 (acrylonitrile can withstand acidification to pH less than 2).

[17]Only required if sample water for VOC analyses is chlorinated; ascorbic acid will be supplied with the VOC preservative kit (NWQL) upon request. Otherwise, obtain ascorbic acid from the OM. DO NOT SUBSTITUTE SODIUM THIOSULFATE for ascorbic acid.

[18]Ultrapure nitric acid also available in 1-mL glass or Teflon ampoules.

[19]Purchase standards that bracket water-quality sample values.

[20]Prepare dissolved-oxygen standard solution fresh on day of use instead of repeatedly purchasing and discarding commercially available solutions.

[21]For assistance with (1) isotope, radiochemical, and other specialized equipment, contact the NAWQA Quality Assurance Specialist; (2) solid-phase extraction equipment, contact the NWQL, Methods Research and Development Program; and (3) chlorofluorocarbons (CFCs), contact Niel Plummer or Ed Busenberg, USGS National Research Program, MS 432, Reston, VA 22092.

Equipment not commonly provided by the Study Unit or USGS suppliers usually can be obtained on the open market (table 3, OM under supplier) and includes portable pumps for collecting samples at monitoring wells, and field instruments, vehicles, and storage facilities associated with ground-water-quality data collection. Each of these items is discussed separately below.

Pump systems

Several low-discharge, submersible pumps are available for collecting water-quality samples from wells. These pumps contain sample-wetted parts that consist mainly of Teflon and corrosion-resistant 316-stainless steel. On the basis of pump characteristics and results from decontamination tests (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1) these pumps are suitable for collecting a wide array of samples, including those required for NAWQA (table 1).

Use of low-discharge, submersible, portable pumps (such as the Fultz Model No. SP-300, Keck Model No. SP-84, Grundfos Model No. Redi-Flo2, and Bennett Model No. 180 or 1800) is required for NAWQA when sample collection from monitoring wells involves microgram-per-liter concentrations of VOCs, pesticides, or possibly trace elements. These pumps also are suitable for the collection of major ion, nutrient, and selected radionuclide samples.

From among suitable pump types, the choice for each Study Unit comes down to weighing the differences in pump performance characteristics (for example, pump diameter, lift capability, flow rate, portability, repairability, and power requirements) against characteristics of wells in the network (for example, well internal diameter, accessibility, purge volumes and times, and lift requirements) to determine the pump(s) that best meet Study-Unit needs. This decision process is illustrated for three pumps and shallow wells (table 4). (A similar process can be used to evaluate other pumps and deeper wells than those illustrated in table 4.) To select which of these pumps best meets sampling needs, the Study Unit can compare selected pump characteristics--primarily lift potential and pumping rate--with anticipated well or site characteristics--primarily depth to water level (lift), purge volume, and purge time (which, for practical reasons, is best kept to less than about 2 hours). If more than one pump type is adequate, other factors, such as repairability, power requirements, or cost can be used to refine the selection process. If most wells can be sampled with one pump type, and only a few wells require a second pump type (for example, deep wells), the Study Unit should consider collaborating with other Study Units or projects within the District to obtain the second pump to collect samples. (Well development is not at issue in this discussion. Pumps to be used for the collection of water-quality samples are not designed, and should not be used, to develop wells.)

Table 4. Example of a method to determine pump-system suitability as a function of selected well and pump characteristics

[in, inches; ft, feet; gal, gallons; ---, not applicable]

Well characteristics					Pump characteristics and suitability	
Well	Diameter (in)	Water-column height (ft)	Required purge volume[1] (gal)	Required lift or total dynamic head[2] (ft)	Maximum pumped volume at given lift in 2 hours for indicated pump system[3,4]	Pump-system suitability[5,6]
1	2	20	10	25	120 (Fultz SP-300)	Suitable
1	2	20	10	25	144 (Keck SP-84)	Suitable
1	2	20	10	25	840 (Grunfos Redi-Flo2)	Suitable
2	4	60	118	75	96 (Fultz SP-300)	Unsuitable
2	4	60	118	75	132 (Keck SP-84)	Suitable
2	4	60	118	75	768 (Grunfos Redi-Flo2)	Suitable
3	2	40	20	160	---[7] (Fultz SP-300)	Unsuitable[7]
3	2	40	20	160	---[7] (Keck SP-84)	Unsuitable[7]
3	2	40	20	160	538 (Grunfos Redi-Flo2)	Suitable

[1]**Required purge volumes** (in gallons) as a function of well diameter and water-column height.

Well diameter (in inches)	Water-column height (in feet)											
	20	40	60	80	100	120	140	160	180	200	240	260
	Required purge volume (in gallons)											
2	10	20	29	39	49	59	69	78	88	98	108	118
4	39	78	118	157	196	235	274	313	353	392	431	470
6	88	176	264	353	441	529	617	705	793	881	969	1,058

Where **purge volume** equals three times the borehole or casing volume. The borehole or casing volume, V (in gallons), is calculated as $V = 0.0408 \times H \times D^2$, where H is the **water-column height** (in feet), and D is the well **diameter** (in inches).

[2]In these examples, the **required lift** is equivalent to total dynamic head and is estimated as the depth to water in the well. This assumes that the purge takes place with the pump intake at the top of the water column, and that the water level in the well does not decline appreciably with pumping. Note that for submersible pumps (for example, helical rotor gear, progressing cavity, bladder, and piston pumps) Lift = pump depth + frictional tubing loss; for centrifugal-pump designs, this is more accurately described as total dynamic head (TDH), where TDH = depth to water + frictional tubing loss.

Table 4. Example of a method to determine pump-system suitability as a function of selected well and pump characteristics--Continued

---

[3]**Maximum pumped volume** is calculated using the pumping rate for a given pump system from manufacturer's specifications at the required lift (or TDH) multiplied by an assumed purging time of 2 hours.

Example pumping rates in gallons per minute (gpm) as a function of lift (TDH) for selected pump systems from manufacturer's specifications. With antibacksiphon device, extension lines, and directional-control flow valves that follow pump-reel system, effective pumping rate is assumed to be 80 percent of that given by the manufacturer. Actual rates, particularly as lifts approach the limit of each system, could be less than those specified.

	Lift (in feet)											
Pump system	0	25	50	75	100	125	150	175	200	225	250	275
	Pumping rate (gpm)											
Fultz Model No. SP-300	1.1	1.0	0.9	0.8	0.7	0.5	0.4	---	---	---	---	---
Keck Model No. SP-84	1.3	1.2	1.2	1.1	1.0	0.9	0.8	---	---	---	---	---
Grunfos Model No. Redi-Flo2	7.2	7.0	6.7	6.4	6.0	5.7	5.0	4.4	3.8	3.0	2.1	---

Example **maximum pumped volume** (gal) as a function of lift for the three pump systems given above, assuming pumping time is 2 hours.

	Lift (in feet)											
Pump system	0	25	50	75	100	125	150	175	200	225	250	275
	Maximum pumped volume in 2 hours (in gallons)											
Fultz Model No. SP-300	132	120	108	96	84	60	48	---	---	---	---	---
Keck Model No. SP-84	156	144	144	132	120	108	96	---	---	---	---	---
Grunfos Model No. Redi-Flo2	864	840	804	768	720	684	600	538	456	360	252	---

[4]For practical reasons, and except when quality-control samples are taken, field teams aim to complete all activities at each well within 4 to 6 hours. Thus, purge times generally need to be kept under 2 1/2 hours, with the pumping rate during the last half hour equal to the sampling rate (no more than about one tenth of a gallon per minute).

[5]Pump-system suitability is determined as follows:

Suitable if the **maximum pumped volume** at a given lift (or TDH) in 2 hours for the indicated pump type is equal to or greater than the **required purge volume**.

Unsuitable if the **maximum pumped volume** at a given lift in 2 hours for the indicated pump system is less than the **required purge volume** or if the **required lift** (or TDH) exceeds the maximum for the pump.

[6]When two or more pump types meet requirements outlined above, other factors considered in pump selection include ability of pump system to be decontaminated adequately, portability, susceptibility of pump to seizure, ease of repair and use in the field, and cost. It is assumed comparison is among pumps that are constructed and can be operated in a manner suitable for NAWQA sampling.

[7]**Required lift** exceeds maximum lift of the pump; therefore, pump is unsuitable under conditions given in this example.

Regardless of the pump type chosen, the pump system (pump intake, tubing, and reel) must meet certain requirements. The pump can be purchased without an antibacksiphon because a suitable antibacksiphon is to be added by the Study Unit (table 3). The pump line should be solid, high-density Teflon tubing. Teflon-lined polypropylene or other tubing is not recommended because the exterior tubing often is not as inert as Teflon. In addition, the outer tubing can separate from the Teflon lining, causing the thin-walled Teflon tubing to pinch or collapse. Suitable pump tubing can be ordered in 50-ft segments connected with 316-stainless steel (SS-316) quick connections, which makes it possible to use the shortest length of tubing needed for each well. In addition, it is recommended that the reel that holds the tubing be designed to turn (while raising or lowering the pump intake and tubing), while the pump is in operation, and while the pump-reel outlet is connected to an extension line that runs to the remainder of the sample-collection setup.

Other types of equipment (bailers, bladder pumps, peristaltic pumps) can be considered for some site conditions, or special data-collection needs. The use of such equipment generally is not recommended. Most alternative sample-collection devices are either limited in their lift potential, constructed of materials that are unsuitable or difficult to decontaminate, or deliver the sample in a manner (for example, under suction) that they cannot be used for most sites, or do not provide data of suitable quality for all NAWQA constituents (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1).

Study Unit staff that need to collect ground-water-quality samples using equipment other than that specified (table 3) must discuss their plans with the NAWQA QA Specialist. At a minimum, it is expected that sufficient QC data are available, or will be collected, to verify that the ground-water data obtained with the alternative equipment is similar in quality to data being obtained by the NAWQA Program in general.

Field instruments

Each Study Unit is to obtain suitable field instruments to collect data for pH, specific electrical conductance (SC), dissolved oxygen (DO), and temperature (T). If samples for trace elements (such as iron, manganese, aluminum, or uranium) are collected, sample turbidity (TU) also is measured. These data (pH, SC, DO, T, and possibly TU) are part of the required water-quality record for each ground-water sampling site (table 1), and also serve as QC measures that are used to assess the chemical variability of water before and at the time samples for other chemical constituents are collected. In collecting these data, however, the field instruments used must meet certain requirements (table 5).

Table 5. Requirements for meters and sensors used for field measurements taken at ground-water-quality sites of the National Water-Quality Assessment Program (modified from Radtke and Wilde, in press)

[°C, degrees Celsius; mV, millivolt; Δmv/ΔpH, change in millivolts divided by change in pH at measurement temperature (in °C); ≥, greater than or equal to; µS/cm, microsiemens per centimeter at 25°C; ≤, less than or equal to; >, greater than; mg/L, milligrams per liter; NTU, nephelometric turbidity units; NWIS-I, National Water Information System-I]

Field measurement	Performance requirements
Temperature (°C) (recommend thermistor-type thermometer)	Reading to 0.1°C for temperatures from -5 to 45°C; bias within 0.2°C. (Requirement applies to any thermistors used in association with other field measurements, including those contained in other field-measurement systems. Sampling thermal systems can require readings and calibration to 52°C.)
pH (standard units; require electrometric method) and field titrations	Reading to 0.1 standard unit (or 0.05 unit for instruments that display more than two digits to the right of the decimal). Temperature compensating; mV readout; rapid electrode response--maximum 15- to 20-second elapsed time for reading to "lock-on" the low pH calibration buffer after meter is calibrated with high pH 7 buffer; pH electrode must pass slope-test [(Δmv/ΔpH) ≥ 0.94 x (Theoretical Nernst slope)], corrected for temperature.[1]
Specific electrical conductance (µS/cm at 25°C)	Reading within 5 percent of full scale at ≤100 µS/cm or within 3 percent of full scale at >100 µS/cm; temperature compensation range from -2 to 45°C or greater, if needed. Instrument must compensate for temperature to provide readings at 25°C, or temperature readings are required to apply correction factor and report measurement at 25°C.
Dissolved oxygen[2] (require amperometric method)	Reading to 0.3 mg/L or less for concentrations ≥1 mg/L. Temperature compensation and temperature measurement required. Field barometer needed to determine barometric pressure correction factor.
Turbidity (recommend nephelometric method)	Select instrument designed to provide precise and unbiased measurements at 0 to 40 NTU. Reading within 5 percent full scale for 1 to 500 NTU, and within 0.02 NTU for turbidity less than 1 NTU. Turbidity entered into the NWIS-I data base must be made using nephelometric measurements.

[1]Slope test and temperature correction are described in Radtke and Wilde (in press).

[2]Use spectrophotometric or iodometric method for accurate measurements of dissolved-oxygen concentrations less than 1 mg/L (Radtke and Wilde, in press).

Water levels are to be determined whenever possible before other water-quality data are collected from wells (Lapham and others, in press). The static water level within a few hundred feet below land surface is measured using a chalked steel tape, and the measurement is repeated until two consecutive measurements differ by no more than 0.02 ft, or until the reason for less precise measurements is determined and documented. In addition, the depth from land surface to the bottom of the well is measured during each site visit whenever possible to verify the integrity of the well construction.

Each field instrument must be calibrated, operated, maintained, and stored, and the necessary calibration and test results documented according to USGS protocols. The protocols for ground-water-quality field measurements are described in Radtke and Wilde (in press).

Water-quality vehicles

Different vehicle designs will be used among Study Units because of differences in terrain, accessibility of sites, travel distances, trip duration, and other factors. In selecting and modifying a vehicle for water-quality data collection, however, it is recommended that safety and quality control be given high priorities. Study Unit staff also are encouraged to research designs already in use and to dedicate vehicle(s) solely to the collection of water-quality data.

Safety is a vital concern. The most important thing a water-quality vehicle will carry is the field team. To protect the team, all equipment is secured and properly stored behind passenger barriers when in transit, and without affecting the driver's visibility. In addition, vehicle supplies should include safety cones; safety glasses; fire extinguishers; first-aid, eye-wash, and chemical-spill kits; and Material Safety Data Sheets--all placed where they are readily accessible. If sample collection or processing occurs inside the vehicle, ventilation must be adequate and there must be sufficient room to operate. Flex hose is used to vent combustion exhaust away from a vehicle that is stationary with the engine running, and is stored and transported outside of the sampling vehicle. Flammable solvents (such as methanol) and pressurized gases (such as nitrogen) are transported according to local and State regulations. Regular service and maintenance and before-departure safety inspections of the vehicle are scheduled by the field team. If questions arise in regard to safety or inspection procedures, methods, or equipment, contact the District safety officer.

Quality assurance of the sampling vehicle is critical to a successful investigation. This vehicle should enable the field team to collect high-quality samples and data. Despite diverse external conditions, the vehicle should provide a clean environment for sampling and equipment, and a suitable environment for protecting equipment from damage during transport. The vehicle design also should provide temporary protection of field instruments, chemical reagents, buffers, preservatives, standards, and most water-quality samples from extreme heat and cold. It also must provide for the temporary (and contaminant-free) storage of some samples (VOCs, pesticides, nutrients), and some reagents (for example, spike solutions for pesticides and VOCs and VOC acid preservative) at near-freezing temperatures. If the vehicle interior is used for the collection or processing of water-quality samples, then adequate lighting, plumbing, and counter space are needed. Sample collection and preservation chambers are used whether working inside or outside the vehicle. These reduce contamination of and from the vehicle interior.

Obtain and design vehicles that can be dedicated solely to water-quality sampling. A vehicle used for water-quality data collection is not used for the storage (even temporary) of a generator using gasoline or other types of fume-producing fuels, or of heavily soiled equipment, clothing, or tools. Nor should a vehicle previously used for such storage be converted to a water-quality vehicle. One might even question the adoption of a used water-quality vehicle if samples were collected and, in particular, preserved within the vehicle without regard to possible vehicle contamination. In each case above, there is a risk that the vehicle will be, or has been, permanently contaminated.

Storage facilities

Field vehicles are not suitable for storage of most supplies and some equipment used for water-quality data collection. When not in operation, the vehicles cannot provide adequate protection from extreme heat or cold, which can destroy or degrade chemical standards, buffers, and other reagents, as well as damage some field instruments. Especially during extremes in temperature, remove sensitive supplies and equipment from an idle vehicle to a safe indoor location on a daily basis. Clean and secure facilities, which are separate from those used for other types of NAWQA equipment (such as generators, fuel, drilling supplies and materials, and permanently soiled gear), are needed for longer periods of storage.

Timing of purchases

Durable equipment and supplies (such as vehicles, pump systems, plastic bottles) are ordered well in advance of the first field season, and thereafter on an as-needed basis. Begin vehicle purchase and modification(s) 12 to 14 months before the vehicle is needed for water-quality data collection. Nonperishable, and limited quantities of perishable supplies (see below) are purchased and on hand at least 3 to 6 months before water-quality data collection begins. Pump systems and other sample-collection equipment also can take up to several months to obtain, assemble, and modify to complement vehicle design.

Some supplies, such as most chemical solutions, have a limited shelf life. As part of their planning, Study Units should (1) follow manufacturer's recommendations on storage, and (2) query their suppliers about shelf life for any preservatives, buffers, standards, and reference samples, as well as for blank, spike, surrogate, and instrument-sensor solutions, or any other chemical reagents. This will prevent overstocking and reduce waste. Upon receiving these supplies, the date of receipt and the expiration date should be marked clearly on time-sensitive supplies. Study Units also are required to record supply lot numbers. Without these records, the QA and QC information that exists for these supplies, and provided by lot number, cannot be utilized by the Study-Unit or NAWQA National Program. This is one of the quality-assurance measures that could be needed to correctly interpret water-quality QC data.

Study-Unit staff are likely to select the most appropriate vehicle design, pump system, and related equipment after information from site visits is obtained, and after sampling teams have had some training (see "Training" below). Following training, the field teams need their equipment and supplies for practice, and to verify that they are suitable for water-quality data collection (see “Field Evaluation” below). Therefore, most nonperishable equipment and supplies need to be on hand at least 3 to 6 months in advance of the first field season of data collection.

Training

Modifications in USGS protocols and recommended procedures (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1), and the need for consistency dictate that training in the collection and management of water-quality data is required for most Study-Unit staff. This training is to be obtained through USGS Level I courses and field experience, ideally before water-quality data collection begins (table 6).

Field Evaluation

Each Study Unit is required to test and evaluate the sample-collection equipment and procedures that commonly will be used (table 6, no. 4). This is separate from, and occurs after, the field training with Study-Unit equipment. To avoid unnecessary delay in planned data collection while awaiting laboratory results, this test should be conducted at least 2 months before sample and data collection begin. Ideally, the evaluation can occur toward the end or after the field exercise devoted to equipment shakedown and cross-training (table 6, no. 3).

To conduct the test, the Study Unit selects a well with measurable concentrations of as many of the following contaminants as possible: VOCs, pesticides, nutrients, and (if targeted for investigation by the Study Unit) trace elements. The field team collects samples for all constituents (in the order and manner in which samples commonly are going to be collected--see “Sample Collection and Processing”). After sample collection, equipment is decontaminated. Field blanks for all constituents are collected with the decontaminated equipment. Two field-spiked, blank samples are prepared for the VOC schedule and for each pesticide schedule. One blank sample for the VOC schedule is spiked by one field-team member, and its replicate is spiked by the other field-team member. One field-team member also spikes the blank sample for one pesticide schedule; the other field-team member spikes the other blank sample for the second pesticide schedule. (Definition of QC samples is provided in “Design of Quality-Control Sampling and Schedules.”) All ground-water-quality samples and QC samples are sent to the NWQL for analysis.

Data from the ground-water-quality and QC samples are evaluated by the Study Unit, and the evaluation and data are forwarded as soon as possible to the National Program (NAWQA QA Specialist). These data are to confirm that (1) the ground water contained measurable levels of some contaminants, (2) decontamination procedures removed contaminants from equipment, and (3) the procedures used to prepare spiked blanks led to acceptable recoveries of selected VOCs and pesticides.

The evaluation assures the field team, Study Unit, and National Program that the protocols and procedures are satisfactory. Potential problems identified by the Study Unit(s) are corrected before sample and data collection begins.

Table 6. Recommended sequence of training-related activities to prepare for National Water-Quality Assessment (NAWQA) Program ground-water-quality data collection

[USGS, U.S. Geological Survey; QC, quality control; NWQL, National Water Quality Laboratory]

1. Determine data-collection and management training needs.

- Review protocols and recommended procedures (this report).
- Review National Field Manual (Radtke and Wilde, in press).
- Incorporate possible modifications to above (commonly described in NAWQA or USGS internal memorandums).

2. Train field team(s) and data-management personnel accordingly and formally.

- Through USGS Level I and higher level training courses.[1] Field Water-Quality Methods for Ground Water and Surface Water (G0282) currently is required for at least one member of each team placed in field for data collection. It is recommended that at least one member of the Study-Unit staff attend the course Quality-Control and Sample Design and Interpretation (GO342). (A field team is assumed to consist of two people.)
- Take data-collection and QC training courses early, ideally in the fiscal year before intensive data collection begins.

3. Enhance and reinforce formal training.[2]

- New field team(s) can accompany or temporarily employ experienced (mentor) teams from another Study Unit that is completing data collection in the fiscal year before the new team will begin data collection. Select mentors on the basis of similarities in types of wells, terrain, equipment, and other factors that the two Study Units have in common.
- New field team(s) should practice data collection with equipment that will be used, and alternate activities to ensure each team member is cross-trained in all aspects of data collection.

4. Evaluate data-collection protocols, recommended procedures, and equipment.[3]

- Conduct data collection at a contaminated well at least 2 months before any water-quality data collection begins. Include field blanks and field-spiked source-solution blanks. Submit ground-water-quality and all QC samples to NWQL for analysis.
- Evaluate and share results with the National Program. (See text for further discussion).

[1]The Level I course provides individual training in ground-water-quality and surface-water-quality data-collection protocols and procedures that include those for the National Water-Quality Assessment Program. Other courses can be taken that cover data management and analysis, such as that recommended for QC.

[2]Because modifications to protocols and recommended procedures are likely to occur, training without taking the formal course currently is not considered an acceptable substitute for all members of a field team.

[3]See discussion in section entitled “Field Evaluation.”

Design of Ground-Water-Quality Sampling Schedules

As part of planning for field sampling, schedules are prepared annually or more frequently, if needed, for the collection of ground-water-quality and QC data for each ground-water component (Study-Unit Survey, Land-Use Study or Flowpath Study) targeted for investigation each year. These schedules list the daily activities for the field team, data managers, and support staff.

For ground-water-quality samples, the schedule describes the timing and order in which wells for each ground-water component are targeted for data collection (table 7). General scheduling considerations include component factors, travel times, personnel requirements, and site conditions (table 8). Each schedule is designed over a period of several months, and before any ground-water-quality samples are collected.

Study Units will pay particular attention to factors that enhance the consistency and quality of samples and data obtained and provide the Study Unit and National Program with the necessary data to determine the quality and suitability of data collected for NAWQA assessments (table 9). The design and scheduling of QC data collection, which are critical and integral parts of water-quality data and data collection (Shampine and others, 1992), are discussed in detail in the next section. For most of the other factors (tables 8 and 9), it is assumed that the information needed is obtained through staff planning meetings and site visits conducted before data collection begins.

As a general rule, except for Flowpath Studies, most Study Units will find that a single, two-person field team often needs a day to conduct data-collection activities at one well. With experience, and under the optimum field conditions, some teams will be able to collect data from more than one well per day. In the case of Flowpath Studies, the close proximity and shallow depths of wells also could permit sampling at more than one well per day. In addition, wells targeted for QC data collection could require an additional team member to complete activities in a single day.

Table 7. Example of a sampling schedule for a 28-well Land-Use Study

[Assumes (a) one (two-person) field team generally collects samples on a weekly run (Monday-Thursday); (b) incorporation of general scheduling considers component factors, travel times, personnel, and site conditions (table 8), as well as requirements to enhance data quality (table 9); and (c) routine quality-control sampling occurs at selected wells distributed throughout the collection period (third person possibly joins team). SRS, standard reference samples for trace elements; VOC, volatile organic compound]

Period of activity		Activity to be conducted by team
Week 1	Day 1 (M)	Depart for Well 1: collect ground-water (GW) samples.
	2 (T)	Well 2: Collect GW and quality-control (QC) samples.
	3 (W)	Well 3: Collect GW samples.
	4 (Th)	Well 4: Collect GW samples, return to office, unload vehicle.
	5 (F)	Evaluation and preparation: Study Unit reviews progress, plans, sampling schedule, and completes final preparations for following week's activities.
Week 2	Days 8-12	Wells 5-8: Similar schedule as week 1, but without QC data collection.
Week 3	Day 15 (M)	Well 2: Review QC data and continue sampling if no problems appear; decision to sample two wells per day when possible is made.
	16 (T)	Team and staff complete preparations, team departs office.
	17 (W)	Well 9: Collect GW and QC samples (including one SRS).
	18 (Th)	Wells 10 and 11: Collect GW samples.
	19 (F)	Team returns to office and, aided by staff, unloads and cleans vehicle.
Week 4	Days 22-26	Wells 12-15: Similar to schedule for week 2.
Week 5	Day 29 (M)	Well 9: Review QC data and continue sampling if no problems appear. Team, aided by staff, completes preparations, and departs office.
	30 (T)	Wells 16 and 17: Collect GW samples.
	31 (W)	Well 18: Collect GW samples.
	32 (Th)	Well 19: Collect GW and QC samples (with VOC trip blank, as planned); team returns to office late in day.
	33 (F)	Team and staff unload, clean, and restock vehicle.
Week 6	Days 36-40	Wells 20-23: Similar to schedule for week 2.
Week 7	Day 43 (M)	Well 24: Team departs office, collects GW samples.
	44 (T)	Well 25: Collect GW samples.
	45 (W)	Wells 26 and 27: Collect GW samples.
	46 (Th)	Well 28: Collect GW and QC samples, team returns to office and with staff unloads and cleans vehicle.
	47 (F)	Vehicle goes in for regular service and maintenance.
Week 8	Day 50 (M)	Team and staff receive QC data (wells 19 and 28). If QC data are satisfactory, sample collection continues unabated. Team and staff prepare for next component to be sampled. Remaining two SRS samples needed for the year will be included in data collection for the next component.

Table 8. Basic considerations in designing annual ground-water-quality sampling schedules for Study-Unit components (Land-Use Studies, Study-Unit or Subunit Surveys, and Flowpath Studies) of the National Water-Quality Assessment Program

1. **Component factors**
   - Number of each type of component.
   - Number of wells per component.

2. **Travel times**
   - Between office and wells.
   - Between wells.
   - Between well and overnight shipping sites.

3. **Personnel**
   - Number of field teams.
   - Number of individuals per team (generally consider two members; possibly third person at wells that include QC sample collection).
   - Experience of personnel in team.
   - Office staff support.

4. **Site and seasonal conditions**
   - Equipment setup time (water-supply or monitoring well).
   - Purge time.
   - Data-collection requirements (ground-water quality only or ground-water quality and quality control).
   - Duration of field season.

Table 9. Requirements for the design of National Water-Quality Assessment Program ground-water-quality sampling schedules to enhance data quality

[QA, quality assurance; QC, quality control; VOC, volatile organic compound; NWQL, National Water Quality Laboratory; µg/L, micrograms per liter]

---

1. **Schedule to avoid seasonal or other problems in data used for spatial analysis**
    - Except for Flowpath Studies, collect all samples for all components in shallow-depth wells between late spring and early fall if those samples include seasonally-applied chemicals.[1]
    - Except as noted below, complete sampling for a given component in the shortest time possible, and before the same field team begins data-collection at another component.

2. **Integrate quality-assurance and quality-control (QA and QC) data collection** into each component schedule
    - Conduct QA procedures and collect QC data at selected sites in each component throughout the period of water-quality data collection.

3. **Set reasonable performance levels;** initially, collect samples at one well per day for Land-Use Studies (or Study-Unit Survey) so that:
    - With time and experience, the long-term average could approach two wells per day.
    - Wells selected for QC data collection typically will require a full day and possibly an additional person.
    - Sampling at more than two wells per day could be possible, particularly for Flowpath Studies (shallow-depth wells in close proximity).

4. **Avoid over-specialization**; schedule frequent rotation of duties among the field-team members
    - Prepare for unexpected absences to prevent a halt in sampling, or the collection of potentially poor-quality data.

5. **Schedule data collection at wells known or suspected of having high (greater than 10 µg/L) VOC or pesticide concentrations** near the end of the data-collection period to avoid cross-contamination of other wells or samples
    - Take additional field blanks to check that equipment is decontaminated before the same equipment is used at another well.
    - Notify NWQL (on Analytical Service Request form--comment to laboratory line) if it is known or suspected that VOC or pesticide concentrations are expected to exceed 10 µg/L.

6. **Plan for resampling**, regardless of whether or not it can be anticipated
    - Despite the best planning, teams sometimes find they are inadequately equipped for data collection..
    - Data-quality reviews could indicate resampling is necessary.
    - Resampling is recommended near the end of the fiscal year (first week in September).

7. **Provide time for data review, schedule revision, and equipment maintenance**, if the component consists of 20 or more wells, which generally will require 2 or more months to sample
    - With intermittent periods (day or two in length) of no data collection.
    - To review progress, make scheduled revisions, and discuss QC data.
    - To restock, maintain, repair, or replace equipment and supplies.

8. **Schedule data collection to avoid exceeding sample-holding time**, which begins when the sample is collected, and ends with sample analysis
    - Holding times for water samples of radon, nutrients, pesticides, and VOCs are the shortest--3, 5, 7, and 14 days, respectively.
    - From late spring to early fall (the peak analysis period) at least half the holding time can expire **after** samples are logged in at the NWQL.
    - Because radon has a short half-life (3.6 days), samples for this element should not be collected on a Friday, unless they can reach the NWQL by noon on that Friday.

---

[1]Pesticide concentrations measured in ground water nationwide appear higher and more uniform throughout this period than the concentrations measured from late fall to early spring (J.E. Barbash and E.A. Resek, in prep., Pesticides in Ground Water; Distribution, Trends, and Governing Factors: Ann Arbor Press, Chelsea, Mich.).

Design of Quality-Control Sampling and Schedules

Each Study Unit is required to collect similar types of QC samples (table 10). Those that are collected regularly throughout each field season are referred to as "routine QC samples." Additional QC samples, referred to as "topical QC samples," occasionally could be collected by some or all Study Units to isolate and resolve problems or evaluate modifications to NAWQA field methods.

The data obtained from routine or topical QC sampling are used to estimate the potential bias (either from contamination or in recovery) and measurement variability for selected analytes. Routine QC samples provide the data required by the NAWQA Program to make general inferences about bias and variability for all water-quality data collected. Bias and variability measurements from routine QC samples reflect combined field and laboratory errors that occur during data collection. Measurements obtained from topical QC sampling will reflect errors associated with a specific field or laboratory procedure employed by NAWQA and targeted for study.

Study Units can use QC data in several ways. Those that can derive bias and variability estimates from routine QC sampling in a timely manner can use the results not only to assess the quality of data being collected, but also, in some cases, to identify wells that need to be resampled (Koterba and others, 1991). In the case of topical QC data, sources of sample contamination or bias that occur as a result of sample collection and processing, initially identified through routine QC sampling, can be isolated and eliminated (Rea, in press; Koterba and others, 1991).

Bias and variability estimates also can be used during data analysis and interpretation of ground-water-quality data. For each ground-water component, the magnitude of these error estimates provide an indication of the quality of ground-water data collected (Koterba and others, 1991 and 1993). In addition, as water-quality data from different Land-Use Studies or Subunit Surveys are compared, contrasted, or combined, the corresponding routine estimates of bias and variability from QC data also can be compared, contrasted, and combined to make inferences about the quality and suitability of the aggregated water-quality data that are being used for Study-Unit or National Assessments.

In some cases, data analysis and interpretation can depend on the timely analysis of routine and topical QC data obtained in the field combined with timely discussion of these data with the National Program and the NWQL. Examples of the above, which led to modifications in Study-Unit field methods and in the QC sampling design, and ultimately improved data quality, analysis, and interpretation include studies by Ferree and others (1992) and Koterba and others (1994). Their experience indicates how critical it is for Study-Unit plans to remain flexible. These plans must allow for the possible modification of the initial designs for routine QC sampling (as described below), or the methods used to collect these and ground-water-quality samples (described later in this report). Such modification could prove critical to correctly identifying the occurrence and distribution of contaminants in ground water and their relation to Study-Unit landscape and subsurface features.

Table 10. Quality-control samples for ground-water components of the National Water-Quality Assessment (NAWQA) Program

[Definitions are consistent with those of the U.S. Geological Survey Branch of Technical Development and Quality Systems (BTD&QS) and the Office of Water Quality. NWQL, National Water Quality Laboratory; VOCs, volatile organic compounds]

Sample type	Description	Purpose
1. Blanks[1]	Types include field, source-solution, and trip.	Assess bias from contamination of blank water.
•Field	Blank water passed through equipment in the field, and collected in a manner similar to that used to collect water-quality data, but after equipment is used and decontaminated.	Verify that decontamination procedures are adequate, and that field and laboratory protocols and recommended procedures do not contaminate samples.
•Source solution[2]	Blank water placed directly in the sample container, but in a clean environment.	Verify that blank water is contaminant-free just before it is used for a field blank.
•Trip	Blank water placed in sample container by NWQL, shipped to study with empty containers, and returned unopened by Study Unit from field for analysis.	Verify that shipping, handling, and intermittent storage of containers does not result in contamination or cross-contamination of samples.
2. Replicates[3]	Two or more ground-water-quality samples collected sequentially for the same analytes.	Assess combined effects of field and laboratory procedures on measurement variability.
3. Field spikes[4]	Types include samples prepared from blank water or from ground water.	Assess recovery bias of analytes in spike solution.
•Source-solution water[5]	Two source-solution blanks to which identical volumes of spike solution are added, but by different members of field team. For VOCs, preserve with NWQL acid before spiking.	Verify equipment and procedures for field spiking, handling, shipping, and analysis lead to similar results among Study Units.
•Ground water	Two or more replicate ground-water-quality samples to which identical volumes of spike solution are added in a manner that does not substantially alter sample matrix. For VOCs, preserve with NWQL acid before spiking.	Assess recovery bias and variability in relation to different ground-water matrices.

Table 10. Quality-control samples for ground-water components of the National Water-Quality Assessment (NAWQA) Program--Continued

Sample type	Description	Purpose
4. Standard reference (mixtures)	Prepared by BTD&QS as mixtures, sent to Study Units collecting trace-element samples, shipped unopened from field to NWQL for analysis.	Assess recovery bias and variability of selected trace elements.

[1]Blank water is certified by supplier as free of analytes of interest at concentrations that exceed NAWQA detection or reporting level. A trip blank is only required for VOCs.

[2]Because blank solutions are not regularly analyzed for dissolved organic carbon (DOC), source-solution blanks are required along with field blanks for this analyte. A source-solution blank for DOC is required each time a field blank for DOC is taken.

[3]Chemical composition of water entering the well and being collected is assumed constant during time needed to collect sequential samples (including replicates).

[4]Spike solutions for NAWQA contain either selected VOC or pesticide analytes; solutions are obtained and used in accordance with instructions from the NWQL. At least one unspiked (background) ground-water sample from the same well used to obtain the samples for field spikes is analyzed in conjunction with field-spiked samples (see text).

[5]Preserved and spiked source-solution blanks for pesticides and VOCs are prepared only as part of the initial evaluation of equipment and procedures before data collection begins.

Routine quality-control samples: type, number, site selection, and timing

The current NAWQA QC sampling design for ground water is based on the integrated approach described by Shampine and others (1992). Under this design, it is recommended that each Study Unit follow similar procedures (tables 11 and 12) to identify (1) the types of routine QC samples collected, (2) the wells at which these samples will be obtained, and (3) the timing of QC sample collection for each of the ground-water components scheduled for data collection in each field season. These procedures ensure that the data obtained for each routine QC sample type (1) represent major differences in the major ion chemistry (sample matrix) of ground water targeted for study, (2) are suitable for estimating measurement bias and variability for the analytes of interest, and (3) reflect possible temporal variations in field and laboratory methods during the time period that ground-water-quality data are collected (table 13).

It would be ideal in terms of planning, efficiency in the field, and costs **if similar routine QC designs** could be used for **all** ground-water components. Because Land-Use Studies, Study-Unit (or Subunit) Surveys, and Flowpath Studies differ in their design and scope, the types and numbers of routine QC samples, the wells selected for collecting these samples, and the timing of visits to the wells selected will differ somewhat among these components.

It would be ideal in terms of planning, efficiency, and costs if **all** routine QC samples could be collected at the **same** well sites for each ground-water component. Representative and suitable QC data, however, often can only be obtained by scheduling the collection of different types of routine QC samples at different wells within a given component (see below), or, in the case of the VOC trip blank and (possibly) trace-element standard reference samples, at wells selected from among several components sampled in the same field season (table 13, footnote 1).

Land-Use Studies. A typical Land-Use Study is focused primarily on one major land-use classification, and for ground water, involves the collection of samples for a variety of analytes (table 1) from each of a relatively small number of wells (about 30, including reference wells) completed at shallow depths and often in a single aquifer. Therefore, a typical design for routine QC data collection requires the collection of many different QC sample types to cover the variety of analytes being investigated (table 12). It also requires a minimal number of samples for each QC-sample type because differences in the quality of ground water among wells are assumed to reflect chiefly the intensity of a single land use on the shallow part a single aquifer.

Some wells in the Land-Use Study will need to be chosen (if possible, and according to methods described later in this section) specifically to collect the required number of routine, replicate ground-water samples and routine field blanks (table 13). These wells are chosen, in part, because they are likely to provide samples with measurable (greater-than-method-reporting-level) concentrations. (Estimating the variability of measurements for a given analyte using replicate samples requires that these samples contain measurable, greater-than- or equal-to-method reporting-level concentrations for that analyte.) They also are selected, if possible, to provide a range in measurable concentrations that reflect the effects of that land use on shallow ground-water quality.

Table 11. Procedures to identify the type and schedule the annual collection of routine quality-control data for ground-water components of the National Water-Quality Assessment Program

---

1. Identify analyte groups for which water-quality data will be collected that field season

- On the basis of national requirements (table 1).
- To which are added local Study-Unit interests, such as trace elements.

2. Identify routine quality-control (QC) data to be collected

- On the basis of the Study-Unit component (for example, see table 12).
- Determine QC sample types by analyte group to be collected.
- Determine number (or frequency) of each type to be collected.

3. Identify wells and develop schedules for routine QC data collection for each component[1]

- Select wells to provide suitable and representative QC data (see text and table 13).
- Schedule visits to these wells to provide QC data collection for each analyte group throughout the months that water-quality data for that analyte group and component are being collected (see text and table 13).

---

[1]If volatile-organic-compound (VOC) and trace-element samples are collected during a given field season, then at least one VOC trip blank, in addition to field blanks and spiked replicate samples, and at least three trace-element standard-reference samples are sent from the field to the National Water Quality Laboratory for analysis.

Table 12. Required type and minimum number (or frequency) of routine quality-control samples for a Land-Use Study of the National Water-Quality Assessment Program

[Field blanks and field-spiked, source-solution blanks taken during the evaluation of methods are not included below. Assume study consists of 25 to 30 wells. Trace-element field blanks use National Water Quality Laboratory (NWQL) Schedule SC172 with selenium (LC0087) and arsenic (LC0112). All other routine quality-control samples use the same NWQL schedule or laboratory code used for the corresponding water-quality samples. DOC, dissolved (filtered) organic carbon; ALK, alkalinity (field-titration, filtered ground-water sample); and ANC, acid-neutralizing capacity (field titration, unfiltered ground-water sample; VOCs, volatile organic compounds]

Analyte group[a]	Routine quality-control sample type	Required number (frequency)
1. Commonly present in measurable concentrations: major ions, nutrients, and DOC. (ALK and ANC--replicates only)	**Field blanks**	Minimally at 2, but preferably at 3, well sites.
	Source-solution blanks	(Every time a DOC field blank is taken, only for DOC.)
	Replicate (2) ground-water samples per well	Minimally from 2, but preferably from 3 wells at different sites.
2. Commonly present in measurable concentrations in some, but usually not all, areas:		
• Pesticides or VOCs	**Field blanks**	Minimally at 2, but preferably at 3, well sites.
	Trip blank	(One per field season, only for VOCs.)
	Field-spiked, replicate (2) samples per well	Minimally at 2 well sites.
• Trace elements (such as NWQL SC2703)[b]	**Field blanks**	Minimally at 3 to 5 well sites.[c]
	Standard-reference-sample mixtures	(Three per field season.)
	Replicate (2) ground-samples per well	Minimally from 3 to 5 wells at different sites.
• Radionuclides (such as radon)	**Replicate (2) ground-samples per well**	Minimally from 3 wells at different sites.

[a]For tritium, deuterium-oxygen isotopes, or chlorofluorocarbons, contact a National Water-Quality Assessment Program Quality-Assurance Specialist.

[b]Through 1995, some Study Units collected and temporarily archived water-quality and quality-control samples.

[c]If trace-element concentrations of interest are low (less than 10 µg/L), collect the maximum number of field blanks, and the minimum number of replicate sample sets specified. For high concentrations, collect the minimum number of field blanks, and maximum number of replicate sample sets.

Table 13. Well- and site-selection criteria for routine quality-control samples collected for ground-water components of the National Water-Quality Assessment Program

[Field blanks and field-spiked, source-solution blanks taken during the evaluation of data-collection methods are not considered below. DOC, dissolved (filtered) organic carbon; VOC, volatile organic compounds; NWQL, National Water Quality Laboratory]

Routine QC sample type	Well (site) selection criteria for Study-Unit (or Subunit) Survey, or Land-Use or Flowpath Study ground-water components
Field blanks (all analytes, except radon)	Select wells where it is known or suspected that ground water (1) at each well contains measurable (greater-than-method-reporting-level) concentrations of most to all analytes and (2) collectively, for the wells chosen, reflects some of the diversity in ground-water-quality conditions (range in concentrations for these analytes) for which the ground-water component is designed.[a]
Source-solution blanks (DOC)	Use the same well sites selected for DOC field blanks (above) for each component.
Trip blank (VOC)	Sent from one randomly selected well site from among all well sites for all components at which VOC samples are collected during the same field season.
Replicate ground-water samples (inorganic analytes, radionuclides (radon), and DOC)	Use the same wells selected for field blanks (above) for each component.[a]
Field-spiked, replicate, ground-water samples (VOC and pesticides)	Select wells where it is known or suspected that ground water at each well (1) contains measurable concentrations of inorganic analytes and DOC (similar to those found at routine QC sites selected for field blanks and replicate ground-water samples), but (2) do not contain measurable concentrations of those VOCs or pesticides found in NAWQA-NWQL spike solutions and of interest to the Study Unit for each component.[a]
Standard-reference samples (trace elements)	Sent from 3 well sites selected from among all well sites for all components at which trace-element samples are collected during the same field season.[a]

[a]Schedule data collection for selected wells so that water-quality and routine QC samples are obtained from at least one of these wells early, at least another of these wells mid-way through, and at least at still another of these wells near the end of the entire time period during which water-quality data that relate to the type of QC sample type specified are being collected for the component or, in the case of trace-element standard reference samples, for the field season.

Field blanks are collected at the same wells used to obtain replicate ground-water samples; namely, at wells likely to have measurable concentrations of analytes in ground water. This makes it possible to verify that (1) the sampling equipment was exposed to measurable concentrations of contaminants, and (2) equipment decontamination procedures were effective. (The latter cannot be verified if the wells selected for field blanks contain no measurable contaminants.)

Additional Land-Use Study wells that differ from those selected for replicate ground-water samples and field blanks need to be selected for VOC and pesticide field-spiked samples. Criteria for selection of wells for spiked samples (table 13) ensure that the QC data are representative--reflect the type(s) of ground water in the Land-Use Study area where VOC or pesticide contaminants are found but that unspiked samples do not contain the VOCs or pesticides of interest. This means that recovery estimates from spiked samples (in which the analytes of interest have been added in the spike solution) are likely to reflect recoveries from ground-water samples that contain these same analytes in similar concentrations.

The criteria also ensure that the field-spiked QC data are suitable--reflect recoveries that are unbiased. Samples that contain measurable concentrations of pesticides or VOCs--in excess of a few tenths of a microgram per liter--and that are spiked with similar VOCs or pesticides in accordance with current NWQL protocols generally will provide recovery estimates that have a positive bias. The bias results because the recovery generally is calculated on the basis of the measured concentration divided by the theoretical concentration of the spiked sample, where the latter is estimated from the amount of analyte added in the spike solution. Recovery estimates cannot be determined precisely by correcting for the background (unspiked) sample concentration, unless at least triplicate unspiked, and triplicate spiked, samples are collected.

The scheduling (timing) of routine QC data collection for the Land-Use Study is determined after the wells for routine QC data collection have been selected. This involves scheduling site visits at these wells such that routine QC data are obtained early, about mid-way through, and near the end of the 1- to 3-month period it commonly takes to complete data collection for a Land-Use Study. This implies that the ground-water sampling schedule for a Land-Use Study, or any other ground-water component, cannot be finalized until the routine QC sampling design is developed (table 7).

Study-Unit (or Subunit) Surveys. A typical Study-Unit Survey is designed to obtain occurrence and distribution data on a variety of analytes (table 1). In this respect, a Study-Unit Survey is somewhat similar to a Land-Use Study. A Study-Unit Survey differs from a Land-Use Study in some respects, which affects the routine QC design.

A Study-Unit Survey can involve data collection from as many as 100 to 120 wells associated with multiple, rather than one, land use. These wells also often will be distributed among several Subunit Surveys, each consisting of about 30 wells. The 30 wells in each Subunit Survey often will be completed in shallow and deep parts of one or more aquifers. Thus, wells in a subunit generally will reflect a greater diversity in land-use and water-quality conditions than that associated with a single Land-Use Study. Overall, data collection from these Subunit Surveys collectively will take more time to complete than it will take to complete a single Land-Use Study.

Because Study-Unit or Subunit Surveys and Land-Use Studies often will involve the collection of similar types of ground-water-quality data, the types of routine QC samples required for a survey for each analyte are similar to those required for a Land-Use Study (table 12). The minimum number of each type of QC sample required for each Subunit Survey is at least the same number as that required for a Land-Use Study. Because of the potential for a greater diversity in landscape and subsurface conditions in Subunit Surveys compared to Land-Use Studies, however, it is recommended that at least one or two additional sites be selected for replicate ground-water samples for the inorganic analytes (major ions, nutrients, alkalinity, acid neutralizing capacity, dissolved organic carbon, and possibly trace elements) and the field blanks in each Subunit Survey.

If the Study-Unit Survey is designed as a single entity (not conducted using Subunit Surveys), then the minimum number of QC samples required for each sample type for the survey is increased in direct proportion to the number required for a Land-Use Study (table 12) on the basis of the total number of wells being sampled for the survey divided by the total number of wells being sampled for a Land-Use Study (which for the purposes of this calculation is taken as 25). Thus, a survey that involves 50 wells requires twice the minimum number of each type of QC sample than generally is required for a Land-Use Study.

Survey wells are selected for routine QC samples and scheduled for data collection using the same approach outlined above for a Land-Use Study. Different wells are selected for the different types of QC samples to provide QC data that are representative of differences in water quality, suitable for providing estimates of measurement bias, variability, and recovery, and cover the time period during which the Survey ground-water-quality data are collected (table 13).

Flowpath Studies. A typical Flowpath Study will assess spatial differences and possibly temporal variability in each of a selected number of analytes among wells located in different parts of a local ground-water flow system. The number of wells used for water-quality data collection commonly will be less than 20, with most wells completed in a single aquifer that underlies a single land use.

The routine QC design for a Flowpath Study involves the selection of routine QC sample types (as described in table 12) that relate to only those analytes that are targeted for investigation by the Study Unit. These routine QC sample types are to be collected at selected sites the first time the flowpath wells are sampled and, thereafter, at sites and times that reflect Flowpath Study objectives--such as evaluating spatial or temporal differences in analyte concentrations. As a general rule, the sites selected and frequency of routine QC sample collection are to be sufficient to establish that possible spatial differences or temporal trends in analyte concentrations at, or among, flowpath wells are not primarily a function of measurement bias or variability that result from field and laboratory methods.

Nested Studies. Ideally, the ground-water design for a Study Unit calls for Flowpath Studies to be located in selected Land-Use Study areas, and that each Land-Use Study be located in a (Subunit) Survey area. Theoretically, this implies that routine QC data collected for one component could serve as routine QC data for another component. Ideally, this also is efficient in terms of planning, field work, and costs. Use of this approach, however, requires the routine QC design requirements be met for each individual component.

To ensure that routine QC data from one component are valid routine QC data for another component, one component must be geographically nested within the other. That is, at least one well must be part of both components--the well that will be used to obtain the QC data common to both components. Data collection for both components must overlap in time, and occur at the well targeted to provide the required ground-water and routine QC data needed for both components during that period of data-collection overlap.

Example of routine quality-control design: a case study

Regardless of the ground-water component, the design, and in particular, selection of sites for routine QC data collection commonly will be determined using limited information. In particular, to obtain representative QC data, the wells selected are to reflect the diversity of water-quality conditions likely to be found among the wells used to collect ground-water data in each component. In a number of cases, however, the quality of ground water in terms of analyte concentrations at each well will not be known until after NAWQA data are collected.

When water-quality data are lacking, other types of data are used to make inferences about the likely quality of water at each well. Useful ancillary data include (1) water-quality data from nearby wells (retrospective data), (2) data on surface features (such as land use, crop types, and associated chemical use) from site visits and published data, and (3) data on subsurface features (such as lithology and well depth) which are obtained during well selection (or installation) and from published data on aquifer characteristics.

An inferential approach to identify and evaluate routine QC-sample data-collection sites and data was employed in the Delmarva Peninsula pilot NAWQA study. In this study, Hamilton and others (1992) used retrospective water-quality data (primarily major cations and anions) to describe spatial and depth-related differences in ground water throughout the Study Unit, and to identify agriculturally-affected ground water as well as unaffected (or natural) types of ground water in the study area (fig. 1-A, encircled regions). To design QC sampling for this Study-Unit Survey, Koterba and others (1991) used the above information along with data on surface features (general land use, and different agricultural activities such as crop type and related liming, and fertilizer and pesticide use) and subsurface features (well depth and aquifer lithology) at each well to select those for replicate routine QC samples (except those for field spikes) and some field blanks. The combined ancillary data described above indicated that different types of ground water were likely to be encountered (fig. 1-A), and that most analytes (major ions, nutrients, organic carbon, trace elements, and perhaps pesticides) were likely to be found at detectable (above detection level, but less than reporting level) or higher concentrations at the selected wells.

Additional wells for QC data collection were selected that reflected a diversity in ground-water types, but where it was initially inferred that pesticides found in NAWQA spike solutions and of interest to the Delmarva Peninsula Study-Unit staff (primarily triazines and acetanilides) were not likely to be found in samples from this second set of wells. These wells were used to obtain samples for pesticide field spikes.

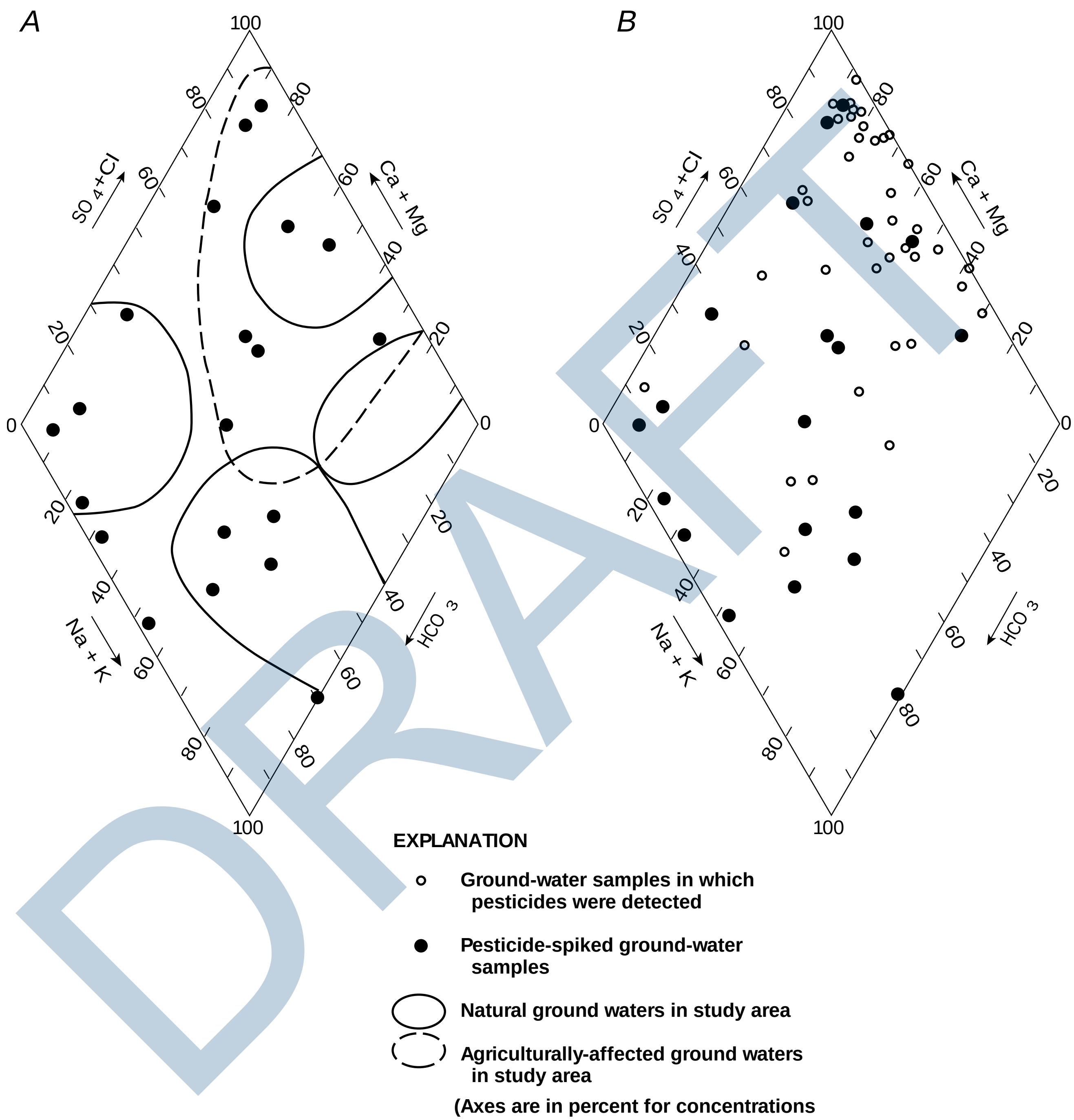


Figure 1. Distribution of wells selected for pesticide spikes in relation to the major-ion composition of (A) natural and agriculturally-affected ground waters, and (B) ground-water samples in which pesticides were detected in the Delmarva Peninsula (Koterba and others, 1993).

As water-quality samples and data were obtained by the Delmarva Study Unit, the major-ion data were plotted, including data from those wells selected for routine QC sampling. In general, plots illustrated that the different types of ground water described by Hamilton and others (1992) were being collected, and in particular, that the sites chosen for QC data collection also reflected most of the different types of ground water found in the Study-Unit Survey area (fig. A1, plotted points). Thus, the QC data were considered representative of the types of ground-water quality found in the study area.

Another key element addressed by the staff of the Delmarva Peninsula Study was to assess the suitability of replicate ground-water sample or field-spiked ground-water sample QC data to provide estimates of the method (field and laboratory) variability in concentration measurements or method bias in recovery, respectively, for selected analytes. This was done in part by using field-blank and unspiked (background) concentration data. In the Delmarva Peninsula Study, field blanks (12) were collected at different sites and times, and in each case, after equipment was contaminated (as later verified by the ground-water samples collected), and then field decontamination procedures were conducted. Blank data provided no evidence that samples (ground-water or other QC, including replicate or field-spiked samples) were subject to contamination in the field (by ambient conditions or equipment cross-contamination) or thereafter (during handling, shipping, and laboratory analysis). Further evidence that the QC data from field-spiked samples was suitable also came from the corresponding unspiked ground-water samples. Of 21 wells selected for field-spiked samples, only one yielded an unspiked sample that had a measurable concentration for any of the pesticides of interest. Thus, on the basis of field-blank and background-sample concentration data, it was demonstrated that there was: (1) no evidence samples of any type were contaminated during or after their collection, (2) that field decontamination procedures were adequate, and (3) that replicate and field-spiked data were not compromised by ambient or cross-contamination, and were suitable for estimating, in an unbiased manner, the method variability in concentration measurements and the method bias in recovery for selected analytes.

Additional data plots (for example, fig. 1-B) were constructed to illustrate that the wells chosen for pesticide field spikes generally reflected the types of ground water in which these same pesticides appeared as a result of what was considered normal pesticide use in the Study-Unit Survey area. Thus, it was argued that field-spiked sample data were representative of the types of ground water in which pesticides sometimes were found.

In terms of estimating pesticide recovery and measurement variability, only one of the 21 wells chosen by the Delmarva Peninsula Study-Unit staff for field spikes yielded a background sample with measurable concentrations of some of the pesticides found in NAWQA spike solutions and of interest to the Study Unit. This implied that, except for the data from that one well, the field-spiked sample data were suitable for obtaining unbiased recovery and variability estimates for those pesticides of primary interest to the Study Unit. Thus, for most of the pesticide analytes in question, recovery and measurement variability estimates were obtained using spiked samples from all 21 wells (Koterba and others, 1993). In the case of the one analyte found in the background sample from one well, the data from only 20 wells was used to estimate recovery and measurement variability.

The preceding discussion offers one approach that made it possible to select wells and design ground-water and routine QC sampling schedules each year to provide representative and suitable QC data for a 100-well Study-Unit Survey, which took 2 years to complete sample collection. Although the example above is for a Study-Unit Survey, the approach also is applicable to Land-Use and Flowpath Studies.

The above approach also illustrates how a Study Unit can graphically demonstrate that the wells selected for routine QC data collection represent different types of ground-water quality found in a component study area. If this visual analysis of QC data is made in a timely manner (before ground-water sampling for a component is complete), it is possible to incorporate wells not yet sampled, or initially selected, into the routine QC design to improve the representative nature of the QC data.

Topical quality-control samples

Field and laboratory equipment and methods for the collection of ground-water-quality data, including those for QC, could be modified as a result of routine QC data analysis, shifts in National Program priorities, or results from other studies. Modifications will be designed and implemented in a systematic manner, preceded by a NAWQA memorandum that explains the nature of the modification, the reason for the modification, and the manner in which the modification will be documented and evaluated. As part of this modification process, which is considered topical in nature, Study-Unit participation could be requested by the National Program. On some occasions, this could require additional QC samples be collected by some or all Study Units.

Individual Study Units could find additional QC samples are necessary to address a topic of local concern. For example, additional field and trip blanks could be required to verify that VOC contaminants are in the ground water, and are not being introduced during and after sample collection (Rea, in press). In other cases, additional blanks and spiked samples could be required to correctly assess method-related problems (Koterba and others, 1994).

Sample Coding and Data Management

The current electronic systems for sample and data management (LIMS-NWQL, NWIS-I-QWDATA, and NWIS-I-QADATA) do not provide a simple means of relating or differentiating among ground-water-quality and QC samples obtained from a single well. Although there are several ways to overcome this problem, the need to aggregate ground-water-quality and QC data on a regular basis at the Study Unit and National Program level requires consistent coding and management of samples and data among Study Units. For this reason, protocols for coding and electronically storing routine QC samples and data were developed (tables 14 and 15). In the case of topical QC data, coding is provided as part of each national topical QC-data request.

Table 14. Sample container coding requirements for ground-water-quality and routine quality-control samples of the National Water-Quality Assessment (NAWQA) Program

[NWQL, National Water Quality Laboratory, Denver, Colo.; SC, laboratory schedule; LC, laboratory code (in lieu of schedule); FA, filtered and acidified (nitric acid); RU, raw (unfiltered) and untreated; FU, filtered and untreated]

---

1. Routine ground-water sample-bottle labels:
   - NAWQA and Study-Unit four-letter code: for example, "NAWQA-POTO" (for Potomac NAWQA Study Unit)
   - Local well identifier code
   - Bottle type--NWQL sample designation schedule or laboratory code: for example, FA-SC2750
   - Date of sample collection (MM-DD-YY, month-day-year), for example, 06-31-94
   - Time of sample collection (HH:**00**, hours-minutes, military time)[a] for example, 12:00

2. Routine quality-control sample-bottle labels:
   - NAWQA and Study-Unit four-letter code, same as above
   - Local well identifier code, same as above
   - Bottle type--NWQL schedule or laboratory code, where schedule or laboratory code used is given below
   - Date of sample collection (MM-DD-YY, month-day-year), same as above
   - Time of sample collection (HH:MM, hours-minutes, military time) where minutes are assigned values other than 00, according to the following format:

Time	Routine QC-sample type time-of-collection codes.[b]
HH:**01**	**Replicate--organic-carbon, nutrient, pesticide, volatile-organic, radon or major ion samples,** use SC2085, SC2752, SC2001 and SC2050, SC2090, SC2091, or SC2092, LC1369, and SC2750 (FA, RU, and FU), respectively. (For replicate cartridges, use SC2010 and SC2050, in lieu SC2001 and SC2051, respectively. Replicates for pesticide and volatile-organic compounds are optional.)
HH:**02**	**Field spike-1st--for pesticide or volatile-organic samples,** use same schedules cited under replicates above.
HH:**03**	**Field spike-2nd--for pesticide or volatile-organic samples,** use same schedules cited under replicates above.
HH:**04**	**Field spike-3rd (optional)--for pesticides or volatile-organic samples,** use schedules cited under replicates above.
HH:**05**	**Field blank--pesticide, volatile-organic, organic-carbon samples--(which require NWQL pesticide and VOC-free blank water, or if no field blank for VOCs taken, require NWQL pesticide-free blank water),** use same schedules cited for replicates above. **Field blank--nutrient samples (which require QWSU inorganic-free blank water),** for SC2752**.**
HH:**06**	**Field blank--major-ion (which require QWSU inorganic-free blank water)** for SC2750.
HH:**07**	**Solution blank--organic carbon only, (required because NWQL blank water is not analyzed for organic carbon),** use SC2085.

Table 14. Sample container coding requirements for ground-water-quality and routine quality-control samples of the National Water-Quality Assessment (NAWQA) Program--Continued

Time	Routine QC-sample type time-of-collection codes.[b]
HH:**08**[b]	**Trip blank--volatile organic samples only (which requires NWQL trip blanks found in box that sample vials are obtained in),** use SC2090.
HH:**09**[b]	**Primary trace-element ground-water-quality sample**, such as for SC2703.
HH:**10**[b]	**Replicate trace-element ground-water-quality sample,** such as for SC2703.
HH:**11**[b]	**Field blank--trace-element samples only (which require QWSU inorganic-free water),** and in lieu of SC2703 use SC172 and add LC0112 (arsenic) and LC0087 (selenium).
HH:12[b]	**Standard Reference Sample--for trace-element samples only,** such as for SC2703.

[a]This is a generic time value--the nearest hour to the true time--that is the basis for linking samples taken from a well during a particular visit. Some situations, or samples, require the true time of collection also be recorded--for example, to identify the time at which radon is taken. True time can be recorded, along with the reason it is being recorded, on the field form, as in the case of radon, in the message to the laboratory section on the NWQL-ASR form.

[b]Except for trace elements (for example, SC2703), additional sample bottles under other schedules can be added under the above time codes if and only if (1) they do not contain analytes in common with the samples and schedules already listed, and (2) if they are composed of blank water, it is the same type of blank water being used for the samples already listed above. If these conditions cannot be met, use other time codes (and NWQL analytical service request forms) for the additional samples. Note that for trace elements, unique time codes are required.

Table 15. Storage and coding requirements for ground-water-quality and quality-control samples and data of the National Water-Quality Assessment Program

[NWIS-I, National Water Inventory System; QWDATA, Quality of Water Data Base; QADATA, Quality-Assurance Data Base; NWQL, National Water Quality Laboratory; BTD&QS, Branch of Technical Development and Quality Systems; QWSU, Quality Water Service Unit; mL, milliliters]

1. Data Storage (check District policy):

- Routine ground-water-quality data in NWIS-I (QWDATA) database.
- Routine quality-control data in NWIS-I (QADATA) database.
- Topical quality-control data in NWIS-I (QADATA) database.

2. Sample and Data Coding on Analytical Service Request (ASR) Forms:

- Use same local well identifier as on sample container, add corresponding station identification code (15-digit latitude-longitude-sequence number) and use same date for all ground-water and quality-control samples collected at a well during a site visit.
- Use different time-of-sample collection codes for quality-control samples.[1]
- Use additional codes below for quality-control samples (in accordance with BTD&QS):[2]

For BLANKS: Coding required

Blank type	Sample medium	Sample type	Blank solution type (99100)	Blank solution source (99101)	Blank sample type (99102)
Trip	Q	2	10, 40, or 50	10, 60, or 80	30
Equipment	Q	2	10, 40, or 50	10, 60, or 80	80
Field	Q	2	10, 40, or 50	10 or 80 only	100
Solution	Q	2	10, 40, or 50	10 or 80 only	1

where Q denotes an artificial sample; 2 implies a blank sample; blank solution type 10, 40, or 50 implies inorganic-free, pesticide-free, or volatile-organic-free blank water, respectively; blank solution source 10, 60, or 80, implies blank water from the NWQL, District, or QWSU (Ocala), respectively; blank sample type 30, 80, 100, and 1 correspond to the blank types specified in the first column, respectively. Only NWQL or QWSU water should be used for field blanks. Record lot number of blank solution on ASR form.[3]

For REPLICATES: Coding required

	Sample medium	Sample type	Replicate type (99105)
Regular sample	6	7	20
Second sample	S	7	20

where 6 implies a ground-water sample; S implies a replicate ground-water sample; 7 implies replicate samples; and 20 implies samples were collected sequentially.

Table 15. Storage and coding requirements for ground-water-quality and quality-control samples and data of the National Water-Quality Assessment Program--Continued

2. Sample and Data Coding on Analytical Service Request (ASR) Forms--continued

- Use additional codes below for quality-control samples (in accordance with BTD&QS)[2]--continued

For SPIKED SAMPLES (pesticides and volatile organic compounds):

	Coding required					
	Sample medium	Sample type	Replicate type (99105)	Type of spike (99106)	Source of spike (99107)	Volume of spike (mL) (99108)
For each spiked sample	S	1	20	10 or 20	10	0.1

where S denotes a replicate ground-water sample; 1 implies a spiked sample; 20 implies a sequentially-collected sample; 10 or 20 implies spike was done in field, or at NWQL, respectively, 10 implies source of spike solution was the NWQL (required); 0.1 implies a 100-microliter volume of spike solution was used. Record lot number of spike vial on ASR form.[3]

For REFERENCE SAMPLES (of trace elements, obtained from BTD&QS):

	Coding required		
	Sample medium	Sample type	Reference type (99103)
For each reference sample	Q	3	35

where Q denotes an artificial sample; 3 implies a reference sample; and 35 implies a reference sample that is a blend of standards. Record reference sample bottle code as received from BTD&QS on ASR form.[3]

[1]Use different time codes to distinguish QC samples and prevent data overwrites (see table 14).

[2]Storage of ground-water-quality and quality-assurance data in NWIS, Branch of Quality Assurance Memorandums 90.03 and 92.01 (unpublished memorandums located in the USGS BTD&QS, P.O. Box 25046, Mail Stop 414, Denver Federal Center, Lakewood, CO 80225).

[3]Write message to lab on comment line on ASR form.

To easily group ground-water-quality and QC data from selected sites, the containers for these samples are coded in a systematic manner that employs some common codes (table 14--NAWQA Study-Unit code, local well-identifier code, schedule or laboratory code, and date of collection). For example, ground-water-quality and routine QC samples from the same well and time of site visit are given the same local well-identifier code (on sample containers), and the same local well and 15-digit (latitude-longitude-sequence number) identification codes in NWIS-I, and the same date of collection (on containers and in NWIS-I). These common codes facilitate linking selected types of samples (field blanks with the ground-water sample collected before the blank was taken, one replicate sample with another, or a spiked sample with an un-spiked sample). If common codes are not used, recoding, or the creation of additional codes by the Study Unit, will be needed to link data requested by the National Program. In either case, the Study Unit will be adding unnecessarily to its workload.

To manage sample data efficiently, and reduce confusion, it is best if routine QC sample data are stored and managed through NWIS-I QADATA, and ground-water-quality sample data are stored and managed through NWIS-I QWDATA (table 15). Efficient data management, re-duced data loss, and improved ease of interpretation also are best achieved if different routine QC-sample types, taken in relation to the same well and time of site visit, are uniquely coded in at least some respects, and ancillary information that relates to each routine QC-sample type is documented on the ASR form (tables 14 and 15). Thus, different time, medium, and QC-sample codes are used for different types of routine QC samples. Ancillary information, such as the lot number of the blank water or the spike solution, also is coded and essential to interpreting QC data correctly. Illustrations of how data and codes are to be stored are provided for each type of QC sample routinely collected (see appendix).

Consistent coding benefits each Study Unit in several ways. First, except for a few codes, such as time of sample collection, most sample containers and forms generally can be filled out before the field team departs for sampling. Most of this same information also can be logged into NWIS-I in advance. This report (tables 14 and 15 along with the appendix) provides a com-prehensive summary of appropriate codes that are needed to complete these presampling coding and management activities.

The prescribed codes will reduce the loss of data through overwrites. Data overwrites can occur in several ways. For example, one of the most common overwrite problems occurs when two different sample containers and their corresponding ASR forms have the same identification, date, and time codes, and one inadvertently requests analyses that involve at least one common analyte (parameter code) for both samples. Another common problem arises when one makes corrections to NWIS-I (QADATA or QWDATA), but does not have these processed through NWQL-LIMS. In either case, corrections are overwritten and data can be lost electronically when the NWQL submits or resubmits analytical results to NWIS-I through LIMS original record or provides updates to this record. To avoid problems, the Study Unit must code samples correctly. In addition, if corrections are made in the District, the Study Unit also must request the corrections be processed through the NWQL-LIMS system.

The prescribed codes will ensure that the sample container for a particular analysis is used for that analysis. For example, if sample containers are sent for major ions (SC2750--FA) and trace elements (SC2703--FA), they must be sent under separate ASR forms with different times to ensure that the trace-element analysis is done using the SC2703 sample and not the SC2750 sample. Because of potential differences in filter loading that affect filtrate concentrations between these two samples, it is critical that trace-element data come from an analysis of the SC2703 sample.

Finally, use of the prescribed codes (tables 14 and 15) is necessary for requests from the National Program for ground-water and QC data. If alternative coding is used, the data will need to be recoded by the Study Unit before the data are forwarded to the National Program.

Final Presampling Plans and Preparations

During the last month or two before the first field season for data collection begins, the Study Unit will complete presampling plans and preparations. This will involve a number of activities (table 16) that, in addition to scheduling water-quality and QC sampling, will include the following:

1. Creating a field file that contains copies of all the information needed for the current sampling run;

2. Preparing sample containers and filter units;

3. Checking that all the equipment and supplies needed for sample collection at each well listed in the file have been obtained and safely stored in the vehicle; and

4. Checking that the vehicle is in good and safe working condition, and that safety equipment is present and functioning properly.

In addition to the well schedule (table 7), the field file contains information critical to completing activities at each well (table 16), which could differ among wells. As sampling continues, the file is updated regularly in terms of those wells scheduled for data collection throughout the remainder of the field season.

Table 16. Activities related to final plans and preparations before sampling begins

---

1. **Create a field file,** in part, from previously collected information, that contains:
   - A well schedule (chronological list of wells to be sampled during the scheduled run).
   - A checklist of the sample and data-collection activities to be carried out at each well--
     (a) a list of analytes to be sampled--by bottle type (for example, FA), in order of collection and processing, including quality-control samples,
     (b) a list of information required, and the necessary forms, to complete any documentation not completed during previous site visits, and
     (c) a form for noting changes in, or providing additional information on, land use.
   - Copies of site, well, measurement point, and sampling setup location maps and photographs for each well.
   - Notes on any special site conditions that could affect sample and data collection at a well, including roaming animals and locked gates, or a well, that on the basis of screening tests, might require special QC sampling and decontamination procedures.
   - The contact person's (well or land-owner's) name and telephone number for each well.
   - Field cover, well-purge, Analytical Service Request, and field-instrument calibration forms--completed to extent possible for each well. Also include some extra, blank copies of each form. (Calibration notebooks can be used instead of individual forms.)
   - Overnight-mail shipping forms and labels, completed to extent possible, and the shipper's telephone number.
   - Study-Unit (SU) sample-transfer and temperature-check form for NWQL (Sample login) with SU-addressed, stamped envelope for each well. (Also have the telephone number for NWQL (Sample login)).
   - Calibration notebook(s) for field meters.
   - Copies of the NAWQA protocols for sample and data collection, and the U.S. Geological Survey National Field Manual for Collection of Water-Quality Data (Radtke and Wilde, in press).

2. **Prepare sample containers and filter units** that are:
   - Cleaned if necessary,
   - Labeled to the extent possible, and
   - Bagged, for each well,
   - With each container tightly capped. (Recommend plastic container be half filled with DIW.)

3. **Provide routine checks** that cover the equipment and supplies stored in field vehicles (see table 3 for detailed list), for:
   - Calibration and use of field meters for temperature, pH, acid-neutralization capacity, alkalinity, specific electrical conductance, dissolved oxygen, and possibly turbidity.
   - Collection, processing, preservation, and, possibly field extraction of ground-water and quality-control samples.
   - Field-equipment decontamination.
   - Sample shipment or temporary storage.
   - Disposal or temporary storage of waste materials.

4. **Provide predeparture checks** each time the field team leaves the District office or a well that:
   - Cover vehicle safety and condition.
   - Ensure all field equipment is properly and safely stored.

As part of the final presampling preparations, some sample containers require rinsing (table 16). For example, it is required that all sample containers and caps for filtered and acidified samples (FA designation), which includes those for major ions and trace elements, be rinsed at least three times with either QWSU IBW or DIW -- ASTM Type 1 water (conductivity less than 1.0 µS/cm at 25°C). It is recommended, however, that FU, RU, and FCC containers also be rinsed as described above before use. After the final rinse, it also is recommended, as a QC measure on the container seal, that each container be half-filled with the same water used for rinsing and capped before storing the container for transport to the field. If the container is less than half full when pulled from storage in the field, the container is discarded, and another similarly rinsed container is used in its place. This implies that several additional containers for each sample type are prepared as above and in advance of at least the first field-team trip. After rinsing, sample containers can be labeled with the appropriate codes, except for date and time of collection, before they are transported to the field. This will reduce the time necessary to complete setup activities in the field before samples are collected.

Although at least three different filter units commonly will be used (table 3), only the one for filtered inorganic samples, the 0.45-µm fibrous filter (capsule), can be prepared before the field team departs for the field. It is required that 1.0 L of QWSU water or DIW (ASTM-Type-1) be passed through this filter before it is used. Preconditioning is to occur within 5 days before use. A peristaltic pump head with Tygon tubing, or a Teflon diaphragm pump head with convoluted Teflon tubing can be used to force the preconditioning water through the capsule filter. The pump also is used to force as much water as possible from the capsule after it is preconditioned. To avoid mildew, the preconditioned capsules are placed in nested, resealable plastic bags and stored in a cool environment (refrigerator or cooler with ice) before use.

Different filter units might need to be prepared to address topics of interest germane to a specific Study Unit component. A Flowpath Study that involves geochemical modeling and other techniques to interpret dissolved inorganic chemical data from ground water requires additional samples be obtained with these samples filtered through a membrane with a pore size of 0.2 or 0.1 µm or less. Currently, only flat (plate) filter membranes are available with a pore size of 0.1 µm or less. Preparation of these membranes and the equipment needed is described in an internal document (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1). To determine the appropriate filter type and pore size, it is recommended that a comparison sample analysis be made between data obtained from NAWQA samples passed through 0.45–µm capsule filters and Study-Unit samples passed through 0.1–µm membranes to determine if there is an appreciable difference in trace-element concentrations.

Final plans before sample collection include the office support effort required to maintain the field effort. The field effort typically involves repeating activities (such as those in table 16) on a regular basis during a single field season. To plan for the office support needed, consider that each time the field team returns: (1) the sampling vehicle(s) generally is (are) unloaded, cleaned, and restocked; (2) forms and other information are transferred from field to office files; (3) the field file is restocked with information on the next set of wells to be sampled; (4) samples brought from the field are archived or shipped from the office; and (5) field and sample-related data and forms are transferred to data managers, with copies being archived into NAWQA site files.

If the planning document or workplan assigns all of the above activities solely to the field team, their field schedule must allow ample time to complete these activities. The workplan also should reflect that team members could have a backlog of work pending as a result of their absence. A field team that keeps good records in the field--of supplies that are running low, or of equipment that is in need of repair or replacement--can expedite preparations for the next field effort. While in the field, mobile phones also provide an efficient means of communicating needs in advance or when emergencies arise.

During final preparations, Study-Unit data managers integrate their plans to review the data-collection process. Workplans, developed during the last month or two before sampling begins, include verification of field forms returned by field teams, the login of sample and data information from these forms, and the updating of any new information (such as changes in land use). Workplans also include regular retrievals and quality-control checks on NWQL data returns. Of particular importance is the timely retrieval and evaluation of routine QC data, which can be used to assure field teams that data collection can continue unabated. Finally, data management workplans are to include the development of NAWQA water-quality files for wells at which ground-water samples are collected. These files generally are distinct from other files, such as the GWSI file, in that they chiefly contain records and information pertaining to ground-water-quality sampling. Thus, each of these files contains copies of sample-collection field forms, NWQL and other laboratory request forms, and water-quality-data summaries (in particular, NWIS-I site and time-specific lists (WATLISTS) of water-quality data).

Field Protocols and Recommended Procedures

A field team could spend 2 to 5 hours traveling to and from each well that is scheduled for the collection of ground-water-quality samples. At each well, the team will perform some, or all, of the following activities:

(1) Equipment setup.

(2) A well purge, to remove standing water, and field measurements.

(3) Sample collection and processing.

(4) Decontamination of field equipment, including possible breakdown and storage of sampling equipment.

(5) Preparation of blank samples.

(6) Preparation of other routine quality-control samples and field extracts for pesticide samples.

(7) Handling and shipping of samples, including completion and verification of field, laboratory, and other forms.

Each activity is described below in its approximate chronological order of occurrence.

Equipment Setup

Upon arrival, the field team contacts the land or well owner (if necessary), and locates the well and areas for conducting on-site activities (table 17). The field team carries out the remaining setup and other on-site activities after selecting one field-team member, hereafter referred to as **Team Member A**, who is responsible for the collection of all water-quality samples throughout the day. From this point on, **Team Member A** generally performs only those on-site activities that are least likely to lead to the contamination of samples during or after collection. The other field person, **Team Member B**, also performs activities required in order to collect samples and data, but in some cases the activities performed potentially heighten the risk of sample contamination if that person also were to collect water-quality samples.

Field team roles, which are maintained throughout the day regardless of the number of wells visited, are alternated between team members on a regular, preferably day-to-day, basis. This ensures that each team member can perform all on-site activities associated with ground-water-quality data collection.

It is recommended that team members wear clothing appropriate to their assigned activities. **Team Member A** wears clothing that is tightly knit and not likely to shed lint. Powderless latex (when using methanol) or powderless vinyl gloves are required. **Team Member B** initially wears work gloves and coveralls over attire, similar to that of Team Member A. Work gloves and overalls are removed after the completion of setup activities that involve handling equipment that could be heavily soiled or contaminated (table 17). **Team Member B** also is required to wear powderless latex or vinyl gloves during sample handling and preservation. Safety goggles or glasses are worn whenever either team member is handling chemical reagents that are potentially toxic or hazardous.

Well Purging, Grab Samples, and Field Measurements

Before water-quality samples are collected, the well is purged of standing water. Grab samples taken near the end of the purge are used to determine (1) the amount of NWQL hydrochloric acid needed to acidify the VOC samples, and (2) the normality of QWSU sulfuric acid to use for field titrations. Field data are obtained during the latter stage of the purge, immediately before sample collection. The purge, as well as grab-sample analyses and field measurements, are carried out in an efficient, and to the extent possible, consistent manner throughout the NAWQA Program (table 18).

The well purge ensures that the field-measurement and sample data that are subsequently collected reflect the chemistry of water in the aquifer, and not that of the water that has been standing in the well. The purge also conditions sampling equipment and reduces turbidity (sediment and colloids) caused by either the lowering and start-up of a portable pump, or the start-up of a water-supply pump.

Table 17. Initial field-team setup activities related to on-site protocols and procedures at wells used for ground-water-quality and routine quality-control data collection for the National Water-Quality Assessment Program

---

1. Field team arrives, consults field file (table 16), and carries out initial setup activities as follows:

   - Contacts land or well owner (if necessary)
   - Verifies following points and areas of interest (modify site-file maps and update photographs and forms as necessary):

     Land use and land cover in vicinity of well[1]
     Well location and water-level measurement point
     Parking areas for vehicle(s)
     Areas for field-equipment setup and well-water discharge

2. To provide quality assurance, the field team divides remaining setup duties, which are carried out as follows:

   - **Team Member A**

     Calibrates and sets up field instruments for titrations, turbidity, and flowthrough chamber[2]
     Assembles sample-wetted equipment for purge and collection[3]
     Completes labeling of sample containers and forms (primarily by adding date and time of collection)[4]

   - **Team Member B**

     Sets up safety cones (as needed)
     Measures water levels (if possible, static depth to water and depth of well)[3]
     Checks for oil residues in well (on measurement tape)
     Calculates purge volume (from well diameter and depth measurements, otherwise assumes it equals three casing (or wellbore) volumes)[5]
     Attaches waste lines to purge setup (see fig. 2, routes to prevent flooding in work area and near power supplies)
     Sets up pump system (as needed, fig.2, for monitoring well, in well drained area)
     Sets up power supply (for portable pump, avoids wastewater areas; using vehicle power, checks fuel is sufficient, attaches exhaust hose(s) to vehicle(s), and voids exhaust downwind of work areas; using portable generator, checks and, if necessary, fills fuel tank)

---

[1]See appendix, figure A1, and update as necessary.

[2]According to “Field Instruments” section and appendix, figures A2 to A6.

[3]See text and figure 2.

[4]According to “Sample Coding and Data Management” section and appendix, figures A8 to A20.

[5]See appendix, figure A7.

Table 18. Field-team activities for purging a well for ground-water-quality and quality-control data collection

[NWQL, National Water Quality Laboratory; HCl, hydrochloric acid; VOC, volatile organic compound; QWSU, Quality Water Service Unit; mL, milliliter; H_2SO_4, hydrosulfuric acid; ANC, acid-neutralizing capacity; ALK, alkalinity]

1. Field team identifies approach to be used to purge well on basis of:
   - Standard purge protocol (see table 19)
   - Recent pumpage from well
   - Possible use of packers
   - Well capacity
   - Possible use of other customized purge criteria
   - Well type (monitoring or water-supply well)[1]

2. Field team divides site duties on the basis of assigned roles for the day, and carries them out as follows:

Team Member A

- Records flow rate and volume of flow from the well and through the equipment setup.[2]
- Collects grab samples near end of purge to determine and record:[3]
  (1) the number of drops of NWQL HCl required to reduce the pH of VOC 40-mL sample to 1.7 to 2.0 (to a maximum of 5 drops for VOC sample preservation), and
  (2) the normality (1.6 or 0.16) of QWSU H_2SO_4 titrant, and volume in milliliters (50 or 100) of the ground-water sample (for field titrations of ANC and ALK).
- Records field measurements, including final median values required under protocol.[2]

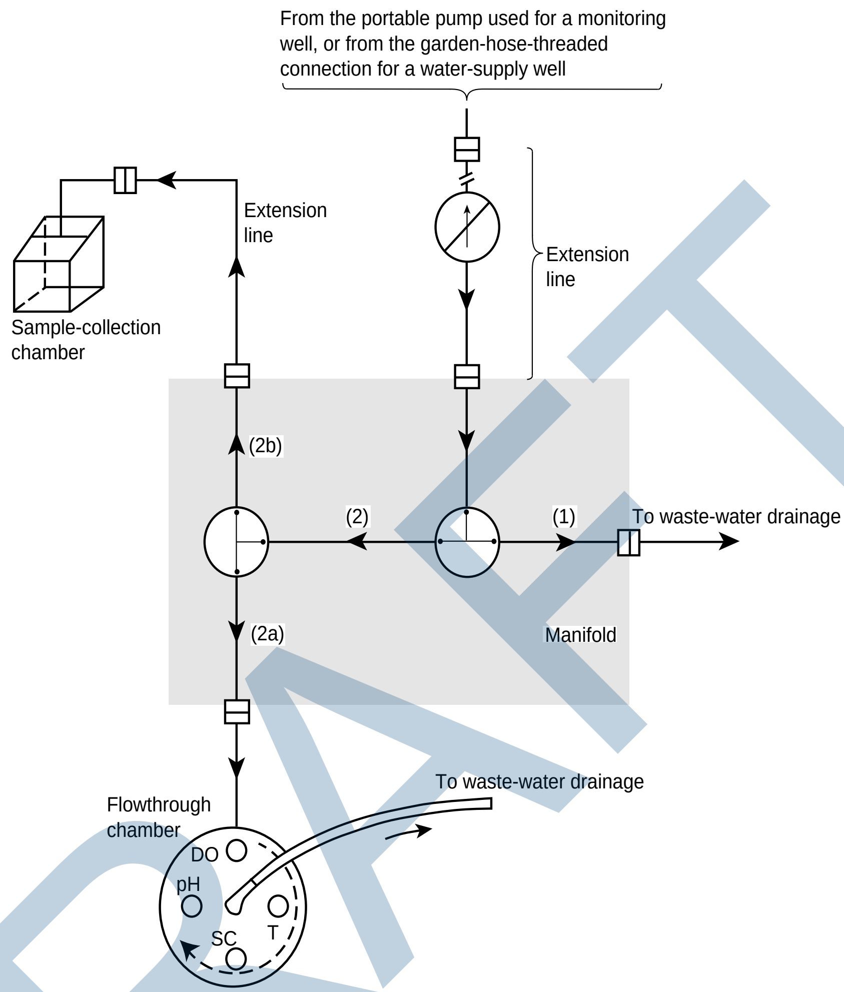
Team Member B

- Conducts purge (and routes flow as needed to obtain field measurement data (see fig.2)).
- Adjusts and measures initial and final flow rates through purging setup and pump rates in well (as required and needed)[1].
- Monitors (if necessary) pump work rate (amperage) and power supplies (fuel levels).

Both Team Members

- Assess stability of chemical and physical measures to determine when samples are collected.[4]
- Document decision on whether or not to sample, and why.

[1]See text, including section on “Purging Different Types of Wells.”
[2]See appendix, figure A7.
[3]See “Grab Samples for Titrations and Volatile-Sample Preservation” and appendix, figures A8 and A9.
[4]See “Final Assessment of Chemical Stability.”



EXPLANATION

Rigid-wall Teflon tubing

Quick connection

Antibacksiphon

Three-way Teflon flow valve

Flow direction, at different times

(1) During initial purge stage

(2) During intermediate and final stages

(2a) To obtain most field measurements

(2b) To obtain turbidity samples, and at end of purge to route flow for collection

Field sensors (flowthrough chamber)

DO Dissolved-oxygen sensor

T Temperature sensor

pH pH sensor

SC Specific electrical conductance sensor

Figure 2. Schematic of equipment setup for well purge and sample collection.

Despite differences in scientific opinion as to when and how much purging are necessary, and the criteria used to assess when purging is complete, NAWQA field teams will use the standard USGS procedures and criteria for purging and collecting field measurements (table 19). In applying the purge protocols, the equipment and procedures used can differ in some respects on the basis of recent pumping, well capacity, study component, and well type (see below). With some exceptions, the same equipment (fig. 2), criteria (table 19), and similar procedures are used to purge and collect ground-water-quality samples. Deviations from the standard purge protocols that are not described below are discussed in advance, if possible, with the NAWQA QA Specialist.

Acceptable deviations from standard purge protocols

Four possible exceptions to the standard purge procedures are recognized and accepted. The first relates to recent pumping. If it can be documented that a volume of water equivalent to the purge volume already has been pumped from a water-supply or monitoring well within the 24-hour period before the field team arrives, sample collection can begin after equipment has been flushed or "conditioned" with ground water and field measurements have been shown to be stable. This effectively reduces the purge time to that needed to achieve stable field measurements (table 19, minimally about 15 to 25 minutes).

The second exception to the standard purge protocols relates to well capacity. When the permeability of the aquifer is low, and a slow recovery limits well capacity, it often is possible to quickly evacuate the standing water from the well. For a monitoring well, the field team lowers the pump intake slowly, and evacuates the well at a pump rate that does not suspend sediments. Field measurements and samples are obtained after the water level has recovered to at least 90 percent of the level measured before evacuation, and provided recovery occurs within 24 hours of evacuation.

The third exception to the standard purge protocols also relates to well capacity. When packers have been placed in a well to restrict the zone of water withdrawal, the purge volume is equivalent to three times the volume between the packers. Given that this purge volume could be quite small, the field team again could find that only a 15- to 25-minute purge at the low flow rate is needed to remove the necessary water and obtain stable field measurements. As a quality-control measure, pressure transducers, installed above and below the packers, are recommended to determine that leakage is not occurring across packers or from above or below the zone isolated for sampling.

The fourth exception to the standard purge protocols is related to the ground-water component sampled. When purge criteria can be customized for the well and in relation to specific sampling objectives, these purge criteria can be used in place of the standard criteria. This exception is most appropriate for investigations that focus on a specific, but limited group of analytes, such as in a NAWQA Flowpath Study (table 1). In fact, it is recommended that Study Units develop and use purging procedures and criteria that best correlate with the concentrations of analytes being investigated. For example, a customized purge criteria for sampling VOCs is described by Gibs and Imbrigiotta (1990).

Table 19. Standard protocols and recommended procedures for conducting and assessing well purging for the National Water-Quality Assessment Program (modified from F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1)

[Assumes that well capacity is not a limiting factor; see text for further discussion of exceptions. °C, degrees Celsius; %, percent; ≤, less than or equal to; >, greater than; <, less than; µS/cm, microsiemens per centimeter at 25°C; mg/L, milligrams per liter; NTU, nephelometric turbidity units]

1. Purge a minimum volume of water equal to three times the casing (or wellbore) volume.[1]
2. Reduce rate of flow from well, if possible, but at least through setup, to no more than about 0.1 gallon (~500 milliliters) per minute for 15 to 25 minutes near end of purge (sample-collection rate).[2]
3. Monitor pH, temperature, specific electrical conductance, and dissolved oxygen throughout the purging process, but particularly during last 15 to 25 minutes. (If trace-element samples are being collected, include turbidity measurements as part of monitoring.)
4. The well is considered purged after at least three casing volumes have been removed and values of monitored parameters between 5 successive measurements separated by about 3- to 5-minute time intervals are within the allowable difference specified below:

Parameter	Allowable difference or value
pH	± 0.1 units (± 0.05 units if instrument displays 2 or more digits to the right of the decimal)
Temperature	± 0.2°C (thermistor)
Specific electrical conductance (SC)	± 5%, for SC ≤ 100 µS/cm ± 3%, for SC > 100 µS/cm
Dissolved oxygen (DO)	± 0.3 mg/L
Turbidity (TU)	± 10%, for TU < 100 NTU: ambient TU is <5NTU for most ground-water systems (visible TU > 5 NTU)

- If measurements appear stable, the median value of the last five measurements for each parameter (except for pH) is recorded on the appropriate forms (see appendix, figs. A7 and A8), and the field team proceeds with sample collection. For pH, only the last measurement is recorded.
- If criteria for stability is not achieved, purging is continued until either the field measurements stabilize, or the equivalent of five or more wellbore or casing volumes have been removed, depending on the judgment of the field team. The field team records the final field measurements in the manner noted above, and notes any parameters which remain unstable.
- If measurements remain unstable, the field team must decide whether or not to continue with sample collection.
- A lack of stability, indicated by a consistent trend in values upward or downward for pH, SC, DO, and TU, indicates possible problems in well design, or purging setup or technique. It is recommended that samples not be collected from a well if the setup or technique cannot be altered to obtain stable measurements.

[1]Standing volume is calculated from depth to water and depth of well measurements (see appendix, fig. A7).

[2]If a high initial rate is used, reduce rate of flow from well and through purge-collection setup to this rate.

Each of the above exceptions actually fulfills the intent of the standard protocols. In each case, the procedures and criteria used ensure the removal of stagnant water, and the chemical and physical stability in flow before samples are collected. In addition, and regardless of what purge criteria are used, the standard field measurements (DO, SC, T, pH, and, if trace-element samples are collected, TU) also are determined and documented. They are part of the NAWQA data collected at each well (table 1). Thus, except for pH, the median value of the last five stable values for each standard measurement, and any customized purge criterion, are recorded as part of the data of record. For pH, only the last measurement is recorded.

Purging with different flow rates

With the exception of some Study-Unit Survey Flowpath-Study components (table 1), wells used by NAWQA generally are completed at relatively shallow depths in water-table aquifers. As a general rule, the purge procedures described above are completed within about 2 to 2 1/2 hours, which includes the 15- to 25-minute period at the low flow rate required for sample collection (about 0.1 gal/min or 500 mL).

A low flow rate is required at the end of the purge (and during sample collection) for consistency and technical reasons. In combination with a portable, submersible pump, a low flow rate:

(1) is obtainable and maintainable for most, if not all, wells;
(2) reflects a discharge that can be sustained at low pump amperage and without surging;
(3) reduces the likelihood that sources of ground water entering the well will change (Reilly and others, 1989);
(4) is likely to lead to uniform, or at least less turbulent, flow;
(5) reduces the potential for degassing of some constituents, such as VOCs and radon;
(6) reduces the likelihood of entraining colloids and other artifacts dislodged and suspended by turbulence; and
(7) provides a rate of flow that is manageable during sample collection.

To achieve some of the above in sampling water-supply wells when the rate of flow through the well is high and uncontrollable, part of the flow is diverted (through the equipment setup) at the required low rate.

Although use of a higher rate of flow throughout the purge and sample-collection period than that required near the end of the purge reduces purge and sample-collection times, it also reduces the likelihood that the benefits described above will be achieved. As a compromise that aids in reducing field times, while maintaining some consistency and quality control, higher flow rates (during the initial part of the purge) than the required low flow rate (near the end of the purge) can be used provided these conditions are met: (1) that the high flow is sustainable, (2) that the high flow is not highly turbulent, (3) that field measurements, including turbidity, which could change precipitously at first under the high flow, stabilize relatively quickly, and remain about the same (no abrupt changes), and (4) that turbidity, in particular, does not remain elevated, but approaches a generally acceptable value (table 19).

Purging different types of wells

Perhaps the most substantial differences among wells that the field team could encounter in applying the standard purging protocol (table 19), or one of the acceptable deviations to that protocol, occurs in relation to well type (monitoring or water-supply well). Because water-supply wells for NAWQA are chosen on the basis of suitable construction for ground-water-quality data collection (Lapham and others, in press), they are equipped with pumps that can be used to obtain water samples. The location of the well pump intake and the pump rate, however, generally cannot be controlled by the field team. This implies that the field team only has limited control of some aspects of the purge and sample-collection process at these wells. This is not the case for most monitoring wells. Because data collection at most monitoring wells selected by NAWQA will require the use of a portable pump whose intake location and flow rate can be modified, the field team has considerable control over the purge and sample collection process for this type of well. Despite the differences in level of control between water-supply and monitoring wells, and to promote consistency in purging and data collection from these two types of wells, it is required that field teams follow the standard procedures (table 19), when possible, or follow acceptable alternative procedures for purging each type of well. Further guidance on purging either type of well is provided below.

Water-Supply Wells. Water-supply wells used by NAWQA are selected, in part, because they have pumps deemed suitable for producing samples of suitable quality. The field team, however, generally cannot alter the rate at which these pumps operate, nor the location of the pump intake. Generally, the field team only can control the flow rate through their own equipment when purging or collecting samples.

To determine the manner in which the purge of a water-supply well is conducted, the field team first estimates the volume of water that will be removed from the well using the ground-water supply-pump rate and the final 15 to 25 minutes of purging (when stability measurements must be made). If the estimated volume is about equal to or exceeds the required purge volume, then evacuation of the required purge volume will take only about 15 to 25 minutes. In this case, the field team sets up the equipment and then conducts the purge. This situation commonly arises for small water-supply wells, such as those used for single dwellings. Setting the equipment up first, and then purging this type of well will prevent overpurging, which could adversely affect the quality of data obtained by NAWQA for some VOCs (Gibs and Imbrigotta, 1990).

For a water-supply well that requires a purge time considerably longer than 15 to 25 minutes (for example, more than 2 hours), the field team has the option to request that the well pump be turned on before they arrive. This approach commonly is needed for high-capacity wells used for irrigation or drinking-water supplies. The field team arrives, however, in time to set up equipment, complete the final 15- to 25-minute phase of purging using the low flow rate through their equipment, and obtain stable field measurements before the required purge volume is evacuated. If this option is used, the field team also requests that static water-level data be collected by the pump operator before pumping begins.

As a final consideration in purging a water-supply well, the field team keeps the water-supply pump operating throughout the purge and sample collection. This ensures the removal of standing water from the well, and clears standing water from any plumbing lines leading to the sampling equipment.

To ensure the water-supply well continues to operate, the field team can open more flow valves than just the one connected to their equipment. This also will reduce the likelihood of backflow of water stored in plumbing lines that could be connected to the line that transports water to the sample-collection setup. Backflow often occurs if the plumbing system is not equipped with antibacksiphons. Antibacksiphons generally are absent in secondary distribution lines on low-capacity supply wells, such as those used by rural homeowners for local supplies.

Since water-supply pumps operate continuously during the purge and sample collection, there is a chance that the supply pump could burn out. Although most commercial pumps are designed to operate for hours without problems, old, worn pumps are a potential problem. If a pump burns out, the field team generally should expect to replace it upon the owner's request. To limit the chance of pump burnout, the field team needs to work quickly and efficiently to keep the total pumping time required to purge and sample as short as possible. If this is achieved by using a high flow rate, through setup equipment, this flow rate is reduced to about 0.1 gal (500 mL) per minute during the final stage of the purge and during sample collection.

Monitoring Wells. Because the field team supplies the pump, they control the rate at which water is pumped from the well and through their equipment, as well as the location of the pump intake in the well. During the purge of a monitoring well, it is important to recognize that pump intake rate, emplacement, and location can influence the quality of the water obtained. Thus, it is important that these pumps be used in a consistent manner for the purge and sample collection at different monitoring wells.

As in the case of a water-supply well, the first step in applying the purge protocol to a monitoring well is to determine if the required purge volume can be evacuated in the 15 to 25 minutes needed for field measurements at the required low-flow rate for sample collection. For this 15- to 25-minute period, and a rate of about 0.1 gal (500 mL) per minute, about 1.5-2.5 gal (7-11 L) will be evacuated from the well. If the required purge volume is less than or equal to this volume, the field team sets up all equipment and then purges the well at this low rate. If the required purge volume exceeds about 1.5-2.5 gal, the field team can purge the well at an initially high, but acceptable, flow rate (as described earlier) to reduce the purge time, and then reduce the flow rate to the sample-collection rate for the final 15 to 25 minutes of the purge, and take and document final field measurements.

Pump intake emplacement is a consideration in the purge of a monitoring well. To reduce the suspension of sediments in the well, the pump intake always is lowered slowly into the well. Initially, the intake is placed just below the surface of the water standing in the well.

With the setup equipment properly configured to route flow directly to waste (fig. 2), the pump is turned on at an initially low rate to avoid sediment suspension in the well. If the required purge volume is small, and the entire purge can be conducted within 2 hours at the low rate required for final field measurements and sample collection, the pump rate is slowly adjusted to a rate of about 0.1 gal (500 mL) per minute. This rate is verified by measuring the outflow from the waste line, and recorded (appendix, fig. A7).

If the required purge volume is high, and an initially high pump rate is desired, the pump rate is slowly increased until either the maximum acceptable flow (as described earlier) or pumping capacity is reached (because of pump limitations or well capacity). In general, unless the well capacity is extremely low and purging cannot be completed within 2 to 2 1/2 hours, rapid evacuation of the standing water in the well is avoided. As noted earlier, the initial flow rate is measured at the waste-line outflow and recorded (appendix, fig. A7).

After the initial flow rate has been measured, the flow is rerouted through the instrumented flowthrough chamber (fig. 2) and the purge continues. Field measurements are made and recorded from this point on (appendix, fig. A7).

As the purge continues, and to enhance the evacuation of all standing water, the pump intake in unpacked wells is lowered slowly until it resides a distance above the open (perforated, or screened) interval that is equal to 7 to 10 times the diameter of the well casing (borehole). Assuming the monitoring well was designed correctly with a short open interval of 2 to 10 ft (Lapham and others, in press), this final location of the intake aids in promoting the flow of water from the entire screened interval to the pump intake.

Any substantial changes in pump intake location (lift) could affect the flow rate. Thus, all changes in pump intake location are completed before the final 15- to 25-minute stage of the purge. At this time, any high pump intake rate is reduced to about 0.1 gal (500 mL) per minute, and the last five sets of successive field measurements are taken, while the last of the required purge volume is evacuated from the monitoring well.

Grab samples for titrations and volatile-sample preservation

During the final 15 to 25 minutes of the purge, or whenever measurements appear stable in relation to the purge criteria (table 19), two grab samples are taken. The first is a 100-mL sample which, if the pH exceeds 4.5, is quickly titrated to roughly determine the acid neutralizing capacity (ANC) of the sample (Radtke and Wilde, in press). From the ANC value, the field team determines the optimum sample volumes and titrant normality (1.6 *N* or 0.16 *N* sulfuric acid) to be used for subsequent, quantitative field titrations (table 20). If the sample pH is 4.5 or less, no field titrations for ANC or alkalinity are required.

If VOC samples are scheduled for collection at the well, a second 40-mL grab sample is obtained in a clean glass beaker to determine the amount of NWQL hydrochloric acid needed to preserve VOC samples (from March 31, 1993 to January 31, 1994, samples were preserved with NWQL-concentrated hydrochloric acid). The acid is added drop by drop to this beaker, the sample is stirred or mixed, and the pH is measured after each acid addition until it is between 1.7 and 2.0. The number of drops of NWQL acid used must be recorded on field forms (appendix, figs. A8, A10-A, A11-A, A12-A, and A13-A). To avoid damage to NWQL instruments, however, no more than 5 drops of NWQL hydrochloric acid are to be added to a VOC sample (Bruce Darnel, VOC National Synthesis Team, U.S. Geological Survey, written commun., 1995).

Table 20. Field-titration procedures for ground-water samples of the National Water-Quality Assessment Program

[mg/L, milligrams per liter; mL, milliliters]

- Except when replicate titrations are scheduled at selected wells, one filtered, and (optionally) one unfiltered, sample will be titrated at each site.[1]
- The unfiltered sample is titrated for acid-neutralizing capacity (ANC, mg/L[2]). The filtered sample is titrated for alkalinity (ALK, as mg/L $CaCO_3$; carbonate, as mg/L CO_3^{-2}, bicarbonate, as mg/L HCO_3^-; and hydroxide, as mg/L OH^-).
- Conducted in the field on fresh samples by the incremental addition of titrant, generally with digital equipment, and the recommended volume of sample and normality of titrant, as follows:

Parameter(s)	Expected Value	Sample Volume	Titrant Normality
ANC or ALK	0.0-50 mg/L as $CaCO_3$	100 mL	0.16
ANC or ALK	50-200 mg/L as $CaCO_3$	50 mL	0.16
ANC or ALK	200-1,000 mg/L as $CaCO_3$	100 mL	1.6
ANC or ALK	Exceeds 1,000 mg/L as $CaCO_3$	50 mL	1.6

- Estimates of ANC, ALK, and contributing species are determined by the Inflection-Point Method (Radtke and Wilde, in press). Inflection points to determine ANC or ALK and contributing species are near pH values of about 8.2 and 4.5 for most waters buffered by the carbonate system.
- If difficulties arise in determining titration endpoints--which could be encountered for saline, low-conductivity, low-alkalinity, anoxic, or organic-rich ground waters--the Gran-Function Plot Method is recommended (Radtke and Wilde, in press).
- Field titration data are recorded (appendix, fig. A9) and later stored electronically under the appropriate parameter codes in NWIS-I QWDATA (for primary ground-water samples) or NWIS-I QADATA (for replicate ground-water samples).

[1]Before 1996, titration of an unfiltered sample was required and titration of a filtered sample was optional.

[2]Reporting values above assigns carbonate chemical species as the primary sources of neutralizing capacity. At this writing, appropriate parameter codes are not available to enter data above in NWIS-I in milliequivalent units.

Final assessment of chemical stability

The field team decides whether or not to collect ground-water-quality samples on the basis of the relative stability of field measurements taken near the end of the purge, as the last of the required purge volume is evacuated from the well (table 19). It is recommended that samples not be collected if unstable field measurements persist. Unstable measurements generally indicate one or more of the following is true: (1) that the source of water entering the well is changing with time, (2) that a decreasing proportion of water leaving the well is water that initially was standing in the well, or (3) that water is entering the well in a disproportionate manner as time elapses from a new source or from several sources. Thus, the resulting water-quality data obtained from sampling a well with unstable field measurements may or may not relate to the land use, aquifer, or other conditions being investigated.

Sample Collection and Processing

Sample collection begins when purge criteria have been met. The type and number of individual ground-water-quality and QC samples obtained, however, depend on the ground-water component (Study Unit Survey, Land-Use Study, or Flowpath Study) for which samples are being collected (table 1). Study-Unit (or Subunit) Surveys and Land-Use Studies commonly include the collection of samples for organic, inorganic, and possibly trace-element, radiochemical, and isotopic analyses. Flowpath Studies generally are limited in scope and require fewer samples than either Surveys or Land-Use Studies. For each component, routine, and possibly topical, quality-control samples also are scheduled for collection at selected wells.

Regardless of the particular component under investigation, protocols and procedures are followed in a consistent, timely, efficient, and quality-controlled manner. The protocols and procedures that follow describe the sample-collection methods to be used for NAWQA ground-water-quality studies (table 21), and include the collection and processing (filtration, preservation, handling, and shipment) of water-quality and QC samples for a given analysis. In addition, the protocols also specify an order or sequence in which groups of samples for different analytes are collected under these protocols, which generally is to be similar at each well in a given component, and among components with similar data-collection requirements.

Overall, the NAWQA sample-collection protocols and recommended procedures (table 21) follow USGS protocols and procedures (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1). Thus, samples for organic analytes (unfiltered, then filtered) are collected first, followed by samples for inorganic analytes (filtered, then unfiltered), which in turn are followed by the collection of samples for other (ancillary) analytes--isotopes, radiochemicals, and chlorofluorocarbons (table 21). Routine replicate ground-water-quality samples, including those for field spikes, are collected in conjunction with the primary ground-water-quality samples (table 21). (Routine QC samples that use blank water are collected in the field after ground-water-quality samples and after the decontamination of sample-collection equipment.)

Table 21. Collection order, processing, preservation, and field storage required for ground-water-quality and replicate samples for the National Water-Quality Assessment Program

[Except as noted, equipment used is described earlier (table 3). Except as noted, samples are (possibly filtered and) obtained in a collection chamber, and (if necessary) chemically preserved in another chamber. Except for filtered inorganic samples (see below), all routine replicate samples, including those for field spikes, are obtained sequentially for each National Water Quality Laboratory (NWQL) schedule or laboratory code. Replicate samples for filtered inorganics (FA, FCC, FU, and alkalinity) are collected after the first set of these samples are obtained, and with a second Quality Water Service Unit (QWSU) capsule.

GCV	glass chilled volatile	GCC	glass chilled chromatograph	SC	(NWQL) schedule	LC	(NWQL) lab code
HCl	(NWQL) hydrochloric acid	**CG**	change gloves	mL	milliliter	mm	millimeters
µm	micrometers	L	liters	$N_2(g)$	nitrogen gas	lb/in^2	pounds/square inch
PBW	(NWQL) pesticide blank water	FA	filtered acidified	FCC	filtered chilled	HNO_3	(NWQL) nitric acid
DIW	deionized water	FU	filtered untreated	RU	raw untreated	U	Uranium
Ra	Radium	ASR	analytical service request	°C	degrees Celsius	≤	less than or equal to]

Sample type (SC, LC) and order of collection	Team Member A: Filtration	Team Member A: Collect, by filling	Team Member A: Quality-assurance checks or measures	Team Member B: Chemical preservation	Team Member B: Temporary storage
1. Organic filtered and unfiltered					
• Volatile organics (SC2090, SC2091, or SC2092 with SC1306)	None	3, GCV, 40-mL amber, glass vials, sequentially; using Teflon tube to fill each vial from its base until overflow occurs	Avoid sample aeration when filling. Replace vial if gas bubble appears after capping. (Team Member B, re-check, immediately after preserving)	Add 1 to 5 drops HCl to each vial, and record amount [on field and ASR forms]	Sleeve and chill[1]
• Organic carbon (SC2085)	**CG**, use tweezers, and place a QWSU, 0.45 µm, 47-mm-diameter silver filter in cylinder. Fill with sample, cap, and (outside of chamber) pressure-filter [$N_2(g)$, ≤15 lb/in^2][2]	1, GCC, 125-mL, amber bottle to neck base after first discarding the initial 25 mL of filtrate to waste (do not rinse bottle)	Do not include plastic filter separator, or flip filter over during removal from package. Do not overpressurize filter cylinder	None	Sleeve and chill[1]
• Pesticides (SC2001 or SC2010, SC2050 or SC2051)[3]	**CG**, use tweezers, and place a NWQL, 0.7 µm, 142-mm-diameter, baked, glass-fiber filter in plate unit, prewet the filter, close unit, and void air[4]	1, GCC, 1.0-L, amber glass bottle for each SC after first discarding the initial 125 mL of filtrate to waste (do not rinse bottle)	Prewet membrane with 10 - 20 mL of NWQL PBW. Do not fill bottle beyond neck to reduce breakage if sample volume expands on chilling	None	Sleeve and chill[1]

Table 21. Collection order, processing, preservation, and field storage required for ground-water-quality and replicate samples for the National Water-Quality Assessment Program--Continued

	Team Member A			Team Member B	
Sample type (SC, LC) and order of collection	Filtration	Collect, by filling	Quality-assurance checks or measures	Chemical preservation	Temporary storage
2. Inorganic, filtered					
• Trace elements (SC2703-FA)	**CG**, and attach QWSU 0.45-µm, preconditioned Supor capsule filter with flexible Teflon tubing, and void air[3] from capsule.	1, FA, 250-ml, clear, prerinsed, poly bottle to neck base after a 25-mL filtrate rinse (include cap)	Invert capsule (arrow up), and tap to evacuate air while filling. Verify DIW is still in sample bottle from office prerinse before use; otherwise replace bottle	Add 1-mL ampoule of HNO_3	In dry cooler, avoid extreme heat or cold
• Major ions (SC2750-FA and archive)	If possible, use same capsule as above, otherwise replace with another preconditioned capsule in manner above.	2, FA, 250-mL, clear, prerinsed, poly bottles to necks after 3, 25-mL filtrate rinses on each (include cap)	Verify DIW is still in each bottle from office prerinse before use; otherwise replace bottle	Add 1-ml ampoule HNO_3 to each bottle, **CG**	In dry cooler, avoid extreme heat or cold
• Nutrients (SC2752-FCC)	**CG**, and, if possible, use the same capsule as above, otherwise replace in manner above.	1, FCC, 125-mL amber, prerinsed, poly bottle to neck base after 3, 25-mL filtrate rinses (include cap)	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	None	Sleeve and chill[1]
• Major ions (SC2750-FU)	If possible, use same capsule as above, otherwise replace in manner above.	1, FU, 250-mL, clear, prerinsed, poly bottle to neck base after 3, 25-mL filtrate rinses (include cap)	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	None	In dry cooler, avoid extreme heat or cold
• Alkalinity (ALK)	If possible, use same capsule as above, otherwise replace in manner above.	1, FA, 250-mL, clear, prerinsed, poly bottle to top after 3, 25-mL filtrate rinses (include cap), and cap bottle	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	On basis of grab sample, pipette the required volume of filtrate into 250-mL beaker, titrate, and record data[5]	None

Table 21. Collection order, processing, preservation, and field storage required for ground-water-quality and replicate samples for the National Water-Quality Assessment Program--Continued

	Team Member A			Team Member B	
Sample type (SC, LC) and order of collection	Filtration	Collect, by filling	Quality-assurance checks or measures	Chemical preservation	Temporary storage
2. Inorganic unfiltered					
• Major ions (SC2750-RU)	None	1, RU, 500-ml, clear, prerinsed poly bottle to neck base after 3 25-mL rinses with raw sample (include cap)	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	None	In dry cooler, avoid extreme heat or cold.
• Acid-neutralization capacity (ANC), recommended	None	1, FA, 250-mL, clear, prerinsed poly bottle to top after 3, 25-mL rinses with raw sample (include cap)	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	On basis of grab sample, pipette the required volume into a clean, 250-mL beaker, titrate, and record data[5]	None
3. Other Samples					
• Trace elements (1.0-L samples, for example, U, and Ra)	**CG**, and attach preconditioned capsule in manner similar to that used for SC2703 above[3]	1, FA, 1-L, clear, prerinsed, poly bottle to neck base for each element after a 25-mL rinse of bottle and cap	Verify DIW is still in bottle from office prerinse before use, otherwise replace bottle	**CG**, and add 2 HNO_3 ampoules to each bottle	In dry cooler, avoid extreme heat or cold.
• Tritium isotopes	None	1, 1.0-L, clear, prerinsed poly bottle, filled to top after 3, 25-mL rinses (include cap with conical insert)	Verify DIW is still in bottle from office prerinse before use, otherwise replace bottle. Leave no headspace in bottle	None	In dry cooler, avoid extreme cold or heat.
• Deuterium-Oxygen isotopes	None	1, 125-ml, glass, amber bottle to top after 3, 25-ml rinses (include cap with conical insert)	Leave no headspace in bottle	None	In dry cooler, avoid extreme heat or cold.

Table 21. Collection order, processing, preservation, and field storage required for ground-water-quality and replicate samples for the National Water-Quality Assessment Program--Continued

	Team Member A			Team Member B	
Sample type (SC, LC) and order of collection	Filtration	Collect, by filling	Quality-assurance checks or measures	Chemical preservation	Temporary storage
3. Other, continued					
• Radon (LC1369)	Disconnect extension line to sample chamber, attach radon-collection unit to manifold, partly close valve on unit. Check all sample-wetted lines up to unit for gas bubbles, and dislodge any by tapping lines with hard object. (Record on ASR form if bubbles reform before samples are obtained)	1, radon scintillation vial, after rinsing syringe barrel twice with sample before injecting 10.0 mL of sample into vial at base of mineral oil. Cap and shake 10 seconds. Note and record actual time on ASR form (comments-to-NWQL line)	Compare oil level in vial before use to that in vial from another tube. Return vial unused to NWQL if oil level is low. Create sufficient back-pressure in device to create easy with-drawal of sample without degassing. Void all air from syringe after second rinse before inserting syringe needle into septum of device. Initially withdraw 15 mL of sample, invert syringe [needle up], void sample to leave 10.0 mL in syringe barrel, re-insert needle (down) into vial to collect	None	Repack vial in shipping tube, wrap ASR form (with collection time) around tube, fix with rubber band, and place tube in resealable plastic bag.
• Chlorofluorocarbons (CFCs)	Modify setup to attach CFC--collection unit (Busenberg and Plummer, 1992) to manifold or pump tubing outlet	Three to five CFC vials filled according to procedures used by Busenberg and Plummer (1992)	Critical to avoid air entrainment or sample degassing during collection (See radon above)	None; can be stored indefinitely if not biologically active	In partitioned box to reduce breakage

[1]Glass containers are placed in foam sleeves, and chilled samples generally stored in ice. Desired temperature of chilled samples is 0 to 4 °C

[2]Cylinder and nitrogen-gas filtration system are available from Hydrologic Instruments Facility (table 3, in this report).

[3]Possible flow adjustment could be required to increase flow from filtration unit to about 0.1 gallon (500 mL) per minute.

[4]Samples under schedules SC2010 and SC2051 require Study Unit to extract water samples and send extracts to NWQL (see section on Pesticide Solid-Phase Extraction).

[5]Volume of filtrate and normality of titrant determined from grab sample taken near end of purge (table 20, in this report). National Field Manual (Radtke and Wilde, in press) discusses incremental and Gran titration methods and calculations. For NWIS-I, recommend using parameter codes as indicated in appendix (fig. A8).

Field-team functions

The setup (fig. 2) used to purge the well is modified slightly for sample collection. The short turbidity-collection line is replaced by an extension line that runs to the sample-collection chamber. The flow, which has been passing through an instrumented flowthrough chamber, is rerouted (for example, using the second three-way flow valve as shown in fig. 2) through this extension line that is connected to the sample-collection chamber. The rate of flow through the sample-collection setup is about 0.1 gal (500 mL) per minute.

In general, samples are obtained and, with one or two exceptions, processed (for example, filtered) by **Team Member A** (table 21). Except for radon and chlorofluorocarbons, which require special collection equipment, and dissolved organic carbon, which requires a pressurized filtration, samples are obtained (sample containers are opened, if necessary, final rinsed, filled, and closed) only within the collection chamber. As each sample container is removed from the chamber, it is set aside on a clean surface, and not handed directly to **Team Member B**. This reduces the likelihood of contamination of **Team Member A**, the chamber, and subsequent samples, as collection continues.

In general, **Team Member B**, who has removed coveralls and work gloves, preserves (if necessary) and temporarily stores samples (table 21). **Team Member B** also performs field titrations.

Chemical preservation of NAWQA samples currently (1995) requires a single preservation chamber (for NWQL hydrochloric and nitric acids). This chamber is separate from that used to collect samples (table 3). During preservation, samples are opened, preserved, and closed in this chamber by **Team Member B**.

Throughout the collection process, the field-team members frequently replace their gloves at logical intervals to further reduce sample contamination (table 21, CG). If either one leaves the collection or preservation areas to perform other tasks, gloves must be replaced before activities in these areas are resumed.

Near the end of the sample-collection process, field titrations (particularly when replicate filtered (ALK) or unfiltered (ANC) samples are taken) generally will require most of **Team Member B's** time. Therefore, **Team Member A** often will complete the collection of all samples after that for ANC with little or no assistance (table 21).

Special considerations for selected sample types

With adequate training and preparation, collection procedures for most sample types require no more than a conscientious effort to rinse and fill a bottle in a clean setting to obtain high-quality data. Situations arise, however, which necessitate processing samples simultaneously with their collection, or which require modifications to the general field-equipment setup and protocols described (table 21).

Filtered Samples. To obtain high-quality samples, care must be taken in the use of filter units and to avoid overpressurizing these units. The NWQL aluminum plate filter (for pesticide samples) is prepared in the collection chamber (table 21) and has a simple nipple fitting, which is connected to the sample outflow orifice inside the sample chamber by a short piece of Teflon tube. Air is evacuated from the plate unit using the trip valve on top of the unit as it is filled by raw sample flow. After evacuating the air, the trip valve is closed. Initially, some filtrate is discarded before any samples are collected (table 21).

The sample for dissolved (filtered) organic carbon (DOC) is collected directly in the DOC filter cylinder in the collecting chamber. The DOC cylinder subsequently is capped, removed from the chamber, and the sample filtered under N_2 gas at a low (15 lbs/in^2 or less) internal pressure. (Pressures in excess of 15 lbs/in^2 can be hazardous and can rupture the filter membrane and invalidate the sample.)

Routine NAWQA 0.45-µm-filtered inorganic samples are obtained using the QWSU capsule filter (for inorganic samples). The capsule is preconditioned before use (see “Final Presampling Plans and Preparations”). The capsule nipples are attached to flexible Teflon lines, which allow the capsule to be inverted (arrow on capsule denotes direction of flow) during its final rinse and use. Inverting the capsule so that the flow is vertically upward while the capsule initially fills with water, combined with tapping the side of the capsule several times while it fills, forces most air out of the capsule. Purging most of the air from the capsule filter helps prevent oxidation and possible precipitation of redox-sensitive analytes (for example, iron, manganese, aluminum, and uranium) that would (negatively) bias filtrate concentrations. Procedures for filtering inorganic samples that require filters with 0.2-µm or smaller pores are described in an internal document (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1).

In some instances, filter clogging by fine sediment, or even finer colloids, could markedly reduce the rate of sample flow through the filter units described. Field teams are not to increase flow by forcing water through a filter unit under increasing pressure. Instead, either clean the clogged unit (see “Decontamination of Field Equipment” below) and reinstall the cleaned filter, or simply replace the clogged unit with a second filter unit of similar type. It is most efficient to have a second unit available. A second capsule filter unit also is required for the collection of replicate, filtered inorganic ground-water samples.

Radon and Chlorofluorocarbon (CFC) Samples. Collection of these samples occurs outside the sample-collection chamber and requires modifying the sample collection setup--replace the extension line from the flow manifold to the sample-collection chamber with the appropriate collection device (fig. 2). In either case, sample extension and pump-reel lines are inspected to determine if gas bubbles are forming inside the line, or if any air is being drawn into the sample flow at any connection. If these lines are adequately insulated to prevent warming of the sample flow and connections are air tight, bubbles generally are not present. The presence of bubbles indicates possible degassing of radon and CFCs from sample flow or entrainment of CFCs from air that enters loose connections. Initially, bubbles often can be dislodged and evacuated with sample flow by striking the extension or pump-reel line sharply with a hard, blunt object. Connections can be tightened to prevent air entrainment. This, combined with backpressure created by partially closing the valve on the radon-collection unit or backpressure created in the operation of the CFC collection unit, often will reduce degassing during sample collection.

For radon samples, the collection unit valve is partially closed, the glass syringe needle is inserted through the septum port of the unit, and the unit valve is further closed until there is sufficient backpressure to create an almost effortless withdrawal of water into the syringe. The syringe is partially filled, withdrawn from the septum, inverted (needle up), and the water ejected to waste. This syringe rinse is repeated at least one time. After the final rinse, and with the syringe plunger completely depressed (no air or water in syringe barrel) the needle is reinserted through the septum, and about 15 mL of sample are withdrawn slowly into the syringe barrel to avoid suction and degassing. The needle is withdrawn from the septum, the syringe inverted (needle up), and the sample slowly ejected to waste until only 10.0 mL remains in syringe barrel. The syringe needle is tipped downwards, and the needle tip inserted into the mineral oil, and to the bottom of the radon sample vial. The 10.0 mL sample is injected slowly, the syringe removed, the vial firmly capped, and the actual time (in military format) of sample collection is recorded (see appendix, fig. A10). If no replicate sample is taken, the vial is shaken for 15 seconds, repacked in tube, the tube capped, and the NWQL-ASR form (lab copy) for radon (LC1369) is wrapped around the tube, secured with a rubber band, and the tube temporally stored (table 21). If a replicate sample also is collected, the height of the oil levels in the two vials is compared before either sample is collected and should be similar. If levels are noticeably different, return the vial with the low oil level to NWQL with a note explaining the problem.

Because it can take a considerable amount of time to set up and collect samples for chlorofluorocarbons (CFCs), they generally are the last samples collected at a well. As in the case of radon, their collection requires that the sample-collection setup be modified. The CFC unit used to collect samples (Busenberg and Plummer, 1992) replaces the extension line and sample-collection chamber, or the CFC unit can be connected directly to the portable pump outlet (fig. 2). Before connecting the CFC unit, it is recommended that flow be routed through the flowthrough chamber, and field measurements be taken to characterize conditions at the onset of CFC sampling. The procedures for collecting CFC samples are described in Busenberg and Plummer (1992).

Decontamination of Field Equipment

Decontamination is the cleaning process used to remove contaminants from equipment. Sample-wetted equipment used by NAWQA is decontaminated after sample collection at each well, preferably before the equipment dries. Decontamination is conducted in clean and protected environments (in field area, vehicle, or chamber) as is appropriate to the equipment being cleaned. If this is not possible, the equipment is at least flushed and rinsed, preferably with a low-phosphate detergent, followed by a clean water (DIW) rinse, before it is temporarily stored for thorough cleaning at a later date and before it is reused to collect samples.

On the basis of NAWQA pilot studies, studies conducted by the Office of Water Quality, and data reported from other sources, the decontamination protocols and procedures for NAWQA (tables 22 and 23) generally are capable of removing a broad suite of contaminants from equipment affected by (a) milligram-per-liter contaminant levels for metals and metal complexes, and (b) microgram per liter contaminant levels for pesticides and volatile organic compounds. The decontamination protocols and recommended procedures for NAWQA assume equipment was (or will be) used to collect filtered and unfiltered samples for most analytes (table 1). The actual efficiency of these protocols and recommended procedures to remove contaminants to below NAWQA method-detection or reporting levels can differ depending on the type of equipment used, the solubility and concentration of the contaminant, and the length of time equipment is exposed to the contaminant.

Table 22. Decontamination of small equipment used for sample collection

[Volumes of solutions used (detergent, deionized water-DIW, methanol, and final rinse water) depend on Study-Unit equipment setup. DIW used for rinses must have a conductivity that does not exceed 1.0 microsiemens per centimeter at 25 degrees Celsius. A 0.1- to 0.2-percent detergent solution is prepared by adding about 5 to 10 drops of detergent concentrate to each gallon of DIW. **CG** indicates field-team members are to change to clean, powderless, latex or vinyl gloves before proceeding. Latex gloves are used when handling methanol. DOC, dissolved (filtered) organic carbon; VOCs, volatile organic compounds]

<table>
<tr><th></th><th colspan="3">SMALL FIELD-EQUIPMENT CATEGORIES[1]</th></tr>
<tr><th>DECONTAMINATION STEPS BY CATEGORY</th><th>Equipment with nonmetallic parts (for inorganics only). Includes convoluted Teflon tubing used on capsule filter, turbidity sample vials, and field-titration Teflon stir bars, glass beakers, volumetric pipettes, graduated cylinders, and polyethylene bottle for ALK (ANC) sample collection.</th><th>Equipment with metal parts and for inorganics, but not exposed to methanol. Includes the DOC filter unit, the short Teflon line with metal quick-connect used to obtain turbidity samples, and the radon-collection equipment--syringe with metal leur-lock fitting, syringe needles, and the sample-collection unit.</th><th>Equipment with nonmetallic parts, and rinsed with methanol for organics. Includes pesticide filter unit, the short Teflon tubes for VOC sample-collection and for attaching pesticide filter unit to a sample-chamber outflow port, tweezers, and the short Teflon-metal hook-up line (without plastic garden-hose-threaded fitting to well).</th></tr>
<tr><td>1. PREPARATION</td><td colspan="3">For each equipment category, disassemble parts, and place them in a small, clean, colorless, polypropylene basin dedicated to that category.</td></tr>
<tr><td>2. DETERGENT WASH</td><td colspan="3">Cover and fill parts in each basin with detergent, and let stand at least 10 minutes; then scrub each part gently with a soft-bristled brush that contains no metal parts and is dedicated to that basin.</td></tr>
<tr><td>3. DIW RINSE</td><td colspan="3">Rinse each part thoroughly with DIW at least three times to remove detergent solution and any particulate matter. Complete rinsing of equipment, and also rinse basin and brush, in one category, and CG before proceeding to equipment in the next category. Place rinsed equipment on a non-contaminating surface dedicated to the equipment in that category, and loosely cover equipment to prevent recontamination. Plastic sheets can be used for equipment in the first category; aluminum foil can be used for equipment in the other categories. Complete decontamination step (5) below for first two categories before proceeding with the methanol rinse (4) of equipment in the last category).</td></tr>
<tr><td>4. METHANOL RINSE</td><td colspan="3">(Third equipment category only) CG (latex), wear safety glasses; in a well-ventilated area free of open flames or sparks, rinse each piece of equipment at least three times with small amounts of methanol from a Teflon squeeze bottle. Place each rinsed part on a clean, noncontaminating surface (such as aluminum foil) and loosely cover rinsed parts (with foil sheet) to avoid recontamination. Rinse each part over the basin previously used for detergent and DIW rinse. Transfer used methanol from this basin to a waste container after all parts are rinsed, and before drying parts.</td></tr>
<tr><td>5. DRY, INSPECT, and STORE</td><td colspan="3">CG and use a portable dryer, or air dry, each part, in clean area. After each part is dried, inspect it. Replace chipped or cracked glassware, or scratched turbidity vials. Replace tubing if mold, mildew, or imbedded sediment are present. Replace filter seals if cracked or severely crimped. Store equipment in the first category in two nested, resealable plastic bags, and that from other categories in Teflon bags or wrap in aluminum foil and then place in a resealable plastic bag.</td></tr>
</table>

[1]Field sensors are each thoroughly rinsed with DIW, blotted dry, inspected along with field meters, and (if necessary) reconditioned and stored according to manufacturers' recommendations.

Table 23. Decontamination of setup equipment used for sample collection

[Volumes of solutions used (detergent, deionized water (DIW), methanol, and final-rinse water) depend on the Study-Unit equipment setup used. DIW used for final rinse must have a specific conductance that does not exceed 1.0 microsiemens per centimeter at 25 degrees Celsius. For methanol-rinsed equipment, it also should be volatile-organic-compound-free and pesticide-free. A 0.1- to 0.2-percent detergent solution is prepared by adding about 5 to 10 drops of detergent concentrate to each gallon of DIW. **CG** indicates the field-team members are to change to clean, powderless latex or vinyl gloves before proceeding. Use latex gloves when handling methanol.]

DECONTAMINATION STEP	Exterior of portable pump intake and pump tubing drawn from pump reel	Interior of pump intake and sample-wetted tubing[1]; including that from reel, flow manifold, flowthrough chamber, and all extension lines
1. PREPARATION	**CG**, raise intake from well, coil tubing onto plastic sheet set to drain, or into plastic basin, and disconnect tubing at pump-reel that runs to remainder of setup.	Place pump intake[2] in clean standpipe.[3] Route flow from pump intake through setup to sample chamber. Temporarily attach one end of a Teflon return-flow line to the outflow tube in the sample chamber, and run the other end of this line back to the standpipe.
2. DETERGENT WASH	Pour detergent solution over pump intake and tubing. Scrub both gently with a soft-bristled brush that has no metal parts.	Fill standpipe with detergent solution to level above pump intake. Begin pumping, and note the time when return-flow line has filled. Direct flow from this line back into standpipe, and cycle detergent at 500 milliliters per minute for at least 5 cycles, or 10 minutes. At end of cycling, add more detergent to the standpipe, route flow to partially fill field-instrument flowthrough chamber and waste lines. Stop pump.
3. DIW RINSE	**CG**, raise intake and tubing above sheet or basin, and rinse at least 3 times with DIW to remove detergent and any particulates. Proceed to inspection and storage (Steps No. 6 and 7).	**CG**, rinse standpipe and intake, individually, at least 3 times to remove detergent. Reroute flow back to sample chamber, add DIW to standpipe, and pump, without cycling, until grab samples from the open end of return-flow line (now directed to waste) indicate DIW rinse is detergent free (no sudsing). Halt pump. Shake flowthrough chamber to suspend any sediment, then drain detergent from this chamber and waste lines. Add more DIW to standpipe, start pump, route flow to the flowthrough chamber, and rinse chamber several times to remove detergent. Repeat for waste lines. (Flowthrough chamber and waste lines are inspected and stored at this time, see below. If methanol is not required, go to Step No. 5, FINAL RINSE, second paragraph).
4. METHANOL RINSE[4]	None. (Detergent scrub considered effective for cleaning exterior of pump intake and pump tubing.)	Reroute flow to sample chamber, and put free end of return-flow line near the methanol waste container. **CG,** rinse intake and standpipe, individually 3 times, place intake in standpipe, and, if possible, force air into first several feet of pump tubing (to mark end of DIW and beginning of methanol rinse.) Fill the stand pipe with methanol to level above pump intake. Add and pump at least 2 liters of methanol into setup. If the setup storage is less than 2 liters, collect methanol as it leaves from end of return-flow line in waste container. Halt pump. Put methanol left in standpipe into waste container. Pump air if possible into tubing (to mark end of methanol). Proceed to final rinse.

Table 23. Decontamination of setup equipment used for sample collection--Continued

DECONTAMINATION STEP	Exterior of portable pump intake and pump tubing drawn from pump reel	Interior of pump intake, and sample-wetted tubing, including that from reel, flow manifold, flowthrough chamber, and all extension lines
5. FINAL RINSE) (DIW)	None	**CG**, and DIW rinse standpipe and intake individually at least 3 times. Add and pump DIW through setup to sample-collection chamber and out return-flow line. On basis of air marking, line storage, and pump rate, collect methanol from return-flow line as it is forced out by final rinse. Pump at least an additional 0.1 gallons of DIW through setup for every 10 feet of methanol-wetted tubing, including return-flow line, to waste after used methanol is collected. Disconnect sample chamber from manifold, discard used chamber bag, DIW-rinse chamber frame, and dry. Repeat above for the preservation chamber. DIW rinse and dry exterior of extension lines and flow manifold. Inspect and store each piece of equipment as it is dried according to procedures below.
6. INSPECTION	Simultaneously dry, inspect, and recoil tubing on pump reel. Dry with large, disposable, lint-free towels. Check for stains, cuts, or abrasions, and repair or replace as necessary. Check and repair pump intake and antibacksiphon for loose or missing screws.	Inspect to ensure flowthrough chamber and waste lines are free of sediment. Extensions lines also are inspected for stains, cuts, or serious abrasions. and sediment. The flow manifold also is checked for stains or sediment, and to ensure valves and quick-connect fittings are in good working order. Repair or replace as necessary to eliminate any problems.
7. STORAGE	Except for pump intake and sufficient pump tubing to place intake in standpipe, cover the pump reel and recoiled tubing with a clean, plastic sheet or bag or other noncontaminating material. Clean pump intake as described on right.	Store flowthrough chamber, waste lines, looped and recoupled extension lines, and flow manifold in clean plastic bags. Place pump intake inside Teflon or other noncontaminating bag, and then under material used to cover pump-reel assembly. Fit sample and preservation chambers with clean bags. Unless field blanks are taken, store equipment in vehicle for transport.

[1] Before their initial use, all sample lines are acid washed to remove oils and other manufacturing residues. (See table 3.)

[2] Pump intake and reel tubing are that used on-site to collect samples. For a hook-up connection that attached setup to a garden-threaded-hose valve on a water-supply pump, a small, portable pump, such as a Teflon diaphragm pump head mounted on a 12-volt electric drive pump, or a valveless metering pump with a ceramic piston (for example, Fluid Metering Instrument Model QB1-CSC or CSV) with 12-volt power can be used. Either pump is fitted with Teflon convoluted or rigid-wall tubing (acid-washed when first obtained). The outflow tube from the pump is fitted with the appropriate quick-connect to attach it to the extension line that ran from the hook-up connection to the flow manifold (fig. 2).

[3] Standpipe is of sufficient height to supply necessary head for pump intake to operate. For some pumps, such as the Grundfos Redi-Flo2, this head requirement is critical. Standpipe also must not absorb methanol (table 3).

[4] Performed when it is known or suspected that equipment was exposed to pesticides or volatile organic compounds.

In general, decontamination by NAWQA field teams includes a low-phosphate, dilute-detergent wash and scrub of equipment, followed by multiple rinses with DIW (tables 22 and 23). A methanol wash also is used on selected equipment that is likely to have been contaminated by volatile organic compounds or pesticides.

Except for CFCs, the equipment required for decontamination, including that for safe handling of methanol, has been described (table 3). Decontamination of CFC sample-collection equipment is to be done by the supplier of that equipment (Eurybiades Busenberg, U.S. Geological Survey, written commun., 1995).

During field decontamination of NAWQA equipment, it is essential that the cleaning solutions used be completely removed as part of the decontamination process before equipment is reused. The residual presence in sample-collection equipment of detergent and methanol can bias some measurements. Reports of organic carbon samples being affected by residues of detergent and methanol have been verified. Removal of methanol and detergent from pump-reel lines or the purge and collection setup (fig.2) requires that adequate volumes of rinse water are passed through these lines. Study Units can calculate the storage volume of these lines (table 24). The sample-collecting setup storage volume is not only useful in estimating the amount of dilute detergent and DIW needed for decontamination, but also is needed to determine the volume of high-purity water needed for field blanks.

Ideally, the final rinse water after the methanol rinse (table 23) should not contain detectable quantities of the analytes of interest. Study Units need to ensure that rinse-water composition does not lead to equipment contamination that can ultimately compromise the interpretation of the water-quality data.

To obtain the suitable quality of DIW final rinse water for methanol-rinsed equipment, ASTM Type 1 DIW is passed through a charcoal filtration system, stored in noncontaminating containers under noncontaminating conditions, and periodically analyzed to ascertain that it is free of the compounds of interest at the method detection limit. Alternatively, NWQL volatile- and pesticide-free blank water (VPBW) can be used for the final DIW rinse.

Decontamination of equipment exposed to high concentrations of contaminants (for example, VOCs in excess of 10 μg/L) could require procedures that are more rigorous than the protocols and recommended procedures described here and involve cleaning agents that differ from those commonly used (such as hexane). Whatever procedures are used, they must be documented by the Study Unit. This enables the National Program to identify potential problems and modify procedures accordingly. Questions regarding equipment decontamination and the use of other decontamination procedures can be directed to the NAWQA QA Specialist.

Table 24. Estimation of decontamination solution volumes for standpipe and sample-wetted tubing

---

The storage volume, Vs, of a set of pump-reel and extension lines can be estimated as follows:

$$Vs = [(Lp \times Cp) + (Le \times Ce)] + [Csp \times Vsp]$$

where Vs is storage volume, in gallons
Lp is length of pump-line segment being cleaned, in feet
Le is length of extension lines, in feet
Cp (or Ce) = 0.023 gallons per foot for a 3/8-inch internal-diameter (ID) line
or = 0.041 gallons per foot for a 1/2-inch ID line
Csp = 0.264 gallons per liter,
Vsp is volume of solution needed to fill standpipe to minimum level required to operate pump, in liters.[1]

Examples:

Given: (1) Lp; the sample-wetted line segment is 100 feet for a pump-reel system that has a 1/2-inch ID line;
(2) Le; two 10-foot, 3/8-inch ID extension lines, one running from the pump-reel outlet to the sample collection chamber, and another running from the chamber back to the pump-reel (return-flow line to standpipe), and
(3) Lsp; that the minimum volume of solution required in the standpipe to operate the pump is 0.8 liter.

(A) Estimate the volume of detergent solution needed for the detergent wash cycle.
Answer:

$$Vs= [(100 \times 0.041)+ (20 \times 0.023)] + [0.264 \times 0.8] = 4.87 \text{ gallons}$$

(B) Estimate volume of District deionized water needed to displace detergent solution.
Answer: Vs, ideally.[2]

(C) Estimate volume of high-purity water needed to displace 2 liters of methanol just pumped into the system.
Answer: Vs, ideally.[3]

---

[1]The minimal volume is that which corresponds to a level of solution in the standpipe which, if maintained, allows the pump to operate without entraining air into flow. Once this level is reached, remove pump and measure this volume.

[2]Estimate assumes no mixing of the two solutions and ignores potential for detergent to adhere to tubing walls. As a general rule, it is recommended that outflow from end of return-flow line be checked for sudsing to determine when detergent has been removed.

[3]Estimate assumes no mixing at the interface of the two solutions and ignores potential for methanol to adhere to tubing walls. As a general rule, it is recommended that an additional 0.1 gallons (~ 0.4 liters) of high-purity water for each 10 feet of pump and extension line used be displaced from sample-wetted lines (pump-reel line-to-sample chamber) to remove methanol residues. Thus in the example above, another 0.2 (= [(100 + 10) x (0.1/20)]) gallons (4 L) of DIW would be pumped from the system. This implies a total of about 6.1 (= 4.9 + 1.2) gallons (24 L) of water would be used to remove methanol from the setup equipment.

Preparation of Blank Samples

To verify that decontamination is adequate, field and possibly other blanks are prepared at selected well sites in each ground-water component (see "Routine Quality-Control Samples: Type, Number, Site Selection, and Timing"; and appendix, figs. A13 (A,B), A14, A18, and A19). These field blanks are collected immediately after the equipment that was used to collect samples at the well has been decontaminated. Methods used to obtain, process, preserve, temporarily store, and analyze field blanks (table 25) generally are similar to those used for corresponding ground-water samples (table 21). With the exception of trace-element field blanks, field blanks are analyzed using the same NWQL schedules used to analyze ground-water-quality samples.

Study Units are required to use specific types of water for field blanks (table 3). Generally, NWQL VPBW is required for VOC field blanks, and either NWQL VPBW or NWQL PBW is required for pesticide field blanks. Field blanks for dissolved organic carbon are obtained using either NWQL water types, but a DOC source-solution blank also must be taken (table 25, footnote 3; and appendix, fig. A14). The QWSU IBW is required for trace-element, major-ion, and nutrient field blanks. These blank solutions are analyzed regularly (by lot number) by the NWQL to certify that they are free of measurable concentrations of NAWQA analytes. Lot numbers are recorded by the field team as part of the required data record for NAWQA field, solution, and trip blanks (see appendix, figs. A13, A14, and A19).

Except for trace elements, all field blanks are analyzed using the analytical NWQL schedule or laboratory code used for the corresponding ground-water-quality samples. For trace-element field blanks, NWQL schedule SC172 and laboratory codes LC0112 (As) and LC0087 (Se) are used in lieu of SC2703 to obtain concentration data at method detection limits (equal to or in excess of 0.1 μg/L).

Preparation of Other Routine Quality-Control Samples and Field Extracts of Pesticide Samples

As part of their data-collection activities, field teams will sometimes need to obtain, prepare, or process selected types of samples at some sites on the basis of required routine QC sampling for each ground-water component (for example, table 12). For example, the field team occasionally will collect replicate ground-water-quality samples at selected wells and field spike these samples with known amounts of selected VOCs or pesticides. If VOC samples are being collected for a Study-Unit (or Subunit) Survey or Land-Use Study, spiked VOC ground-water samples are required at selected sites. The field team also will submit at least one trip blank per field season for VOCs from the field. If pesticide ground-water samples are being collected, pesticide field spikes are required. The field team also has the option of either extracting pesticides (under NWQL schedules SC2010 and SC2051) from spiked or unspiked ground-water samples, or sending these water-quality samples to the NWQL for extraction (under NWQL schedules SC2001 and SC2050). Finally, if trace-element samples (SC2703) are collected, the field team will send three standard reference samples per field season from the field to the NWQL for analysis. Each of these activities requires that special equipment be used, or that specific procedures be followed (described below). It is strongly recommended that field spikes, solid-phase extraction, and the preparation of trip-blank and reference samples be done after all ground-water samples have been collected, equipment has been decontaminated, and (if applicable) field blanks have been collected.

Table 25. Field-blank sample-collection protocols and procedures for ground-water components of the National Water-Quality Assessment Program

[DIW, District deionized water with specific conductance less than 1.0 microsiemens per liter; NWQL-VPBW, National Water Quality Laboratory volatile organic and pesticide-free blank water; NWQL-PBW, pesticide-free blank water; QWSU-IBW, Quality Water Service Unit inorganic-free blank water; DOC, dissolved (filtered) organic carbon; gal, gallons; L, liters; ~, approximately]

1. **Assumptions:** Equipment just used to collect ground-water samples has been decontaminated and, except for the pump intake being in a standpipe, is set up on site in the same manner as it was for the collection of ground-water samples.

2. **Determine Blank-Solution Types and Volumes Required[1]:**

Field blank(s) collected	Required blank-solution type	Minimum volume in gal (L)	Required procedure
VOCs and DOC[2] or pesticides and DOC	NWQL-VPBW NWQL-PBW	1.5 (~ 6)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of VPBW or PBW water through the system.
VOCs, DOC, and pesticides	NWQL-VPBW	2.0 (~ 8)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of VPBW or PBW water through the system.
Major ions, and nutrients, or trace elements	QWSU-IBW	1.0 (~ 4)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of IBW water through the system.
Major ions and nutrients, and trace elements	QWSU-IBW	1.5 (~ 6)	Waste 0.5 gal, then collect field blanks; if necessary, use DIW to force last of IBW water through the system.
Combinations of organics and in-organics above	NWQL-VPBW or NWQL-PBW and QWSU-IBW	1.5 to 2.0 1.0 to 1.5	Waste 0.5 gal of the VPBW or PBW water, then collect organic field blanks; can use the IBW water to force the VPBW or PBW water through the system; waste 0.5 gal of IBW water, then can collect inorganic field blanks using DIW to force IBW water through the system.

Table 25. Field-blank sample-collection protocols and procedures for ground-water components of the National Water-Quality Assessment Program--Continued

---

3. **General Field-Blank Collection Procedure**--The procedure for collection of blanks assumes organic (VOC--SC2090, SC2091, or SC2092, Pesticide--SC2001 or SC2010 and SC2050 or SC2051, and DOC--SC2085) and inorganic (Trace-element--SC2703, Major ion--SC2750, and Nutrient--SC2752) field blanks are collected. This is the most complex type of field-blank collection.[3]

- Divide Field-Team Duties--Recommend that a three-person team be used. The standard two-person field team collects samples in a manner similar to that used to collect ground.-water samples; the third person adds blank water(s) to standpipe, and controls flow through system as needed to facilitate field-blank collection.

- Check Flow Setup--from standpipe to sample collection chamber (fig.2), ensure that adequate volumes of DIW and the required blank water(s) are arranged in order and within easy reach of person stationed at standpipe.

- Set Low Flow Rate--Once pumping is initiated, set flow (on basis of measurement at chamber outflow) to about 0.1 gal. (500 mL) per minute or less to avoid wasting excessive amounts of blank water.

- Route blank solutions in presorted manner--As solutions are changed, pump operator should change to clean gloves, empty residual solution from standpipe, and rinse pump intake and standpipe, individually, at least three times each, with the next solution, and attempt to pump air segment into pump line before adding next solution to standpipe to mark change in solution type.

  If air segment cannot be used to mark end of one solution and beginning of next, then the change in solutions is determined solely on the basis of the storage volume in lines (table 24) divided by the pumping rate (estimated above) to determine the time it takes for the solution to travel from the standpipe to the outflow chamber. Once pump is started, and this time has elapsed, it is assumed the correct solution is flowing from chamber outflow.

  Regardless of whether air segments or timed flow or both are used to assess when the desired solution arrives at the chamber, 0.5 gal (~ 2 L) of the solution are passed to waste before the field blanks that require that water type are collected.

  To limit the amount of blank water used, and left standing in pump-reel or extension lines after all samples that require that blank-water type have been collected, one type of water can be used to force the last of another type from the lines and to the chamber for collection.

- Collect field blanks in prescribed manner --The order, manner, and quality-control measures and checks associated with obtaining, processing, preserving, and temporarily storing field blanks are identical to the order, manner, and quality-control measures and checks that would be used to collect a corresponding set of ground-water-quality samples (see table 21).

Table 25. Field-blank sample-collection protocols and procedures for ground-water components of the National Water-Quality Assessment Program--Continued

---

4. Break Down Equipment Setup--After field blanks have been collected, equipment is broken down and stored, accordingly (see tables 22 and 23). Exceptions include filter units using filter membranes that are removed and discarded, and the sample preservation chamber. If filters for organics (pesticides and DOC) were used, the units are opened and filters discarded. Units are final rinsed, reassembled and stored (see table 22, step 5, and table 23, step 7). The sample-preservation chamber also is decontaminated before it is stored.

---

[1]If portable pump was used, the same pump and length of pump line used to collect ground-water samples is decontaminated and used to obtain field blanks.

[2]Note that VPBW and PBW are not certified free of organic carbon. A solution blank of that lot of water used for the DOC field blank is sent to the NWQL for DOC analysis (see footnote no. 3 below).

[3]NWQL-PBW cannot be used for VOC field blanks. Either NWQL water type can be used for DOC field blank, but both water types contain about 0.1 mg/L of organic carbon. A solution blank sample of water from the same lot of NWQL water used for DOC field blank, poured directly into DOC 125-mL amber sample bottle) is required for every DOC field blank. The lot number of the water used for the solution blank is recorded on the ASR form (see appendix, fig. A14).

[4]With one exception, samples are analyzed using NAWQA schedules. The exception is trace-element field blanks, for which the low-level NWQL blank schedule (SC172 with laboratory codes added for arsenic and selenium) is recommended (see appendix, fig. A18).

Pesticide and volatile-organic-compound (VOC) spiked samples

Required equipment and procedures to spike ground-water samples in the field are obtained from the NWQL in kits prepared for the NAWQA Program (table 3). Training in field spiking is required, and can be obtained through the basic course required for NAWQA ground-water field teams (table 6). Because of the need for recovery and variability data on field spikes for the National Program, Study Units that wish to modify spike equipment or procedures as described below, or in NWQL kits for the NAWQA Program, by using different spike solutions or volumes for routine QC spiked samples, are to discuss their plans with the National Program (NAWQA QA Specialist).

At each site where pesticide field spikes are scheduled, at least three 1.0-L ground-water sample bottles are required for each NWQL pesticide schedule (SC2001 or SC2010 and SC2050 or SC2051). These samples are collected sequentially during the collection of ground-water-quality samples and chilled (table 21). One bottle for each schedule serves as the ground-water-quality sample for the well. It also serves as a background sample (to determine what pesticides, if any, were present in the other two sample bottles before they were spiked). The other two sample bottles are used for replicate field spikes. Each of these is spiked with 100 µL of NWQL-pesticide-spike solution.

Currently, for VOC field spikes (SC2090, SC2091, or SC2092), at least seven sample vials of ground water are collected sequentially and chilled (table 21). Three vials are needed for the ground-water-quality sample, which also is the background sample for the field-spiked samples. Replicate, field-spiked VOC samples (consisting of two vials each) are prepared by spiking each vial with 100 µL of NWQL-VOC-spike solution.

In general, all samples (pesticide or VOC) are spiked with 100 µL of spike solution, which results in a concentration of about 1 to 3 mg/L, depending on the analyte. If the background sample concentration of the analyte (in the unspiked sample) exceeds about one-tenth the concentration in spiked samples, the recovery data from spiked samples generally is considered positively biased (dependent in part on the amount of analyte present before spiking). Use of a volume of spike solution in excess of 100 µL, or a spike solution with higher concentrations than that commonly prepared by the NWQL, could reduce the bias. Recovery data from the use of such a spike solution, however, will relate only to the high, and not the low, concentrations of the analyte.

Once prepared, field-spiked samples are chilled to 0 to 4°C, and generally treated in a manner identical to that of the corresponding background sample. Important information that relates to the spiked sample (lot number, volume, and source of spike solution) are recorded on field and NWQL ASR forms (appendix, fig. A12).

Pesticide solid-phase extractions

The option is available for Study Units to extract pesticides from ground-water-quality samples (unspiked and spiked) or field blanks in the field, rather than having extractions done at the NWQL. Extracts are collected on solid-phase cartridges and sent to the NWQL for analysis under SC2010 and SC2051. Extraction equipment and procedures, prepared by the NWQL for

NAWQA, can be obtained from HIF or NWQL (table 3). Training in the extraction procedure is required, and is obtained through the basic course required for NAWQA ground-water sampling field teams (table 6).

The decision to submit solid-phase extracts instead of water samples to the NWQL requires careful consideration. Field extractions are practical and should be considered in situations where transporting glass bottles, shipping weights, or shipping times pose a serious problem. Extraction is recommended if pesticide water samples (for SC2001 and SC2050) cannot be shipped and reach the laboratory within 72 hours after collection, or when information is available that indicates the analytes of interest could degrade rapidly during transit. Field extractions also are recommended if the transportation of large, glass, sample bottles, or the sheer weight of water samples, poses a hazard for the samples or the field team (for example, if wells are located in remote areas that are accessible only by foot or light plane).

For Study Units that require a quick turnaround time on analytical results, sending field extractions rather than water samples, particularly at peak production times at the NWQL, could expedite data returns. The Study Unit should contact the NWQL in advance of adopting this strategy, however, as there may be no backlog in analysis. In addition, special handling to expedite analysis can be arranged with the NWQL at an additional cost.

Sending field extractions instead of water samples has another potential benefit. Field extractions allow the field team to extract less than a liter of sample, which is useful if water samples are known or suspected to contain concentrations that exceed the linear operating range of NWQL methods (currently about 100 µg/L). In such cases, a measured (by weight difference) sub-volume of the original 1-L water sample can be extracted. As an alternative, however, the field team can request that the NWQL extract only part of a water sample (use comment line on NWQL ASR form), and thereby achieve the same results.

Field extractions can reduce the costs of NWQL analysis and overnight shipping, particularly if the Study Unit is some distance from the NWQL. Whether or not sending field extractions instead of water samples is cost effective depends on whether or not the reduced costs in analysis and shipping are less than the cost of obtaining, using, and maintaining extraction equipment and related supplies. The cost and time of labor associated with extracting samples also should be factored into the decision. A 1-L sample typically requires one field-team member about 45 minutes to extract, not including the time and labor cost needed for equipment assembly and decontamination. Overall, Johnson and Swanson (1994) found laboratory processing required 32 percent fewer hours than on-site processing of extracts by a field team for each of two prototype sites in the Central Nebraska Study Unit.

The time involved to set up equipment, conduct the extraction, and decontaminate, disassemble, and store this equipment can make it difficult for a two-person field team to perform extractions on-site at every well, given all the other on-site activities that the field team typically is required to perform. Therefore, extractions usually are performed after most other on-site activities are completed. Alternatively, extractions can be performed by a third person, perhaps off-site at a designated facility. This is probably the only practical method to field extract numerous pesticide samples in the field. For example, each routine QC site for pesticides requires a minimum of six field extractions (one 1-L ground-water sample, plus two 1-L spiked ground-water samples for each of the two pesticide schedules).

VOC trip-blank and trace-element standard reference samples

Two types of routine QC samples require no sample collection, but are routinely sent from selected sites in the field--the VOC trip blank and the standard trace-element reference sample (table 10). Neither is ever opened by Study Unit personnel.

The VOC trip blank can be found in the box in which NWQL VOC vials are shipped. When shipped by the NAWQA team from the field, the lot number (if not on the vial) can be found on the box, and is recorded on the NWQL ASR form sent with the vial (appendix, fig. A15).

Each Study Unit that conducts trace-element sampling in a given field season must request three standard trace-element reference samples from the BTD&QS (table 10). These reference samples are sent from different ground-water sites by the field team during that field season. At each site, the field team records on the NWQL ASR form the original sample identification code found on each bottle and relabels the bottle with the site identification code (appendix, fig. A19) before the sample is shipped.

Handling and Shipping of Samples

Handling and shipping protocols divide ground-water-quality and routine QC samples collected at a well into three groups (table 26). One group requires samples be shipped overnight at less than 4°C. Another group can be shipped by surface (first class) mail at an ambient temperature. The third group is stored by the Study Unit, and possibly shipped for analysis at a later date by surface mail.

To ensure that the samples collected will provide the data desired, the field team verifies that all sample containers required from the well are present, and that all the information required on container labels and field, NWQL-ASR, and other forms, is complete. It is important that the containers are properly labeled, and that all forms contain the information needed by the NWQL and the Study-Unit data manager (see appendix).

Samples that require overnight shipping (table 26, Group One) can undergo physical, biological, or radiochemical transformation or degradation within a short period of time. This is reflected in their maximum holding times (elapsed time between sample collection and analysis). The maximum holding time for Group One samples is 3 to 5 days, except for VOCs, which have a 14-day holding time. Holding times for most of these samples are dependent on maintaining low sample temperature (less than 4°C). During the period when most samples are being sent to the NWQL (about April through October), at least half the holding time can expire after these samples reach NWQL login and before they are analyzed. Thus, all of these samples must be shipped without delay. In addition, and except for radon, these samples also must be packed in a sufficient amount of ice to maintain low temperatures until received at NWQL and refrigerated.

Table 26. Sample handling for shipment of ground-water-quality and quality-control samples

[°C, degrees Celsius; lbs, pounds; mil, manufacturer bag thickness; SASE, self addressed and stamped envelope; NWQL, National Water Quality Laboratory; ASR, Analytical Service Request; SC or LC, NWQL schedule or laboratory code; FCC, FA, FU, and RU are bottle-type designations; CFC, chlorofluorocarbon]

Sample	Shipping	Procedures
Group One:		
Volatiles--SC2090, SC2091, and SC2092 Pesticides--SC2001 and SC2050 or SC2010 and SC2051 Nutrients--SC2752-FCC Organic Carbon--SC2085 (Add small (250-mL) polyethylene bottle filled with water and labeled "For Temperature Check, at Login.")	Overnight at 0 to 4°C, and for safe handling, at weight less than 50 lbs.	Place samples in mesh bag and place "Temperature Check" bottle in middle of sample containers. Place a large, 4-mil plastic bag in cooler, add layer of ice, and place mesh bag on ice inside plastic bag. Surround and cover mesh bag with ice, then twist and seal outer plastic bag with waterproof tape.
Radon--LC1369	Overnight (with above or separate from above).	Place resealable plastic bag containing radon tube(s) atop large plastic bag above. Combine ASR forms with Study-Unit Login reply form and SASE in nested, resealable, plastic bags, and tape to inside of cooler lid. Put return address on inside of lid. Close lid, secure it, and cooler drain cap with strong tape. Attach air bill.
Group Two:		
Major ions--SC2750--FA FU, and RU Trace elements--samples SC2703 (blanks--SC172)	Surface, first-class mail, at ambient temperature and, for safe handling, weight less than 50 lbs.	Place trace-element samples in two nested, resealable plastic bags and place sealed bags in a heavy cardboard container; pack in bubble pack, enclose forms (ASR and login-reply forms, and SASE) in nested, resealable plastic bags. Seal container with strong tape and attach mailing label with return address.
Group Three:		
Isotopes of tritium, deuterium, and oxygen; major-ion (archive) sample (SC2750--FA); and possibly CFC samples	Initially archive in a dry, cool, and clean storage area; possibly ship (via regular surface mail).	Archive individual samples in a partitioned, heavy cardboard container. List sample types and date on side of container. Also archive ASR and any other forms.

To verify that low temperatures are maintained, each overnight shipment includes a small (250-mL) polyethylene bottle filled with uncontaminated water (for example, deionized), marked “For Temperature Check at Login.” This bottle is placed in the middle of the other samples being shipped. The NWQL login personnel will check the temperature of the water in this bottle, record it on the Study-Unit’s “Login-Reply Return Form” (appendix, fig. A20), and return this form via the self-addressed and stamped envelope provided by the Study Unit. This form and envelope initially are included with the NWQL ASR forms, which are double bagged in resealable plastic bags, and taped to the inside of the shipping cooler (table 26). Study-Unit data managers are to file the return forms, and keep a record of sample temperatures, particularly those that exceeded 4°C.

As a rule, water-quality samples with 3- to 5-day holding times should not be collected on a Friday, particularly Fridays associated with 3-day weekends, because 3 to 5 days could elapse before samples are analyzed. Radon, with a short half-life of approximately 3.6 days, is definitely not collected if it cannot be shipped within 24 hours of collection and arrive at NWQL login before 12:00 p.m. on any Friday.

Samples sent by regular surface mail (first class) have longer holding times than overnight samples and do not need to be chilled (table 26, Group Two). It is recommended, however, that these samples be shipped within a week or two of collection.

Samples archived by the Study Unit (table 26, Group Three) can include replicates (distinct from those required for routine QC samples) of major ions (SC2750, FA bottle only), trace elements (for example, SC2703), isotope samples (for tritium, deuterium, and oxygen), and chlorofluorocarbon (CFC) samples. Archived major-ion and trace-element samples should be discarded as soon as it is known that analytical reruns are not required. Isotope samples can be held for several years provided bottles remain sealed. Samples for CFCs can be held for at least several years, provided they are not biologically active (Eurybiades Busenberg, U.S. Geological Survey, written commun., 1995).

REFERENCES CITED

Alley, W.M., ed., 1993, Regional ground-water quality: New York, Van Nostrand Reinhold, 634 p.

Alley, W.M., and Cohen, Philip, 1991, A scientifically based nationwide assessment of ground-water quality in the United States: Environmental Geology and Water Science, v. 17, no. 1, p. 17-22.

Bachman, L.J., Shedlock, R.J., and Phillips, P.J., 1987, Ground-water-quality assessment of the Delmarva Peninsula, Delaware, Maryland, and Virginia--Project description: U.S. Geological Survey Open-File Report 87-112, 18 p.

Busenberg, Eurybiades, and Plummer, L.N., 1987, pH measurement of low-conductivity waters: U.S. Geological Survey Water-Resources Investigations Report 87-4060, 22 p.

Busenberg, Eurybiades, and Plummer, L.N., 1992, Use of chlorofluorocarbons (CCl_3F and CCl_2F_2) as hydrologic tracers and age-dating tools--the alluvium and terrace system of central Oklahoma: Water Resources Research, v. 28, no. 9, p. 2257-2283.

Christenson, S.C., and Parkhurst, D.L., 1987, Ground-water-quality assessment of the Central Oklahoma aquifer, Oklahoma--Project description: U.S. Geological Survey Open-File Report 87-235, 30 p.

Christenson, S.C., and Rea, A.H., 1993, Ground-water quality in the Oklahoma City urban area, *in* Alley, W.M., ed., Regional Ground-Water Quality: New York, Von Nostrand Reinhold, p. 589-611.

Cohen, Philip, Alley, W.M., and Wilber, W.G., 1988, National water-quality assessment--future directions of the U.S. Geological Survey: American Water Resources Association, Water Resources Bulletin, v. 24, no. 6, p. 1147-1151.

Ferree, D.M., Christenson, S.C., Rea, A.H., and Meander, B.A., 1992, Ground-water-quality assessment of the Central Oklahoma aquifer, Oklahoma--Hydrologic, water-quality, and quality-assurance data, 1987-90: U.S. Geological Survey Open-File Report 92-641, 193 p.

Gibs, Jacob, and Imbrigotta, Thomas, 1990, Well-purging criteria for sampling purgeable organic compounds: Ground Water, v. 28, no. 1, p. 68-78.

Gilliom, R.J., Alley, W.M., and Gurtz, M.E., 1995, Design of the National Water-Quality Assessment Program--occurrence and distribution of water-quality conditions: U.S. Geological Survey Circular 1112, 33 p.

Hamilton, P.A., Denver, J.M., Phillips, P.J., and Shedlock, R.J., 1993, Water-quality assessment of the Delmarva Peninsula, Delaware, Maryland, and Virginia--effects of agricultural activities on, and distribution of, nitrate and other inorganic constituents in the surficial aquifer: U.S. Geological Survey Open-File Report 93-40, 87 p.

Hamilton, P.A., Shedlock, R.J., and Phillips, P.J., 1992, Water-quality assessment of the Delmarva Peninsula, Delaware, Maryland, and Virginia--analysis of available ground-water-quality data through 1987: U.S. Geological Survey Water-Supply Paper 2355-B, 65 p.

Hardy, M.A., Leahy, P.O., and Alley, W.M., 1989, Well installation and documentation, and ground-water sampling protocols for the pilot national water-quality assessment program: U.S. Geological Survey Open-File Report 98-396, 36 p.

Hirsch, R.M., Alley, W.M., and Wilber, W.G., 1988, Concepts for a national water-quality assessment program: U.S. Geological. Survey Circular 1021, 42 p.

Johnson, S.M., and Swanson, R.B., 1994, Operational procedures for collecting water-quality samples at monitoring sites on Maple Creek near Nickerson and the Platte River at Louisville, Eastern Nebraska: U.S. Geological Survey Open-File Report 94-121, 24 p.

Koterba, M.T., Banks, W.S.L., and Shedlock, R.R., 1993, Pesticides in shallow ground-water in the Delmarva Peninsula: Journal of Environmental Quality, v. 22, no. 3, p. 500-518.

Koterba, M.T., Dysart, J.E., Phillips, S.W., and Zynjuk, L.D., 1994, Use and value of quality-control data in studies in the Chesapeake Bay Region, *in* Proceedings of the National Symposium on Water-Quality, American Water Resources Association, Chicago, Ill., November 5-11, p. 65-74.

Koterba, M.T., Shedlock, R.J., Bachman, L.J., and Phillips, P.J., 1991, Regional and targeted ground-water-quality networks in the Delmarva Peninsula, chapter 6, *in* Nash, R.G., and Leslie, A.R., eds., Ground-Water Residue Sampling Design, American Chemical Symposium Series 465, American Chemical Society, Washington DC, p. 111-138.

Lapham, W.W., Wilde, F.D., and Koterba, M.T., in press, Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program--selection, installation, and documentation of wells, and collection of related data: U.S. Geological Survey Open-File Report 95-398.

Leahy, P.P., Rosenshein, J.S., and Knopman, D.S., 1990, Implementation plan for the National Water-Quality Assessment program: U.S. Geological Survey Open-File Report 90-174, 10 p.

Leahy, P.P., and Wilber, W.G., 1991, The National Water-Quality Assessment (NAWQA) Program--A basis for water-resource policy development: Irrigation and Drainage Proceedings, July 22-26, 1991, IR Div/ASCE, Honolulu, Hawaii, p. 711-717.

Mattraw, H.C., Jr., Wilber, W.G., and Alley, W.M., 1989, Quality-assurance plan for the pilot national water-quality assessment program: U.S. Geological Survey Open-File Report 89-726, 21 p.

Radtke, D.B., and Wilde, F.D., eds., in press, National field manual for collection of water-quality data--Field measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.

Rea, A.H., in press, Factors related to water quality in the Central Oklahoma aquifer, *in* Christenson, Scott and Havens, J.S., eds., Ground-water-quality assessment of the Central Oklahoma aquifer--results of investigations: U.S. Geological Survey Open-File Report 93-441.

Reilly, T.E., Franke, O.L., and Bennett, G.D., 1989, Bias in groundwater samples caused by wellbore flow: Hydraulic Engineering Journal, v. 115, no. 2, p. 270-276.

Reynolds, G.W., Hoff, J.T., and Gillham, R.W., 1990, Sampling bias caused by materials used to monitor halocarbons in ground water: Envrionmental Science & Technology, v. 24, no. 1, p. 135-142.

Shampine, W.J., Pope, L.M., and Koterba, M.T., 1992, Integrating quality assurance in project work plans of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 92-162, 12 p.

Smith, R.A. and Alexander, R.B., 1989, Reply To: Discussion by A.R. Russell and K.H. Coale on “Trends in lead concentrations in major U.S. rivers and their relation to historical changes in gasoline-lead consumption”: Water Resources Bulletin, v. 25, no. 6, p. 1279-1281.

van der Kamp, G., and Keller, C.K., 1993, Casing leakage in monitoring wells--detection, confirmation, and prevention: Ground Water Monitoring & Remediation, v. 13, no. 4, p. 136-141.

Welch, A.H., and Plume, R.W., 1987, Water-quality assessment of the Carson River ground-water basin, Nevada and California--project description: U.S. Geological Survey Open-File Report 87-104, 27 p.

APPENDIX. EXAMPLES OF FIELD FORMS FOR THE COLLECTION OF GROUND-WATER DATA AND SAMPLES FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Examples of field and analytical service request forms for the National Water Quality Laboratory are provided in this appendix. Included are forms for the following:

A1. Land-use and land-cover field sheet for the 1991 Study Units, National Water-Quality Assessment Program.[1]
A2. Example of quality-control and calibration form for the dissolved-oxygen sensor and meter.
A3. Example of quality-control and calibration form for the specific electrical conductance sensor and meter.
A4. Example of quality-control form for a thermistor thermometer.
A5. Example of quality-control form for a pH sensor and meter.
A6. Theoretical slope values of Nerst equation for pH electrode (modified from Plummer and Busenberg, 1981).
A7. Example of a purge form for a well.
A8. Example of a ground-water-quality sample-collection field form.
A9. Example of field-titration form.
A10-A. Example of an analytical service request form for primary ground-water-quality samples that require overnight shipping.
A10-B. Example of an analytical service request form for primary ground-water-quality samples that can be shipped surface (first class) mail.
A11-A. Example of an analytical service request form for replicate ground-water-quality samples that require overnight shipping.
A11-B. Example of an analytical service request form for replicate ground-water-quality samples that can be shipped surface (first class) mail.
A12-A. Example of an analytical service request form for replicate field-spiked, ground-water samples for pesticides and volatile organic compounds: first set, TIME: HH:02.
A12-B. Example of analytical service request form for replicate field-spiked, ground-water samples for pesticides and volatile organic compounds: second set, TIME: HH:03. (If optional third set is taken, use a third form similar to the one above but with TIME: HH:04.)
A13-A. Example of analytical service request form for field blanks that require National Water Quality Laboratory blank water <u>and</u> overnight shipping.
A13-B. Example of an analytical service request form for field blanks that require Quality of Water Service Unit inorganic-free blank water (QWSU-IBW) <u>and</u> surface mail shipping.
A14. Example of an analytical service request form for dissolved (filtered) organic carbon (DOC) solution blank composed of either NWQL volatile pesticide-free blank water (VPBW) or pesticide-free blank water (PBW).
A15. Example of an analytical service request form for a volatile-organic-compound (VOC) trip blank.
A16. Example of an analytical service request form for a primary trace-element ground-water sample (SC2703).
A17. Example of an analytical service request form for a replicate trace-element ground-water sample (SC2703).
A18. Example of an analytical service request form for a ground-water trace-element (SC2703) field blank.
A19. Example of an analytical service request form for a standard-reference trace-element (SC2703) sample for ground water.
A20. Example of Study Unit login reply form sent with samples shipped by overnight mail.

---

[1]Land-use and land-cover field sheet for the 1991 Study Units is being evaluated for use by the 1994 Study Units.

LAND-USE/LAND-COVER FIELD SHEET - GROUND-WATER COMPONENT OF NAWQA STUDIES - Page 1 (04/93)

1. NAWQA Study-Unit name using 4-letter abbreviation: ____________
Field-check date ___/___/___ Person conducting field inspection:______________________________
Well station-id:____________________ Latitude:__________________ Longitude:____________________

2. LAND USE AND LAND COVER CLASSIFICATION - (modified from Anderson and others, 1976, p.8). Check all land uses that occur within each approximate distance range from the sampled well. Identify the predominant land use within each distance range and estimate its percentage of the total area within a 1/4-mile radius of the well.

Land use and land cover	Within 100 ft	100 ft-1/4 mi	Comments
I. URBAN LAND			
--Residential			
--Commercial			
--Industrial			
--Other (Specify)________			
II. AGRICULTURAL LAND			
--Nonirrigated cropland			
--Irrigated cropland			
--Pasture			
--Orchard, grove, vineyard, or nursery			
--Confined feeding			
--Other (Specify)________			
III. RANGELAND			
IV. FOREST LAND			
V. WATER			
VI. WETLAND			
VII. BARREN LAND			
Predominant land use			
Approximate percentage of area covered by predominant land use			

3. AGRICULTURAL PRACTICES within 1/4 mile of the sampled well.

a. Extent of irrigation - Indicate those that apply.
Nonirrigated ____ Supplemental irrigation in dry years only ____, Irrigated ____

b. Method of irrigation - Indicate those that apply.
Spray ___ Flood ___ Furrow ___ Drip ___ Chemigation ___ Other ___ (Specify) ____________

c. Source of irrigation water - Indicate those that apply.
Ground water ____ Surface water ____ Spring ____
Sewage effluent ____ (treatment): Primary ____ Secondary ____ Tertiary ____

d. Pesticide and fertilizer application - Provide information about present and past pesticides and fertilizers used, application rates, and application methods.____
____

e. Crop and animal types - Provide information about present and past crop and animal types, and crop rotation practices.____
____

Entered by____________________ Date ___/___/___ Checked by __________________ Date ___/___/___

Figure A1. Land-use and land-cover field sheet for the 1991 Study Units, National Water-Quality Assessment Program.

LAND-USE/LAND-COVER FIELD SHEET - GROUND-WATER COMPONENT OF NAWQA STUDIES-Page 2 (04/93)

Well station-id: ______________________________ Field-check date: ____/____/____

4. LOCAL FEATURES - Indicate all local features that may affect ground-water quality which occur within each approximate distance range from the sampled well.

Feature	within 100 ft	100 ft - 1/4 mi	Comments
Gas station			
Dry cleaner			
Chemical plant or storage facility			
Airport			
Military base			
Road			
Pipeline or fuel storage facility			
Septic field			
Waste disposal pond			
Landfill			
Golf course			
Stream, river, or creek Perennial __ Ephemeral __			
Irrigation canal Lined __ Unlined __			
Drainage ditch Lined __ Unlined __			
Lake Natural __ Manmade __			
Reservoir Lined __ Unlined __			
Bay or estuary			
Spring Geothermal (> 25 C)__ Nongeothermal__			
Salt flat or playa Dry __ Wet __			
Mine, quarry, or pit Active __Abandoned__			
Oil well			
Major withdrawal well			
Waste injection well			
Recharge injection well			
Other ______________			

Figure A1. Land-use and land-cover field sheet for the 1991 Study Units, National Water-Quality Assessment Program--Continued.

LAND-USE/LAND-COVER FIELD SHEET - GROUND-WATER COMPONENT OF NAWQA STUDIES -Page 3 (04/93)

Well station-id: ______________________________ Field-check date: ____/____/____

5. LAND-USE CHANGES - Have there been major changes in the last 10 years in land use within 1/4 mile of the sampled well? Yes __, Probably __, Probably not __, No __ If yes, describe major changes.

____

____

____

____

____

____

6. ADDITIONAL COMMENTS - Emphasize factors that might influence local ground-water quality.

____

____

____

____

____

Remarks

Figure A1. Land-use and land-cover field sheet for the 1991 Study Units, National Water-Quality Assessment Program--Continued

Model ______________________; Serial Number (W) ________________

Date	Time	Electrode Condition					Calibration									
		Membrane	Membrane changed last	Gold cathode and silver anode	Electro-lyte	Battery	Red-line	Zero	Meter[1] temper-ature (°C)	Saturated DO at temperature (mg/L)	Atmo-spheric. pressure (mm Hg)	Correction factor	Calibra-tion DO (mg/L)	Adjusted (Y or N)	Initials of testor

°C = degrees Celsius; mg/L = milligram per liter; mm Hg = millimeters of mercury
[1]See temperature quality-control form for thermistor used with this instrument (fig. A4).

Figure A2. Example of quality-control and calibration form for the dissolved-oxygen (DO) sensor and meter.

Model ____________________; Serial number (W) _____________________

	Condition of:			Conductance calibration:						
Date	Electrode	Meter	Thermistor[1]	Standard # 1 less than 100 µS/cm	Reading µS/cm at 25°C	Within 5% of standard	Standard # 2 greater than 100 µS/cm	Reading µS/cm at 25°C	Within 3% of standard	Initials and action taken

[1]See thermistor form for quality-control tests on thermistor, all readings at 25° Celsius (25°C) in microsiemens per centimeter (µS/cm).

Figure A3. Example of quality-control and calibration form for the specific electrical conductance sensor and meter.

Model ____________________ Serial number (W) __________________

Date	Low temperature (0 to 5°C)			High temperature (15 to 35°C)			Action taken	Initials
	ASTM thermometer[1] reading ($^{\circ}$C)	Meter reading ($^{\circ}$C)	Within 0.2°C?	ASTM thermometer reading ($^{\circ}$C)	Meter reading ($^{\circ}$C)	Within 0.2°C?		

[1]American Society for Testing and Materials (ASTM) thermometer, serial number ________________________.

Specify thermistor use by checking one below:

pH ____ Specific electrical conductance ____ Dissolved oxygen ____ Turbidity ____ Temperature _____

Figure A4. Example of quality-control form for a thermistor thermometer measuring degrees Celsius ($^{\circ}$C).

Date	Low pH buffer	High pH buffer	Reading		Reading		Buffer temperature (°C)	Actual slope[1] $\Delta mV/\Delta pH$	Theoretical slope at temperature[2]	Slope ratio[3] (%)	Pass (Y or N)	Response time[4] (seconds)	Initials/ action taken[5]
			mV low	mV high	pH low	pH high							

[1]Actual slope = $\Delta mV/\Delta pH$, where ΔmV is difference in millivolt readings between low and high pH buffers, and ΔpH is difference in measured pH (that meter locks on) between low and high pH buffers.

[2]Theoretical slope of Nernst equation (see fig. A6) as function of buffer temperature in degrees Celsius (°C).

[3]Slope ratio in percent = (actual slope/theoretical slope) x 100. An acceptable ratio is one greater than or equal to 95.0 percent.

[4]Response time for meter to lock onto low pH buffer after calibration on high pH buffer. An acceptable value is less than or equal to 15 seconds.

[5]Initials of person performing quality control, and action taken by that person. See temperature quality-control form for thermistor used with this instrument (fig. A4).

Figure A5. Example of quality-control form for a pH sensor and meter.

Temperature[1]	Theoretical slope[2]	Temperature	Theoretical slope
0	54.197	21	58.364
1	54.396	22	58.562
2	54.594	23	58.761
3	54.792	24	58.959
4	54.991	25	59.157
5	55.189	26	59.356
6	55.388	27	59.554
7	55.586	28	59.753
8	55.784	29	59.951
9	55.983	30	60.149
10	56.181	31	60.348
11	56.380	32	60.546
12	56.578	33	60.745
13	56.777	34	60.943
14	56.975	35	61.141
15	57.173	36	61.340
16	57.372	37	61.538
17	57.570	38	61.737
18	57.769	39	61.935
19	57.967	40	62.133
20	58.165		

[1]Degrees Celsius, record to nearest tenth of degree.
[2]Interpolate theoretical slope for buffer temperatures between whole degree values.

Figure A6. Theoretical slope values of Nerst equation for pH electrode at temperature specified (modified from Plummer and Busenberg, 1981).

WATER-LEVEL MEASUREMENTS, PURGE VOLUME, AND FIELD MEASUREMENTS BEFORE SAMPLING

USGS I.D.: ______________________________ Date ___________________________ Time ____________________

Local Well I.D.: ___________________________ Field Team I.D.: _________________________

Well diameter (D, inches): ____________ Depth to water[1] (feet): _____________ Depth of well[1] (feet):______________

Height of water column (H, feet): __________________ Casing (borehole) wetted volume (= $0.0408HD^2$, gallons)

____

Purge volume (= 3 x casing volume, gallons): ____________________ Pump type: _________________________________

Time (min.)	Pump depth (feet)	Pump rate (gpm)	Volume pumped (gal)	Water appearance (clear, cloudy, etc.)	Temper-ature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm at 25°C)	Turbidity (NTU)
Except for pH, median values of final 5 measurements; to be used on ASR forms and field sample-collection forms (fig. A9).[2]									

min. = minutes; gpm = gallons per minute; gal = gallons; °C = degrees Celsius; mg/L = milligrams per liter; µS/cm at 25°C = microsiemens per centimeter at 25°C; NTU = nephelometric turbidity unit

[1]Reference datum was measurement point __________________ Land surface datum (surveyed) ____________________

Equipment used ____ Accuracy ______________________

[2]For pH, after other final measurements are taken, temporarily divert flow and use final pH value obtained on standing water in flowthrough chamber.

Figure A7. Example of purge form for a well.

LOCAL ID ______________________ **RECORD #** ______________________

Station identification number (lat. / long. / seq.)	Type	Date (Y M D)	Time
1 | 2–16	17	18–23	24–27

Local Well Number	Site	Geologic Unit	Hydrologic Unit

State	District	County

Sampled by ______________________

Location ______________________

*	Code	Value	Remarks
Yield when sampling (GPM)	00059		
Minutes pumped before sampling	72004		
Sampling method	82398		

4010 = thief sample
4020 = bailer
4030 = suction pump
4040 = submersible pump
4050 = squeeze pump
4060 = gas reciprocating
4070 = air lift
4080 = peristaltic pump
4090 = jet pump
4100 = flowing well

	Code	Value	Remarks
Sampling condition	72006		

0.10 = site was being pumped
0.11 = site had been pumped recently
4. = flowing
8. = pumping
30. = seeping

	Code	Value	Remarks
Static water level (feet)	72019		
Altitude lsd (feet)	72000		
Depth to top sample interval	72015		
Depth to bottom sample interval	72016		
Finished well depth (feet)	72008		
Hole depth (feet)	72001		

	Code	Value	Remarks
Water temperature	00010		
Air temperature	00020		
Specific conductance	00095		
Dissolved oxygen	00300		
Turbidity	72008		

	Code	Value	Remarks
pH field	00400		
Alkalinity total field*	39086		
Bicarbonate total field	00453		
Carbonate total field	00452		
Acid neutralization capacity*	00419		

*For Gran-method titrations, values of Alk and ANC in mg/L have parameter codes 29802 and 29813, respectively.

Bottles Filled	Volume	Treatment

Comments:

Quality-control samples taken? ☐ Yes ☐ No

Any land-use changes? ☐ Yes ☐ No

Was form updated? ☐ Yes ☐ No

VOCs--acid used: Drops to pH 2 ☐ Drops used ☐

DRAFT

Figure A8. Example of a ground-water-quality sample-collection field form.

Units of acid	pH	Δ pH	Δ units acid	Δ ph/ Δ units

Units of acid	pH	Δ pH	Δ units acid	Δ ph/ Δ units

Station identifier | Date | Time

Normality of acid | Volume of acid to pH ~ 8.3

Type of titration: Incremental, inflection point | Volume of acid to pH ~ 4.5

ANC, mg/L $CaCo_3$[a]

Comments:

Alk, mg/L $CaCo_3$[b]

Bicarbonate, mg/L HCO_3^-

Carbonate, mg/L $CO_3^=$

[a]ANC - acid neutralizing capacity; on unfiltered sample from inflection point at about pH = 4.5.

[b]ALK - alkalinity, carbonate, and bicarbonate, on filtered sample from inflection points at about pH = 8.3 and 4.5.

Figure A9. Example of field-titration form.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382454075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0800
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES

SCHEDULE 1: SC2090
SCHEDULE 2: SC2001
SCHEDULE 3: SC2050
SCHEDULE 4: SC2085
SCHEDULE 5: SC2752

**SAMPLE MEDIUM: 6
GEOLOGIC UNIT: 112BVDM
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 9 or 7[a]
**HYDRO EVENT: 9

CODE	A/D	CODE	A/D	CODE	A/D	CODE	A/D
1369	82303						

FIELD VALUES[b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095	245		51/ 00400	6.1		2 / 00419	11.5	
/00010	11.1		/ 00300	2.2		/00452	1.2	
/00076	2		/99105	20		/00453	9.3	
						39086	112	

+COMMENTS: (LIMIT TO 138 CHARACTERS: [c] Time of radon sample: 08:40; VOC, HCl added: 4 drops

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-48400 DATE: 01 /20 /95[d]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___ FA	___ RU	___ FU	___ FAM	___ RAM	___ RC	___ FC	___ FAB	___ CU
___ RA	___ RAH	___ S=	___ CN-	___ RCB	1 DOC	___ TOC	___ SOC	___ COD
___ VOA	___ CHY	___ O&G	___ PHENOL	2 GCC	3 GCV, 1 RN, 1 FCC OTHER			

CUSTOM/SPECIAL SAMPLE APPROVED BY: ______ APPROVAL NO. ______
PROGRAM/PROJECT: XX NAWQA ___ DRINKING H20 FILL IN OTHER ______
POSSIBLE HAZARDS ______

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY
*MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Use 7 if any replicate ground-water samples are taken for the above schedules or those on figure A10-B.

[b]If 9 used for sample type, add all P-codes, including those under field values, except for 99105, which is left blank. If 7 used for sample type, inlcude P code 99105. Also add P codes to QWDATA record for sample.

[c]This is a priority message, must appear.

[d]Overnight shipping is recommended for all samples. Do not put radon tube in ice.

Figure A10-A. Example of an analytical service request form for primary ground-water-quality samples (including radon) that require overnight shipping.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID | SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0800
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES

SCHEDULE 1: SC2750
SCHEDULE 2:
SCHEDULE 3:
SCHEDULE 4:
SCHEDULE 5:

**SAMPLE MEDIUM: 6
GEOLOGIC UNIT: 112BVDM
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 9 or 7[a]
**HYDRO EVENT: 9

CODE:	A/D	CODE:	A/D	CODE:	A/D	CODE:	A/D

FIELD VALUES[b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21 / 00095	245		51 / 00400	6.1		2 / 00419	11.5	
/00010	11.1		/ 00300	2.2		/00452	1.2	
/00076	2		/99105	20		/00453	9.3	
						39086	11.2	

+COMMENTS: (LIMIT TO 138 CHARACTERS: _[c]

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-48400 DATE: 01 /27 /95[d]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA	1 RU	1 FU	FAM	RAM	RC	FC	FAB	CU
RA	RAH	S=	CN-	RCB	DOC	TOC	SOC	COD
VOA	CHY	O&G	PHENOL	GCC			OTHER	

CUSTOM/SPECIAL SAMPLE APPROVED BY: APPROVAL NO.
PROGRAM/PROJECT: XX NAWQA DRINKING H20 FILL IN OTHER
POSSIBLE HAZARDS

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Use 7 if any replicate ground-water samples are taken for the above schedules or those on figure A10-A.

[b]If 9 used for sample type, add all P codes, including those under field values, except for 99105, which is left blank. If 7 used for sample type, include P code 99105. Also add P-codes to QWDATA record for sample.

[c]No comments; otherwise, priority comments on figure A10-A could be overwritten.

[d]Recommend samples be sent surface mail within 2 weeks of collection date.

Figure A10-B. Example of an analytical service request form for primary ground-water-quality samples that can be shipped surface (first class) mail.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID | SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 38245907500301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0801
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES

SCHEDULE 1: SC2085
SCHEDULE 2: SC2752
SCHEDULE 3: SC2090
SCHEDULE 4: SC2001
SCHEDULE 5: SC2050

**SAMPLE MEDIUM: S
GEOLOGIC UNIT:
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 7
**HYDRO EVENT: 9

	A/D		A/D		A/D		A/D
CODE: 1369	82303	CODE:		CODE:		CODE:	
CODE:		CODE:		CODE:		CODE:	
CODE:		CODE:		CODE:		CODE:	
CODE:		CODE:		CODE:		CODE:	

FIELD VALUES[a]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/99105	20		/			/		
/			/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS: [b]Time of radon sample: 08:45; VOC, HCl added: 4 drops

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 |20 |95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA	___RU	___FU	___FAM	___RAM	___RC	___FC	___FAB	___CU
___RA	___RAH	___S=	___CN-	___RCB	___DOC	___TOC	___SOC	___COD
___VOA	___CHY	___O&G	___PHENOL	2 GCC	3 GCV, 1 RN, 1 FCC OTHER			

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add P codes noted above to form and to QADATA record for this sample.

[b]This is a priority message, must appear.

[c]Overnight shipping with primary samples (fig. A10-A) is recommended.

Figure A11-A. Example of an analytical service request form for replicate ground-water-quality samples (including radon) that require overnight shipping.

US. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52 — STATION ID OR UNIQUE NO: 38245907500301

FIELD OFFICE: TOWSON, MD — *PHONE NO.: (410) 512-4800 — *PROJECT CHIEF: SHEDLOCK — FIELD SAMPLE ID: WICh52 — SITE TYPE: GW

*STATE: 24 — *DISTRICT/USER: 024 — CNTY: 045 — *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0801
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES

SCHEDULE 1: SC2750 — **SAMPLE MEDIUM: ____ — **SAMPLE TYPE: 7
SCHEDULE 2: ____ — GEOLOGIC UNIT: ____
SCHEDULE 3: ____ — **ANALYSIS STATUS: H — **HYDRO EVENT: 9
SCHEDULE 4: ____ — **ANALYSIS SOURCE: 9
SCHEDULE 5: ____ — **HYDRO CONDITION: 9

CODE:	A/D	CODE:	A/D	CODE:	A/D	CODE:	A/D

FIELD VALUES[a]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095	245		51/ 00400	6.1		2 / 00419	11.5	
/00010	11.1		/ 00300	2.2		/00452	1.2	
/00076	2		/99105	20		/00453	9.3	
						39086	11.2	

+COMMENTS: (LIMIT TO 138 CHARACTERS): [b]

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA — PHONE: (410) 512-48400 — DATE: 01 /27 /95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA, RA, VOA — 1 RU, RAH, CHY — 1 FU, S=, O&G — FAM, CN-, PHENOL — RAM, RCB, GCC — RC, DOC — FC, TOC — FAB, SOC — CU, COD — OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA — DRINKING H20 — FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 — +COMMENTS TO BE STORED BY THE LABORATORY — *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS — **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add P codes noted above to form and to QADATA record for this sample.
[b]No comments; otherwise, priority comments on figure A11-A could be overwritten.
[c]Surface (first-class) shipping with primary samples (fig. A10-B) is recommended.

Figure A11-B. Example of an analytical service request form for replicate ground-water-quality samples that can be shipped surface (first class) mail.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52 — STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE	*PHONE NO.	*PROJECT CHIEF	FIELD SAMPLE ID	SITE TYPE
TOWSON, MD	(410) 512-4800	SHEDLOCK	WICh52	GW

*STATE	*DISTRICT/USER	CNTY	*PROJECT ACCT NO
24	024	045	442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0802
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2090
SCHEDULE 2: SC2001
SCHEDULE 3: SC2050
SCHEDULE 4:
SCHEDULE 5:

**SAMPLE MEDIUM: S
GEOLOGIC UNIT:
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 1
**HYDRO EVENT: 9

CODE	A/D	CODE	A/D	CODE	A/D	CODE	A/D
99105	20	99107	10				
99106	10	99108	0.1				

FIELD VALUES

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/			/			/		
/			/			/		

put lot numbers for all spikes on this form

+COMMENTS: (LIMIT TO 138 CHARACTERS): [b]SC2090: spike lot no.; SC2001: spike lot no.; SC2050: spike lot no.

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 /20 /95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL 2 GCC 2 GCV ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ________ APPROVAL NO. ________
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ______
POSSIBLE HAZARDS ________

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Use indicated spiked-sample P codes; include in QADATA record for sample.
[b]Include lot number of each spike vial used with each schedule.
[c]Ship overnight with primary unspiked (background) ground-water samples (fig. A10-A).

Figure A12-A. Example of an analytical service request form for replicate field-spiked, ground-water samples for pesticides and volatile organic compounds; first set, TIME: HH:02.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID | SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0803
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2090
SCHEDULE 2: SC2001
SCHEDULE 3: SC2050
SCHEDULE 4:
SCHEDULE 5:

**SAMPLE MEDIUM: S
GEOLOGIC UNIT:
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 1
**HYDRO EVENT: 9

CODE	A/D	CODE	A/D	CODE	A/D	CODE	A/D
99105	20	99107	10				
99106	10	99108	0.1				

FIELD VALUES [b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21 / 00095			51 / 00400			2 / 00419		
/			/			/		
/			/			/		

put lot numbers for all spikes on this form

+COMMENTS: (LIMIT TO 138 CHARACTERS): [b] SC2090: spike lot no.; SC2001: spike lot no.; SC2050: spike lot no.

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 / 20 / 95 [c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL 2 GCC 2 GCV OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ________ APPROVAL NO. ________
PROGRAM/PROJECT: XX NAWQA ___ DRINKING H20 FILL IN OTHER ________
POSSIBLE HAZARDS ________

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Use indicated spiked-sample P codes; include in QADATA record for sample.
[b]Include lot number of each spike vial used with each schedule.
[c]Ship overnight with primary unspiked (background) ground-water samples (fig. A10-A).

Figure A12-B. Example of an analytical service request form for replicate field-spiked, ground-water samples for pesticides and volatile organic compounds; second set, TIME: HH:03. (If optional third set is taken, use a third form similar to the one above but with TIME: HH:04.)

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52 | STATION ID OR UNIQUE NO: 38245907500301

FIELD OFFICE: TOWSON, MD | *PHONE NO.: (410) 512-4800 | *PROJECT CHIEF: SHEDLOCK | FIELD SAMPLE ID: WICh52 | SITE TYPE: GW

*STATE: 24 | *DISTRICT/USER: 024 | CNTY: 045 | *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0805
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2090
SCHEDULE 2: SC2001
SCHEDULE 3: SC2050
SCHEDULE 4: SC2085
SCHEDULE 5: ______

**SAMPLE MEDIUM: Q
GEOLOGIC UNIT: ______
**ANALYSIS STATUS: 4
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 2
**HYDRO EVENT: 9

CODE	A/D	CODE	A/D	CODE	A/D	CODE	A/D
99100	50						
99101	10						
99102	100						

FIELD VALUES [b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21 / 00095			51 / 00400			2 / 00419		
/			/			/		
/			/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS): NWQL VPBW: Lot no.

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 / 20 / 95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RA ___VOA ___RU ___RAH ___CHY ___FU ___S= ___O&G ___FAM ___CN- ___PHENOL ___RAM ___RCB 2 GCC ___RC 1 DOC ___FC ___TOC ___FAB ___SOC ___CU ___COD 3 GCV ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ______ APPROVAL NO. ______
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER______
POSSIBLE HAZARDS ______

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P-codes to form and to QADATA record for sample.

[b]Priority comment, blank water lot number. If SC2090 not taken, NWQL pesticide-free blank water can be used, and if it is used, change the P code 99100 to "40" and the comment to "NWQL PBW: lot no."

[c]Ship blank samples with corresponding ground-water-quality samples.

Figure A13-A. Example of an analytical service request form for field blanks that require National Water Quality Laboratory blank water and overnight shipping.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID | SAMPLE SET

WICh52
STATION NAME

382459075200301
STATION ID OR UNIQUE NO

TOWSON, MD — FIELD OFFICE
(410) 512-4800 — *PHONE NO.
SHEDLOCK — *PROJECT CHIEF
WICh52 — FIELD SAMPLE ID
GW — SITE TYPE

24 — *STATE
024 — *DISTRICT/USER
045 — CNTY
442400000 — *PROJECT ACCT NO

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0806
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2750
SCHEDULE 2:
SCHEDULE 3:
SCHEDULE 4:
SCHEDULE 5:

**SAMPLE MEDIUM: Q
GEOLOGIC UNIT:
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 2
**HYDRO EVENT: 9

CODE:	A/D	CODE:	A/D	CODE:	A/D	CODE:	A/D
	50						
	10						
	100						

FIELD VALUES

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/99100	10		/ 99102	100		/		
/99101	80		/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS:[b] QWSU IBW: Lot no.

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 27 95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA, RA, VOA; 1 RU, RAH, CHY; 1 FU, S=, O&G; FAM, CN-, PHENOL; RAM, RCB, GCC; RC, DOC; FC, TOC; FAB, SOC; CU, COD; OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: APPROVAL NO.
PROGRAM/PROJECT: XX NAWQA DRINKING H20 FILL IN OTHER
POSSIBLE HAZARDS

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes to form and to QADATA record for this sample.

[b]Priority comment, must appear.

[c]Recommend field-blank samples be shipped surface mail with corresponding ground-water samples (see figs. A10-A,B).

Figure A13-B. Example of an analytical service request form for field blanks that require Quality of Water Service Unit inorganic-free blank water (QWSU-IBW) and surface mail shipping.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

WICh52
STATION NAME

382459075200301
STATION ID OR UNIQUE NO

TOWSON, MD	(410) 512-4800	SHEDLOCK	WICh52	GW
FIELD OFFICE	*PHONE NO.	*PROJECT CHIEF	FIELD SAMPLE ID	SITE TYPE

24	024	045	442400000
*STATE	*DISTRICT/USER	CNTY	*PROJECT ACCT NO

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0807
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES[a]

SCHEDULE 1: SC2085
SCHEDULE 2: ____
SCHEDULE 3: ____
SCHEDULE 4: ____
SCHEDULE 5: ____

ORY CODES *SAMPLE MEDIUM: Q
GEOLOGIC UNIT: ____
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 2
**HYDRO EVENT: 9

CODE:	A/D	CODE:	A/D	CODE:	A/D	CODE:	A/D

FIELD VALUES[b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/99100	50		/ 99102	1		/		
/99101	10		/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS)[c]: NWQL VPBW: Lot no.

LOGIN COMMENTS: ____

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 | 20 | 95[d]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA	___RU	___FU	___FAM	___RAM	___RC	___FC	___FAB	___CU
___RA	___RAH	___S=	___CN-	___RCB	1 DOC	___TOC	___SOC	___COD
___VOA	___CHY	___O&G	___PHENOL	___GCC			___OTHER	

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.

[b]If DOC field blank (fig. A13-A) taken with NWQL PBW, instead of NWQL VPBW, change the P code 99100 to "40" and the comment to "NWQL PBW: lot no."

[c]Priority comment, must appear in relation to blank water used (NWQL PBW or NWQL VPBW).

[d]This DOC solution blank is shipped overnight with the corresponding DOC field blank (fig. A13-A).

Figure A14. Example of an analytical service request form for dissolved (filtered) organic carbon (DOC) solution blank composed of either NWQL volatile pesticide-free blank water (VPBW) or pesticide-free blank water (PBW).

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO ____ NWIS RECORD NO ____ LABORATORY ID ____ SAMPLE SET ____

STATION NAME: WICh52 STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD *PHONE NO.: (410) 512-4800 *PROJECT CHIEF: SHEDLOCK FIELD SAMPLE ID: WICh52 SITE TYPE: GW

*STATE: 24 *DISTRICT/USER: 024 CNTY: 045 *PROJECT ACCT NO: 442400000

BEGIN DATE: YEAR 1995 MONTH 01 DAY 20 TIME 0808
END DATE:

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2090 **SAMPLE MEDIUM: Q **SAMPLE TYPE: 2
SCHEDULE 2: ____ GEOLOGIC UNIT: ____ **HYDRO EVENT: 9
SCHEDULE 3: ____ **ANALYSIS STATUS: H
SCHEDULE 4: ____ **ANALYSIS SOURCE: 9
SCHEDULE 5: ____ **HYDRO CONDITION: 9

CODE: ____ | A/D ____ (4 columns × 4 rows, blank)

FIELD VALUES [b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21 / 00095			51 / 00400			2 / 00419		
/99100	50		/ 99102	30		/		
/99101	10		/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS: VOC trip-blank vial: Lot no.

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 20 95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL ___GCC 2 GCV ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

DRAFT

[a]Add all P codes noted to form and to QADATA record for this sample.
[b]NWQL VPBW is assumed for trip blanks; priority comment, lot no. of VOC trip blank vials.
[c]Ship overnight with corresponding volatile ground-water samples collected in vials from same lot (fig. A10-A).

Figure A15. Example of an analytical service request form for a volatile-organic-compound (VOC) trip blank.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0809
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2703
SCHEDULE 2: ____
SCHEDULE 3: ____
SCHEDULE 4: ____
SCHEDULE 5: ____

**SAMPLE MEDIUM: 6
GEOLOGIC UNIT: 112BVDM
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 9 or 7[b]
**HYDRO EVENT: 9

CODE	A/D [c]	CODE	A/D	CODE	A/D	CODE	A/D
LC0112							
LC0087							

FIELD VALUES [d]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095	245		51/ 00400	6.1		2 / 00419	11.5	
/00010	11.1		/ 00300	2.2		/00452	1.2	
/00076	2		/99105	20		/00453	9.3	
						39086	11.2	

+COMMENTS: (LIMIT TO 138 CHARACTERS: (INDICATE HERE IF SC EXCEEDS 2,000)

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 /27 /95[e]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA [f] __ RU __ FU __ FAM __ RAM __ RC __ FC __ FAB __ CU
__ RA __ RAH __ S= __ CN- __ RCB __ DOC __ TOC __ SOC __ COD
__ VOA __ CHY __ O&G __ PHENOL __ GCC __ OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA __ DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.

[b]If a replicate trace-element sample is collected (fig. A17), code sample type as 7; otherwise, code as 9.

[c]Add labcodes for arsenic (LC0112) and selenium (LC0087).

[d]Include field measurements (median values), particularly for specific electrical conductance (SC) at 25 degrees Celsius (P code 00095), and note on comment line if SC exceeds 2,000.

[e]Recommend sample be shipped surface mail with other primary inorganic samples (see fig. A10-B).

[f]Only the FA sample bottle is required if Study Unit acidifies sample, provides field SC value, and indicates in comment field if SC exceeds 2,000 microsiemens per centimeter at 25 degrees Celsius.

Figure A16. Example of an analytical service request form for a primary trace-element ground-water sample (SC2703).

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SAMPLE SET

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0810
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2703
SCHEDULE 2:
SCHEDULE 3:
SCHEDULE 4:
SCHEDULE 5:

**SAMPLE MEDIUM: S
GEOLOGIC UNIT:
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 7
**HYDRO EVENT: 9

A/D [b]
CODE: LC0112 |
CODE: LC0087 |
CODE: |
CODE: |

A/D
CODE: |
CODE: |
CODE: |
CODE: |

FIELD VALUES

LAB/P CODE| VALUE| RMK
21/ 00095 | 245 | | [c]
/99105 | 20 |
/ | |

51/ 00400 | |
2 / 00419 | |

+COMMENTS: (LIMIT TO 138 CHARACTERS:

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 /27 /95[d]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA [e] __RU __FU __FAM __RAM __RC __FC __FAB __CU
__RA __RAH __S= __CN- __RCB __DOC __TOC __SOC __COD
__VOA __CHY __O&G __PHENOL __GCC __OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: APPROVAL NO.
PROGRAM/PROJECT: XX NAWQA __DRINKING H20 FILL IN OTHER
POSSIBLE HAZARDS

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.

[b]Add labcodes for arsenic (LC0112) and selenium (LC0087).

[c]Include field measurements (median values), particularly for specific electrical conductance (SC) at 25 degrees Celsius (P code 00095), and note on comment line if SC exceeds 2,000.

[d]Recommend sample be shipped surface mail with other primary inorganic samples (see fig. A10-B).

[e]Only the FA sample bottle is required if Study Unit acidifies sample, provides field SC value, and indicates in comment field if SC exceeds 2,000 microsiemens per centimeter at 25 degrees Celsius.

Figure A17. Example of an analytical service request form for a replicate trace-element ground-water sample (SC2703).

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID | SAMPLE SET

STATION NAME: WICh52 | STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD | *PHONE NO.: (410) 512-4800 | *PROJECT CHIEF: SHEDLOCK | FIELD SAMPLE ID: WICh52 | SITE TYPE: GW

*STATE: 24 | *DISTRICT/USER: 024 | CNTY: 045 | *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0811
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC172[b] | **SAMPLE MEDIUM: Q | **SAMPLE TYPE: 2
SCHEDULE 2: | GEOLOGIC UNIT: | **HYDRO EVENT: 9
SCHEDULE 3: | **ANALYSIS STATUS: H
SCHEDULE 4: | **ANALYSIS SOURCE: 9
SCHEDULE 5: | **HYDRO CONDITION: 9

CODE	A/D [c]	CODE	A/D	CODE	A/D	CODE	A/D
LC0112							
LC0087							

FIELD VALUES[d]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/99100	10		/ 99102	100		/		
/99101	80		/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS) QWSU IBW: Lot no.; SC is less than 2,000

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 /27 /95[e]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA [f] | RU | FU | FAM | RAM | RC | FC | FAB | CU
RA | RAH | S= | CN- | RCB | DOC | TOC | SOC | COD
VOA | CHY | O&G | PHENOL | GCC | OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: APPROVAL NO.
PROGRAM/PROJECT: XX NAWQA DRINKING H20 FILL IN OTHER
POSSIBLE HAZARDS

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.
[b]SC172 required for field blanks instead of SC2703--provides detection-level or higher concentration data.
[c]Add labcodes for arsenic (LC0112) and selenium (LC0087).
[d]Include priority comments; note that SC value is not given under the P code (this is blank water).
[e]Recommend sample be shipped surface mail with other primary inorganic samples (fig. A10-B).
[f]Only the FA sample bottle is required if the Study Unit acidifies sample and provides SC comment.

Figure A18. Example of an analytical service request form for a ground-water trace-element (SC2703) field blank.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO ______ NWIS RECORD NO ______ LABORATORY ID ______ SAMPLE SET ______

STATION NAME: WICh52 STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD *PHONE NO.: (410) 512-4800 *PROJECT CHIEF: SHEDLOCK FIELD SAMPLE ID: WICh52 SITE TYPE: GW

*STATE: 24 *DISTRICT/USER: 024 CNTY: 045 *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0812
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2703 **SAMPLE MEDIUM: Q **SAMPLE TYPE: 3
SCHEDULE 2: ______ GEOLOGIC UNIT: ______ **HYDRO EVENT: 9
SCHEDULE 3: ______ **ANALYSIS STATUS: H
SCHEDULE 4: ______ **ANALYSIS SOURCE: 9
SCHEDULE 5: ______ **HYDRO CONDITION: 9

CODE	A/D [b]	CODE	A/D	CODE	A/D	CODE	A/D
LC0112							
LC0087							

FIELD VALUES [c]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/99103	135		/			/		
/			/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS: Bottle Code: ; SC less than 2,000

LOGIN COMMENTS: ______

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 /27 /

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA[e] ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL ___GCC ______OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ______ APPROVAL NO. ______
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ______
POSSIBLE HAZARDS ______

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.

[b]Add labcodes for arsenic (LC0112) and selenium (LC0087).

[c]Include priority comments; note that SC value is not given under the P code (this is blank water). Specify bottle code originally found on bottle as received from BTD&QS.

[d]Recommend sample be shipped surface mail with other primary inorganic samples (fig. A10-B).

[e]Only the FA sample bottle is required if the Study Unit acidifies sample and provides the SC comment.

Figure A19. Example of an analytical service request form for a standard-reference trace-element (SC2703) sample for ground water.

LOGIN REPLY SHEET

Date Mailed: ___________________ Person sending shipment: _______________________

Place from which shipment was mailed: _____________________________________

Shipped via: ____

Type of Sample (circle one): ORG NUT PEST VOC RADON INORG

Station Numbers of Samples in This Shipment

______________________________________ ____________________________________

______________________________________ ____________________________________

______________________________________ ____________________________________

______________________________________ ____________________________________

______________________________________ ____________________________________

LOGIN STAFF:

Please enter the following information on this form and mail the form back to us with the attached self-addressed, franked envelope. Note that there is an 8-ounce bottle of tap water in this shipment marked "TEMPERATURE" for use in measuring water temperature.

Person logging in shipment: ____

Date Shipment Arrived:

Water Temperature:

Comments (if applicable):

If you have any questions about this shipment, please contact:

Name: ____________________________________

Telephone: ( ) __________ - _______________

E-mail or Internet: ___________________________

Thank You For Your Participation in This Quality Assurance Program.

Figure A20. Example of Study Unit login reply form sent with samples shipped by overnight mail.

Errata for Open-File Report 95-399

Corrections are by Michael Koterba; January 24, 1996

Page 16, Table 3, Footnote 21, Item (1)--**change from:**

"For assistance with (1) isotope, radiochemical, and other specialized equipment, contact the NAWQA Quality Assurance Specialist;"

to:

"For assistance with (1) deuterium-oxygen isotopes, and quality-assured sample bottles and caps for these isotopes, contact Tyler Coplen, Isotope Fractionation, USGS National Research Program, MS 431, Reston, Va. (via isotopes@usgs.gov); for assistance with tritium isotopes, and quality-assured sample bottles and caps for these isotopes, contact Robert Michel, Isotope Tracers, MS 434, USGS National Research Program, Menlo Park, Calif. (via tritium@mailrcamnl.wr.usgs.gov);"

Page 66, Table 21, 3. Other Samples--Columns for Tritium isotopes and Deuterium-Oxygen isotopes **change from:**

Team Member A

Sample type (SC, LC) and order of collection	Collect, by filling	Quality-assurance checks or measures
• Tritium isotopes	1, 1.0-L, clear, prerinsed poly bottle, filled to top after 3, 25-mL rinses (include cap with conical insert)	Verify DIW is still in bottle from office prerinse before use, otherwise replace bottle. Leave no headspace in bottle
• Deuterium-Oxygen isotopes	1, 125-ml, glass, amber bottle to top after 3, 25-ml rinses (include cap with conical insert)	Leave no headspace in bottle

to:

Team Member A

Sample type (SC, LC) and order of collection	Collect, by filling	Quality-assurance checks or measures
• Tritium isotopes	1, 1.0-L, dry, high-density-poly (preferred) or glass bottle, without prerinsing, until it overflows, and seal with a cap with conical insert	To reduce breakage of glass bottles caused by samples freezing during shipment, pour out sample until the water level is at the bottle shoulder seam.
• Deuterium-Oxygen isotopes	1, 60-mL, dry, clear, glass (preferred) or poly bottle, without prerinsing, until it overflows, and seal with a cap with conical insert	To reduce breakage of glass bottles caused by samples freezing during shipment, pour out sample until the water level is at the bottle shoulder seam. Samples collected in poly bottles are sent immediately for analysis, and are unsuitable for archiving.

.