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Book 9
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National Field Manual for the Collection of Water-Quality Data

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Chapter A9. SAFETY IN FIELD ACTIVITIES

By
Susan L. Lane and Ronald G. Fay

USGS
science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
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January 1998

Subject: Publication of Chapter A9 of the *National Field Manual for the Collection of Water-Quality Data*: *Safety in Field Activities*

Dear Environmental Resources Colleague:

Previously, you (or a colleague in your position) received Chapter A7 of the *National Field Manual for the Collection of Water Quality Data* entitled *Biological Indicators*, and a binder into which Chapter A7 and future chapters of the manual can be inserted. Your name is on our list to receive a copy--or the number of copies requested--of each chapter as it is released. With this letter, please find the following recently published chapter:

> Chapter A9. *National Field Manual For the Collection of Water-Quality Data: Safety in Field Activities,* by Susan L. Lane and Ronald G. Fay

The *National Field Manual for the Collection of Water-Quality Data* articulates policy, protocols, and recommended procedures for collection of water-quality data by U.S. Geological Survey (USGS) personnel. USGS water-quality specialists are asked to distribute the copies they receive to the appropriate personnel within their purview. The protocols and procedures described in the manual are intended to complement formal training courses, such as "Field Water-Quality Methods for Ground Water and Surface Water" given at the USGS National Training Center.

Please direct any questions, comments, or requests regarding these or other chapters of this manual to the Office of Water Quality:

U.S. Geological Survey
412 National Center
12201 Sunrise Valley Drive
Reston, VA 20192

E-mail: nfm-owq@usgs.gov

CHAPTER A9

of the
National Field Manual for the
Collection of Water-Quality Data

This package contains:

Chapter A9, Safety in Field Activities, which is to be added to the binder you received with Chapter A7 of the *National Field Manual for the Collection of Water-Quality Data*.

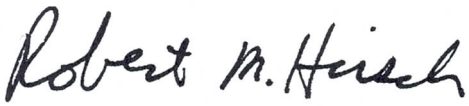
Chapter 9, Section A, of the *National Field Manual for the Collection of Water-Quality Data*, Book 9, Handbooks for Water-Resources Investigations.

December 1997

Foreword

The mission of the Water Resources Division of the U.S. Geological Survey (USGS) is to provide the information and understanding needed for wise management of the Nation's water resources. Inherent in this mission is the responsibility to collect data that accurately describe the physical, chemical, and biological attributes of water systems. These data are used for environmental and resource assessments by the USGS, other government and scientific agencies, and the general public. Reliable and objective data are essential to the credibility and impartiality of the water-resources appraisals carried out by the USGS.

The development and use of a *National Field Manual* is necessary to achieve consistency in the scientific methods and procedures used, to document those methods and procedures, and to maintain technical expertise. USGS field personnel use this manual to ensure that data collected are of the quality required to fulfill our mission.



Robert M. Hirsch
Chief Hydrologist

Techniques of Water-Resources Investigations

Book 9
Handbooks for Water-Resources Investigations

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- 6.6 Alkalinity and Acid Neutralizing Capacity
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- 7.1 Fecal Indicator Bacteria
- 7.2 Five-Day Biochemical Oxygen Demand

A8. Bottom-Material Samples

A9. Safety in Field Activities

[1]Bold type indicates published chapters, and shaded type indicates chapters that are in preparation.

SAFETY IN FIELD ACTIVITIES A9.

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Chapter A9. SAFETY IN FIELD ACTIVITIES

By Susan L. Lane and Ronald G. Fay

ABSTRACT

The *National Field Manual for the Collection of Water-Quality Data* (*National Field Manual*) describes protocols (requirements and recommendations) and provides guidelines for U.S. Geological Survey (USGS) personnel who collect data used to assess the quality of the Nation's surface-water and ground-water resources. This chapter of the manual addresses topics related to personal safety to be used in the collection of water-quality data, including: policies and general regulations on field safety; transportation of people and equipment; implementation of surface-water and ground-water activities; procedures for handling chemicals; and information on potentially hazardous environmental conditions, animals, and plants.

Each chapter of the *National Field Manual* is published separately and revised periodically. Newly published and revised chapters will be announced on the USGS Home Page on the World Wide Web under "New Publications of the U.S. Geological Survey." The URL for this page is <http://pubs.usgs.gov/publications/index.html>.

INTRODUCTION

As part of its mission, the U.S. Geological Survey (USGS) collects data needed to assess the quality of our Nation's water resources. The *National Field Manual for the Collection of Water-Quality Data* (*National Field Manual*) describes protocols (requirements and recommendations) and provides guidelines for USGS personnel who collect data used to assess the quality of the Nation's surface-water and ground-water resources.

The *National Field Manual* is Section A of Book 9 of the USGS publication series Techniques of Water-Resources Investigations (TWRI). A complete list of TWRI publications is included at the end of this report. The *National Field Manual* is comprised of individually published chapters. Chapter numbers are preceded by an "A" to indicate that the report is part of the *National Field Manual*.

Chapter A9 has been designed to assist field personnel in the safe execution of water-quality data collection. This report provides general guidance and information on common safety issues, promotes awareness of preventive measures, identifies hazards that might threaten safety, and stresses a panic-free and common-sense approach when confronted with field hazards. The USGS also provides training, equipment, and medical programs that address a variety of safety situations. The references cited in this report and safety officers in local, district, or regional offices of the USGS can provide additional detailed information.

PURPOSE AND SCOPE

Chapter A9 provides USGS personnel with information about hazards they may encounter during field work, and describes procedures that, when implemented properly, will help ensure the safety and health of field personnel. The report is designed to be taken to the field as an immediately available reference.

Chapter A9 addresses only the most common safety issues in water-quality sampling. Safety guidelines of a general nature are included regarding basic policies, protocols, and regulations adhered to by the USGS, including use of vehicles, surface-water and ground-water field activities related to the collection of water-quality data, handling of chemical substances, and appropriate response when confronted by environmental (weather, animals, plants) hazards. Each USGS office is unique and has special safety requirements. An exhaustive discussion of detailed safety issues is beyond the scope of this chapter. Chapter A9 is meant to be used in conjunction with more comprehensive manuals cited in the references that provide details on rules, regulations, remedies, and recommendations that apply to the myriad of specific locales, climates, field conditions, and circumstances.

FIELD MANUAL REVIEW AND REVISION

Chapters of the *National Field Manual* will be reviewed, revised, and reissued periodically to correct any errors, incorporate technical advances, and address additional topics. Please send comments or corrections to: NFM-QW, USGS, National Center 412, Reston, VA 20192 (or send electronic mail to: nfm-owq@usgs.gov). Newly published and revised chapters will be announced on the USGS Home Page on the World Wide Web under "New Publications of the U.S. Geological Survey." The URL for this page is <http://pubs.usgs.gov/publications/index.html>.

ACKNOWLEDGMENTS

The information included in the *National Field Manual* is based on existing manuals, a variety of reference documents, and a broad spectrum of colleague expertise. In addition to the references provided, important source materials include USGS handbooks, manuals, and technical memorandums. Special thanks is extended to Maynard Cox for suggestions for improving the sections on animals and plants and for generously allowing the use of his material.

The authors wish to acknowledge the following individuals in the USGS who provided valuable contributions as technical reviewers that improved the accuracy and quality of this document: F.L. Andrews, C.E. Arozarena, D.J. Cowing, R.D. Gist, G.J. Hwang, T.A. Muir, and K.R. Thompson. F.D. Wilde was the managing editor, with editorial and publication assistance from I.M. Collies, L.S. Rogers, C.T. Mendelsohn, and A.M. Weaver.

SAFETY IN FIELD ACTIVITIES A9.

"Safety first" is the motto for all USGS personnel involved in field activities. This chapter of the *National Field Manual* is required reading for USGS personnel who will be involved in the collection of water-quality data. Using the information in this chapter, field teams are responsible for establishing and implementing safety procedures appropriate for their field activities.

Safety: the condition of averting or not causing injury, danger, or loss.

To ensure safety, field work requires an awareness of potential hazards and a knowledge of regulations and recommended procedures. The collection of water-quality data in the field brings field personnel in touch with numerous hazards. Personnel routinely work in extreme environmental conditions and in remote locations. Many assignments require working with, or around, heavy machinery. Water-quality studies involve the transportation and use of equipment and chemicals. Personnel routinely come in direct and indirect contact with waterborne and airborne chemicals and pathogens, and with potentially dangerous animals and plants.

- You are the first line of defense for on-the-spot evaluations of situations that may compromise your safety. Be aware of your environment, use common sense, do not exceed your limits (for example, operation of equipment; lifting heavy objects and equipment; physical tolerance to exertion, heat, and cold), and trust your instincts. Listen to that "little voice" inside you if you feel uneasy about your situation.
- Remain calm if you find yourself in danger.
- Use the information in this manual to help you take appropriate actions.

The only worthwhile safety protocol is an implemented one.

SAFETY POLICIES, REGULATIONS, AND REQUIREMENTS 9.1

The information presented has been summarized from more detailed reports (referenced below) and from field experience, in order to make essential safety guidelines readily accessible to the field team at the time of sampling. USGS employees are encouraged to become familiar with the policies, regulations, and requirements provided in documents published by the U.S. Department of the Interior, the USGS, and other Federal agencies.

USGS AND FEDERAL POLICIES 9.1.1

The USGS, as a bureau of the U.S. Department of the Interior (DOI), structures its safety program using DOI safety guidelines. These guidelines are described in the Departmental Manual handbook titled *Safety and Health Handbook* (*485 DM*) (U.S. Department of the Interior, 1991), which is updated periodically to reflect current DOI policies. USGS safety policies and regulations are found in USGS Handbook 445-1-H, the *Safety and Environmental Health Handbook* (U.S. Geological Survey, 1989), and in USGS Handbook 445-2-H, the *USGS Occupational Hazards and Safety Procedures Handbook* (U.S. Geological Survey, December 1993). Additional safety requirements are described in *A Guide to Safe Field Operations* (U.S. Geological Survey, 1995), and in Water Resources Division (WRD) numbered memorandums (see "Selected References and Internal Documents"). A safety officer is designated in each District and Region of the USGS, Water Resources Division, to provide additional information and guidance.

Consult the DOI and USGS publications cited above for detailed information on safety issues, including the following topics:

- Chemical hygiene plan.
- Hazard communication, handling of waste materials, and hazardous waste sites.
- Exposure to ionizing radiation.
- Blasting and firearms.
- Hearing conservation.
- Reporting accidents and unsafe conditions.

You are required to know and follow safety policies and requirements.

Numerous safety and environmental laws are regulated and enforced by Federal, State, and local governments. Recent congressional acts, such as the Federal Facility Compliance Act of 1991, require Federal agencies to comply with Federal, State, and local regulations. Many USGS and DOI policies reflect compliance with U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), U.S. Environmental Protection Agency (EPA), and U.S. Department of Transportation (DOT) regulations. State and local governments and USGS and DOI safety programs can supplement but cannot supersede Federal OSHA, EPA, or DOT regulations.

- OSHA policies are found in the *U.S. Code of Federal Regulations* (CFR) title 29—Labor, parts 1900-1910 (U.S. Department of Labor, 1995). This volume defines general industry safety requirements. For example, 29 CFR 1910.132 describes Federal requirements for personal protective equipment.
- EPA policies are described in the *U.S. Code of Federal Regulations* (CFR) title 40 (U.S. Environmental Protection Agency, 1995). For example, 40 CFR 260-272, under direction of the Resource Conservation and Recovery Act (RCRA) of 1976, regulates toxic substances control and hazardous waste disposal (including small-quantity exemptions). Many USGS memos concerning handling and disposal of chemicals reference 40 CFR.
- DOT policies are found in the *U.S. Code of Federal Regulations* (CFR) title 49 (U.S. Department of Transportation, 1995). DOT regulates transportation of hazardous materials by authority of the Hazardous Materials Transportation Act (HMTA) of 1974. For example, 49 CFR, parts 171-177, give transportation guidelines which include material description and classification, packaging and package labeling, and quantity limitations.

JOB HAZARD ANALYSIS 9.1.2

Many accidents and injuries can be prevented by analyzing and communicating hazards. A job hazard analysis (JHA) identifies hazards and describes actions to avoid mishaps. For example, JHA's are used to determine and document the proper personal protective equipment required for the job. JHA program requirements are given in DOI Departmental Manual 485, chap. 14, and in USGS Handbook 445-2-H, chap. 2.

JHA components include:

- The sequence of steps associated with an activity.
- Identification of hazards involved for each step.
- Determination of controls needed to eliminate or reduce the hazard.

Visit the field site, if possible, to be sure that you and your equipment can get to, sample at, and leave the site safely. Talk to employees who may have visited the site—you might receive your most valuable safety information from them. **Always check the study workplan, field folder and site records, and other available information before departure.**

PERSONAL PROTECTIVE EQUIPMENT 9.1.3

Personal protective equipment (PPE) is defined as safety equipment for your skin, eyes, ears, face, head, extremities, and respiration (see USGS Handbook 445-1-H, chap. 9 and OSHA 29 CFR 1910, Subpart I). **The USGS is required to supply PPE, and you are required to use it!**

Proper PPE selection is based on the hazards likely to be encountered, as well as compliance with regulatory safety requirements. Examples of PPE are cited throughout this chapter (see sections 9.4, 9.6, and 9.11.1).

> TECHNICAL NOTE: Respirators might be required to ensure protection from some chemical and biological hazards. **You must be medically approved, trained, and tested for fit before using a respirator.** If one is needed, follow USGS policy given in USGS Handbook 445-2-H, chap. 5. Do not share a respirator.

9.1.4 TRAINING

Field personnel must be aware of safety training requirements and certification or recertification needed to perform specific tasks. For example,

- Personnel who operate government-owned or leased vehicles must be certified and periodically recertified in defensive driving.
- Cardiopulmonary resuscitation (CPR) and other first-aid certification and recertification are mandatory for field personnel.

Safety training and certification requirements, recommendations, and opportunities are subject to change—check with your safety officer periodically to keep current with prevailing requirements.

Complete safety training and certification requirements before beginning field work.

FIELD TRIP PREPARATIONS AND EMERGENCY CONTACTS 9.2

Before leaving for the field, obtain the information shown on figures 9-1 and 9-2, and carry this with you in the field—either at the front of Chapter A9 or in the field folder. Put Chapter A9, or the sections of it that are applicable to your work, in a binder and keep it with you. **Become familiar with the information provided here before you are in the field and confronted with an emergency.**

Certain types of data-collection activities require a field team of two or more people (Horowitz and others, 1994). While the multi-person field team also might be important to carrying out technical procedures, the field team or buddy system can be a life-saving practice. Mobile telephones provide a minimum precaution if personnel will be unaccompanied. Satellite communication services might be available for remote areas where cellular service is not available.

Don't forget to leave names of emergency contacts and their phone numbers at work and (or) with family or colleagues.

Basic preparations that should become routine before every sampling activity:

- Use safety checklists when preparing for a field trip. Examples of checklists are in section 9.11. Develop your checklists from existing site safety information and site reconnaissance (job hazard analysis or site safety plan).
- Keep a field folder for each surface-water and ground-water site at which water-quality data will be collected. The safety-related contents of a field folder include:
  - Copies of the checklists mentioned above.
  - Site type (hazardous waste, confined space, cableway, wading site, bridge site, boat site) and site description.
  - Site location (include map, site sketch, and description).
  - Locations and phone numbers of emergency facilities, such as a hospital or first aid station, police and fire departments, utility companies.
  - Additional information specific to the site: for example, if it is open to hunting, and season dates; appropriate clothing (such as orange safety vests).
- Make an itinerary for every field trip and leave a copy at the office and with family or colleagues. Schedule times to check in at work and with family or colleagues when field trips require overnight stays. Follow the established schedule. Notify all concerned parties if your schedule changes.
- Obtain or reserve communication equipment, such as a cellular phone or two-way radio.

Emergency Contacts

Personal contacts

Name: _____ Phone: (home) _____ (work) _____

Name: _____ Phone: (home) _____ (work) _____

U.S. Geological Survey contacts

District Office _____

Safety Officer _____

National Water Quality Laboratory, Arvada, CO.

Emergency coordinator (303) 467-8000 _____

Local emergency contacts (or call 911)

Hospital _____ Phone: _____

Address: _____

Other medical facility (24-hour care) _____ Phone: _____

Address: _____

Police _____

Fire _____

Utility _____

Health Information Centers

Center for Disease Control

Information Hotline: (404) 329-3311 _____

Fax: Disease Directory: (404)-332-4565 _____

Other

_____

_____

Figure 9-1. Example of emergency contact form to be completed and taken on field trips.

Medical Information for Office Personnel

Employee name: _____ Home phone: _____

Treatment preference: medical _____ other (specify) _____

Doctor: _____ Phone: _____

Other emergency contact: _____ Phone: _____

Allergies and other medical conditions	Medications being taken	Medications to avoid

Relevant medical history:

Allergies and other medical conditions:

Special instructions:

Figure 9-2. Example of medical information form to be completed and taken on field trips.

TRANSPORTATION 9.3

Various modes of transportation are used to reach field sites. Each type of transportation comes with specific guidelines for safe operation, for which appropriate training must be completed before leaving for the field. Training requirements are described in the USGS Handbook 445-2-H and are provided by office or regional safety officials. Perform a safety inspection on all transportation equipment before using. Safety inspection checklists are found in USGS Handbook 445-1-H, chap. 12.

ROAD VEHICLES AND TRAILERS 9.3.1

Passenger cars, vans, and 4-wheel-drive vehicles can differ in operation and in safety features, depending on the vehicle's age, make, and model. Become familiar with all operating systems of the vehicle before you leave for the field—test operation of lights, locks, seat belts, windows, 4-wheel drive and winch, and hood release.

"Musts" that apply to all USGS employees driving government vehicles:

- Have a valid U.S. State driver's license.
- Take a course in driver safety—the current requirement is to take the course every 3 years.
- Inspect all vehicles before use.
- Tie down or otherwise secure all cargo.
- Wear a seat belt.
- Obey all traffic regulations and operate your vehicle safely.

Inspect each vehicle thoroughly before departing from the office (USGS Handbook 445-I-H, chap. 12): discovering that the 4-wheel drive is not working when you are in the backwoods can result in considerable inconvenience and place you in a dangerous situation.

- Check that your vehicle is equipped with the proper safety equipment (see 9.11.2).
- Create checklists specific to each vehicle and (or) each type of sampling trip to make the inspection process routine.
  - Towing a trailer or equipment with your vehicle requires additional planning, caution, and proficiency in driving.
  - Vehicles and trailers vary in maximum load capacity.
  - Vehicles and trailers must be compatible and have a matching hitch ball and coupling.
  - Trailers are required to have standard safety equipment such as safety chains (placed in an "x" under the coupling), lights, brakes (if applicable), and load-securing devices.
  - Be aware that air turbulence from passing vehicles can cause your trailer to sway.
  - Before towing, consult USGS Handbook 445-1-H, chap. 14, p. 14-5, for additional guidance.
- Drive slower.
- Disengage the vehicle's automatic "overdrive gear" option when towing.
- Maintain extra following and stopping distance to allow for the increased load. Loads must be balanced.
- **Do not exceed the maximum recommended load capacity.** (Check owner's manuals or contact vehicle or trailer manufacturers for this information).

Never permit anyone to ride in or on trailers.

Obtain the training that will help you handle potentially dangerous driving conditions; for example, wet, icy, or snow-filled roads; high wind velocity; glare from bright sunshine; poor visibility from dust storms, fog, or heavy precipitation. In very hot climates, keep the windows slightly open when the vehicle is parked to avoid shattering windows from the heat. **To avoid asphyxiation from carbon monoxide, never sit or work in a closed vehicle with the engine running for more than a few minutes.**

WATERCRAFT 9.3.2

Boats are used extensively by USGS personnel for sampling the quality of water in rivers and lakes. All boats must carry equipment as required by the U.S. Coast Guard. Checklists are useful for ensuring that all the proper equipment is in place (see 9.11.3). WRD Memorandum No. 96.25 and the DOI Departmental Manual 485 provide regulations for watercraft safety.

Head back to harbor in the event of a storm. You are required to follow U.S. Coast Guard regulations for waterway safety and etiquette. Carry extra lines, foul-weather gear, and backup equipment. Remember, all cargo must be secured. For additional information see USGS Handbook 445-1-H, chap. 17, and USGS Handbook 445-2-H, chap. 16.

AIRCRAFT 9.3.3

Airplanes and helicopters are sometimes used for sampling trips to remote areas. Pilots and passengers must follow stringent guidelines when using these means of transportation. Any sampling activity involving the use of aircraft must be carefully planned and coordinated with USGS safety officials, the DOI Office of Aircraft Services, and appropriate local and regional safety officials, as described in USGS Handbook 445-1-H, chap. 16, and USGS Handbook 445-2-H, chap. 13. WRD Memorandum No. 95.49 provides an example of a safety plan for aircraft use.

OTHER METHODS OF TRANSPORTATION 9.3.4

Additional methods of transportation include snowmobiles, all-terrain vehicles, horses or mules, and backpacking. Evaluate and practice these methods before use, taking care to consider the measures necessary for a safe trip and making sure to obtain proper training. USGS Handbook 445-1-H, chap. 14, and USGS Handbook 445-2-H, chap. 14, provide more detailed information.

9.4 SURFACE-WATER ACTIVITIES

Collection of water-quality samples can be as simple as hand dipping water from a slow moving stream to as complex as using heavy power equipment while working from a cableway. Know the safety steps needed for any sampling method used.

9.4.1 WADING

Examine the section of a stream or river you plan to wade. Check the field folder for information relating to safety, including maximum depths in relation to stage, wading-section anomalies such as slippery conditions and drop-offs or holes (a wading rod can be used to help assess streambed conditions), and velocity curves for determining wadable stages. **Do not attempt to wade a stream for which values of depth multiplied by velocity equal or exceed 10 ft^2/s.** For example, a stream only 2 ft deep but with velocities of 5 ft/s or more can be dangerous to wade.

While wading to collect a water sample:

- Wear a personal flotation device (PFD) during wading activities.
  - Approved PFDs for wading include the standard jacket type and the suspender type. The PFD must fit properly, be rated for your weight, and be in good condition.
  - The PFD should be dried and kept indoors between trips.
- Wear hip boots or chest waders. Boots and waders provide protection from cold and pollutants, as well as from underwater objects. Be aware of the possibility of slipping and going underwater (feet up, head down) while wearing them. Practice wearing hip boots and waders in a controlled, group-training situation before using for field work. The following recommendations are the result of experiments with boots (Joseph, 1957) and field experience.
  - Hip boots with a strap at the top are better than boots that are open. The strap should be pulled closed. This allows air to be trapped in the boot in case you are submerged. The air cushion can be used as a partial mechanism for flotation until you reach shore or are rescued.

  - Avoid hip boots with tight ankles. These are difficult to remove in an emergency situation.
  - Avoid chest waders that are tight fitting at the top. Like tight-ankled hip boots, they are difficult to remove in an emergency situation. Whenever chest waders are worn, a PFD also must be worn.

- Be aware of surrounding conditions.
  - Watch for debris floating downstream, such as logs, aquatic vegetation, or "rafts" of animals seeking higher ground.
  - Watch for sand channels that can shift under foot and become quicksand.
  - Watch the stream stage, especially when it could rise rapidly.
  - When wading below a dam or control structure, contact the gate operator before entering the stream.

Rule of Thumb: Don't wade a stream if (Stream Depth) × (Velocity) ≥ 10 ft²/s.

WORKING ON BRIDGES 9.4.2

A bridge safety plan is required by WRD Memorandum No. 95.17. For every bridge site, develop and diagram a detailed procedure that conforms to State and Federal regulations. Keep this procedure and diagram in the field folder. The bridge procedure includes plans for safety cones and signs, lane blockage, and traffic control.

Equipment used for sampling from a bridge can be heavy and unwieldy. Practice assembling and using the equipment before starting field activities, and make sure the equipment is operational before leaving the office. When using a bridge crane, keep a pair of heavy-duty wire cutters readily available for cutting the cable in case debris snags the sounding line.

Be aware of boat traffic. The bridge crane cable should have strips of bright plastic flagging attached in intervals to make it easily visible to all boat traffic.

- **A PFD must be worn when working on bridges.** The suspender type PFD is approved for bridge work.
- Workers involved in peripheral activities should wear high-visibility vests with reflective tape.

9.4.3 WORKING FROM BOATS

Safety regulations for the various types of boats used by the USGS when obtaining water-quality samples are comprised of U.S. Coast Guard (USCG) and OSHA rules, and are supplemented by USGS requirements.

Before working from a boat, obtain the appropriate training for the vessel being used, as specified in WRD Memorandum No. 96.25. This training should cover all the specifics regarding boat operation as per USCG regulations. Before taking a boat on the water, ensure that the vessel is in operating condition. Boats are to be inspected annually. If a vehicle is being used to trailer the boat to the site, the vehicle and trailer are to be included in the preliminary inspection. Equip the boat with all USCG-required equipment (see the checklist in 9.11.3) as well as items that the study team deems appropriate for emergencies or equipment failures. Some Districts[1] keep a duffel bag on each boat stocked with standard emergency supplies such as flashlights, air horns, and whistles.

A float plan for each field trip must be left with the supervisor or other designee. The plan should include, at a minimum:

- Date and purpose of trip.
- Name(s) of operator(s) and name(s) of passengers.
- Destination and route to be taken.
- Time of departure and estimated time of return.
- Radio frequency or cellular designation, if applicable.
- Type of watercraft, and its length, color, identification number, and other unique features.

Check weather conditions before departure. In coastal areas, pay particular attention to tidal cycles.

[1]The term "District" as used in this report refers to an organizational unit of the USGS located in any of the States or Territories of the United States.

Each person on the boat must wear an orange USCG-approved PFD, which should have at least 200 cm² of retroreflective material on the front, back, and reversible sides. Inspect all PFDs for damage before and after each use. Store PFDs properly and discard damaged PFDs.

- Do not wear hip boots or waders in a boat. Wearing boots or waders could be a safety hazard if the boat should tip or you are thrown out.
- **Don't panic if you fall out of a boat!** Think through and execute the basic safety procedures that you have been taught.

Attach bright colored plastic flagging in intervals to the tag line used to designate the transect along which samples will be collected, so as to make it easily visible to boat traffic. In areas of frequent boat traffic, station a member of the field team on shore who can drop the tag line rapidly, should it present a hazard to boats.

All boat passengers should be practiced in emergency procedures and the location of emergency equipment. Boat operators are required to have current training in first aid and CPR. They must also know how to use the type(s) of fire extinguisher(s) on the watercraft.

Head back to shore if a storm is approaching.

WORKING FROM CABLEWAYS 9.4.4

Water-quality sampling from a cableway requires extensive measures that are described in *Streamgaging Cableways* (Wagner, 1991) and in WRD Memorandum No. 91.42. These guidelines must be followed. Become familiar with cableway procedures and requirements and obtain the necessary training before attempting to work from a cableway. Check the field folder for special considerations pertaining to each cableway. Cableways must be inspected by trained professionals at prescribed intervals. At the site, always:

- Visually inspect each cableway before use.
- Wear a PFD, hard hat, and work gloves.
- Take an extra cable-car puller and heavy-duty cutting pliers to the site.

9.4.5 SCUBA DIVING

Scuba diving to collect samples is permitted only after every requirement of OSHA 29 CFR 1910.401-441, Subpart T, has been met. Diving activities are regulated by the USGS Diving Control Board and the Diving Safety Officer.

Extensive training is required to be certified in scuba diving and sufficient skill must be demonstrated before diving is permitted for any USGS activity. If diving is necessary for sample collection, personnel involved must coordinate the endeavor with the USGS Diving Officer through district and regional safety officials. Guidance is provided in Departmental Manual 485, chap. 28, and in the USGS Diving Safety Manual (U.S. Geological Survey, July 1994).

9.4.6 ELECTROFISHING

Electrofishing involves applying an electrical charge in water to stun and capture fish. The requirements for this procedure, as stated in WRD Memorandum No. 93.19, include:

- Field teams must consist of at least two people, one of which will have been trained and certified in a USGS-approved course in the safety and technical procedures of electrofishing.
- At least two individuals in each team must be trained and currently certified in CPR.
- Each member of the field team must use proper personal protective equipment.

Field team members must obtain all necessary immunizations before electrofishing (WRD Memorandum No. 96.29).

GROUND-WATER ACTIVITIES 9.5

Each well site is unique. Site hazards may not be known before, or be evident during the site visit. Check the field folder for site information relating to safety to prepare for the field trip.

WELL SITES 9.5.1

Wells can be located in open, unprotected areas as well as in enclosures such as shelters, well houses, or vaults. These sites and enclosures can contain dangerous chemicals and fumes, animals and plants, and large machinery with high-capacity power systems.

Before departing for the field site, obtain permission, oral or written, from the well owner or an authorized representative to enter the site. Entering a privately owned site without permission is considered trespassing. Inventory the safety equipment you will need for your sampling trip using the standard checklists as described in section 9.11, adding items specific to your program or study.

When arriving at the site, use your senses. Do you see warning signs posted or animals grazing? Hear gunshots? See exposed electrical connectors and wires? Smell fumes? Decide how to handle such circumstances to ensure the safety of the field team.

- Well houses or shelters constructed over wells often are havens for bees, wasps, spiders, snakes, and rodents. Snakes have been found inside shelters and in well casings.
  - Check your surroundings carefully for signs of animals before starting work.
  - If you smell, hear, or see signs of animal infestation, proceed only after taking necessary precautions (see 9.9.6). Before entering, the enclosure should be ventilated, disinfected, and cleaned.

- Check the well house or shelter carefully for chemical fumes and for faulty power systems.
  - Poorly ventilated shelters are especially hazardous and can be classified as "confined spaces," which are defined and regulated by OSHA and USGS policies. Confined spaces are discussed in detail in USGS Handbook 445-2-H, chap. 11, and in OSHA 29 CFR 1910.146.
  - Use testing devices such as a portable photoionization detector ("sniffer") if the site has potential for chemical or radioactive contamination.
- Never turn on or remove a well-owner's pump without permission. The system may be turned off for a safety reason. Not only could you cause yourself great harm, you could injure someone who might be near or working on the system.

Before leaving the well site, minimize any hazard to yourself, others, and the environment from field activities:

- Clean and decontaminate yourself and all sampling and processing equipment.
- Channel or contain purge and waste water to avoid transforming the site into a slippery swamp.
- Contain all trash and chemical wastes.
- Follow Federal, State, and local safety regulations for handling and disposal of contaminated waste materials.

Before putting your hands or feet into a confined space, visually inspect the area.

MACHINERY, PUMPS, AND OTHER EQUIPMENT 9.5.2

Ground-water samples usually are collected from a well using suspension and (or) pumping equipment. Water and formation samples also could be collected during site reconnaissance or well installation, which requires working around heavy machinery and, often, large industrial systems. Heavy machinery, equipment, and power supplies are potentially dangerous, whether permanently installed or transported to the sampling site.

- USGS and OSHA have general safety requirements for working around heavy machinery and power supplies. USGS Handbooks 445-1-H and 445-2-H cover electrical safety, lockout/tagout procedures, and personal protective equipment (see section 9.1.3). OSHA 29 CFR 1910 covers, in great detail, industry requirements for working with machinery.
- Since equipment and power systems vary greatly, knowledge of their operation is paramount to a safe and successful sampling trip. Use the correct equipment for the job. Keep instruction manuals readily available.

When working with permanently installed pumps or sample-collection systems:

- Watch for unguarded moving parts, exposed and ungrounded wiring, hazardous fuels, and faulty or inadequate repairs.
- Use caution when lowering a well tape down a well to measure water level. Lines can get caught around rotating parts of pumps and be wrenched from your hands. Wells with electrically powered submersible pumps can be energized by a short in the electrical circuit, and in turn can conduct the power surge to you through the steel tape.

When using portable pumps or sample-collection systems:

- Make sure power systems are compatible with the equipment and are used correctly. Portable pumps or systems usually require portable power. Most power is supplied by a gasoline, diesel, or natural gas engine to run a generator or compressor.
  - Store fuel in appropriate containers and refill engines carefully.
  - Make sure electrical generators are properly grounded—refer to the system's instruction manual for proper grounding procedures.
- Do not attempt a multi-person task alone. Portable pump systems can be heavy and awkward to use. Remember that the suspended weight of the pump increases as it is lowered down the well.
- Avoid lodging a pump in a well. Construct a "dummy probe" which is slightly larger than the pump. Make sure it can safely reach the desired depth and be retrieved before lowering the pump into the well.

When working around well-drilling operations, you are subject to all the hazards and safety requirements associated with working around a drill rig:

- Wear personal protective equipment such as steel-toed boots, hardhat, hearing protection, and a respirator if necessary (see 9.11.1).
- Communicate with the drilling crew and heed their instructions on safety.
- Be aware that heat generated from friction between drill rods or auger flights and earth materials can cause the escape of volatile organic compounds, posing a possible health hazard if inhaled.

CHEMICALS 9.6

USGS employees are routinely exposed to chemicals during the water-quality sampling process. Chemicals—as solids, liquids, or gases—range from dilute salt solutions to strong acids, bases, dyes, and organic compounds. Field measurements and the processing of sample water can cause chemical reactions that generate dangerous fumes and by-products.

Be cognizant of the regulations that govern the use, transportation, and disposal of chemicals and wastes. Because regulations vary greatly from state to state, contact your safety officer or state agency for the proper procedures in your locality.

USE AND HANDLING 9.6.1

For safe use of chemicals, follow the guidelines given below, communicate hazards to all members of the field team, use proper personal protective equipment, and apply common sense when working with dangerous substances.

- **Obtain information about the chemical or compound.**
  - Material Safety Data Sheets (MSDS) supply material characteristics such as chemical description, fire and explosion data, chemical compatibility and reactivity, protection precautions, and spill procedures. These documents are required by OSHA 29 CFR 1910.1200 (hazard communication) and usually are shipped with chemicals when purchased. Your safety officer or chemical supplier also can provide the MSDS needed.
  - Chemical safety information is available from many Federal and private sources. For example, the Permissible Exposure Limit (PEL) of a given chemical is listed by OSHA 29 CFR 1910.1000, subpart Z, and in the *Pocket Guide to Chemical Hazards* published by the National Institute for Occupational Safety and Health (June 1994).
  - DOI and USGS internal memorandums describe chemical usage and handling policies of our most commonly used chemicals. For example, refer to:

    DOI Departmental Manual 485, chap. 29, for general guidelines on chemical safety in laboratories.

    USGS Handbook 445-2-H, chap. 7, for Hazard Communication Program goals.

WRD Memorandums No. 93.44, 94.06, and 94.07 for storage, transportation, handling, and disposal of formaldehyde, hydrochloric acid, and methyl alcohol, respectively.

Office of Water Quality Technical Memorandums 94.02 and 94.16 for information on discontinuing field use of mercury-filled thermometers and mercury-based sample preservative, respectively.

Do not use mercury thermometers in the field.

- **Use Personal Protective Equipment (PPE) (see sections 9.1.3 and 9.11.1).**
  - Wear protective clothing, including gloves, glasses, lab coat, and if necessary, use a respirator. **Remember that you must be certified before using a respirator** (see USGS Handbook 445-2-H, chap. 5).
  - Select PPE appropriate to the chemical(s) to be contacted. PPE can be designed for specific chemicals. For example:

    Respirator cartridges are ineffective if they fail to filter the chemical hazard encountered.

    Wear gloves that will provide adequate protection. Gloves become ineffective if they are dissolved by the chemical you are using. Vinyl gloves are used for handling inorganic acids and bases. Latex gloves are used for handling relatively mild organic solvents, such as methanol and acetone; nitrile gloves can be used for some stronger organic solvents.

- **Use the following standard procedures.**
  - Avoid unnecessary exposures and spills. Never place chemical containers where they can be knocked over. For example:

    Clean up chemical residues or spills immediately and appropriately.

    Keep chemical spill kits near the work area.

- Work with adequate ventilation or under a hood when working with hazardous or reactive chemicals and gases.
- Keep eye wash kits readily accessible while working with chemicals.
- Handle and mix chemicals and compounds appropriately (check the MSDS). For example:

  When transferring flammable liquids, all metal containers must be grounded to eliminate igniting the liquid with an electrical spark.

  When preparing a hydrochloric or nitric acid cleaning solution, the sequence is to put water in the vessel first and then add the acid.

Remember the rhyme: "Add acid to water, like you ought-ter!"

- Open chemical containers slowly and carefully, wearing proper PPE. Allow hot containers to cool before opening. Open frozen or encrusted lids with caution. For example:

  To open fused-glass ampules, break the ampule at the base of neck, in a direction away from you and others. Use an ampule breaker if it is safer for you, and wear gloves.

  Check containers and ampules for contents lodged near the container top or neck. Dislodge trapped material by gently tapping the container at the top.
- Properly dispose of all parts of the spent ampule (Office of Water Quality Technical Memorandum 92.11). Temporarily store used ampules in an appropriate container. Do not let these wastes accumulate in your vehicle or work area—they produce corrosive and potentially explosive fumes.

9.6.2 TRANSPORT

The USGS must follow applicable Federal, DOT, EPA, and supplemental State guidelines when transporting chemicals and chemical wastes. References include the *Emergency Response Guidebook* (U.S. Department of Transportation, 1990) and the *Driver's Pocket Guide to Hazardous Materials* (J.J. Keller & Associates, 1993). USGS chemical transportation guidelines are summarized below.

- The USGS transports small quantities of chemicals for use in field and office-laboratory procedures. The USGS is not considered a commercial carrier which, by definition, transports materials in commerce or in the furtherance of a commercial enterprise (transporting for profit).
- Because the USGS transports small quantities of chemicals and wastes, the Federal EPA and DOT small-quantity exemption rules apply. According to these guidelines, the USGS is exempt from many industry handling and shipping regulations and training requirements. Check your State's laws on intrastate transport of small quantities of chemicals in a Federal government vehicle.
- It is not necessary to placard your vehicle when transporting small quantities of chemicals. Placarding a vehicle informs enforcement and emergency response personnel that the vehicle contains large amounts of the placarded material. For their own safety, first-response teams might not immediately approach a wrecked vehicle that is placarded for a highly dangerous or reactive material.

For safe containment and transport of chemicals:

- Protect yourself and passengers in the vehicle by stowing and securing chemicals away from the passenger compartment and behind a safety screen or barrier.
- Stow compressed gas cylinders securely and in a vertical position, if possible. Never transport cylinders with regulators attached, or with safety caps missing.

- Try to transport chemicals in their original DOT-approved shipping containers with the package correctly sealed. If the original packaging is not available, use a container that will resist and contain the material in the event of an accident. Use of an overpack container, such as an ice chest, is recommended to further protect against breakage and spills.
- Carry spill kit(s) appropriate for the chemicals being transported.
- Label packages as to their contents, and remove old, inappropriate labels from containers that are being reused.
- Keep a chemical inventory list in the glove box or side door pocket of the vehicle. This list should also have an emergency contact name and phone number. Keep a copy of each chemical's Material Safety Data Sheet (MSDS) here, as well.
- Waste products should be transported in the same safe and approved manner as other hazardous materials. The container must be of adequate composition and strength and must be labeled with the type and concentration(s) of chemical(s).

STORAGE AND DISPOSAL 9.6.3

Chemicals require strict storage procedures for safety reasons, as well as to avoid chemical degradation, volatilization, and contamination. Specific storage areas should be designated in your vehicle and office laboratory. Use appropriate, approved chemical storage cabinets. Never store incompatible materials together. Refer to USGS Handbook 445-1-H, chap. 8, for chemical compatibility and storage.

- Separate storage is needed for acids, corrosives, and flammables.
- High purity, laboratory-grade flammables should be stored apart from other flammables, such as gasoline and solvents.

Chemical and waste disposal requirements, and exemptions, are regulated federally by the EPA. Supplemental State guidelines must also be followed. Contact your safety officer or waste disposal representative for details, and follow these general disposal guidelines:

- Do not indiscriminately dump chemicals or pathogens down sinks, toilets, or drains.
- Do not let chemical wastes accumulate in your vehicle, office, or laboratory. Waste disposal storage areas should be established and used.
- Do not mix incompatible wastes. Waste disposal companies have strict and costly requirements for accepting mixed wastes.
- Always label the storage container of a waste product to indicate its contents.
- Put chemical containers, such as spent ampules containing chemical preservative, in chemically separated storage containers and dispose of properly. Instructions are given in Office of Water Quality Technical Memorandum 92.11, and in Horowitz and others (1994).
- The dilute acid solution used for equipment cleaning can be prepared for safe disposal by following procedures described by Horowitz and others (1994, p. 12).

Do not discard wastes into the environment.

CONTAMINATED WATER 9.7

Water being sampled could be contaminated with pathogens and hazardous chemicals. Use caution and extra protection when working with water known or suspected to contain high concentrations of pathogens. Sample containers, shipping containers, and paperwork must indicate the type and severity of the contamination. This alerts personnel to the appropriate personal protective equipment and procedures needed. **Communicate known or suspected contamination to all personnel who could come in contact with the sample.**

Waterborne, disease-causing organisms (pathogens) are found in nearly all surface-water systems, and occur in some ground-water systems as well. Most pathogens originate from the body fluids and feces of animals and humans. Pathogens enter surface-water resources primarily through sewage discharges and spills, storm and agricultural runoff, and direct contact. Microorganisms also are transported on small particles such as dust or aerosols (gaseous suspension of very fine particles). Pathogens enter ground water through infiltration from septic tank effluent, leachate from fields and ponds, and from faulty well seals and casings. Bacteria, viruses, and other pathogenic organisms can occur in the most pristine environments. **Never drink sample water, no matter how pristine the environment appears.**

To minimize exposures to and effects from contaminated water:

- Receive required inoculations. The USGS immunization program requires inoculations for field personnel working around polluted water (WRD Memorandum 96.29). Employees receive inoculations for waterborne pathogens such as typhoid, tetanus, hepatitis, polio, and rabies at USGS expense. Contact your safety officer about receiving appropriate inoculations before you sample.

- Use personal protective equipment, including respiratory equipment (certification required) when working over turbulent, polluted flows, and in shelters containing evidence of excrement (see WRD Memorandums 94.30 and 95.06). Pathogens can enter your body through many openings such as your mouth, eyes, nose, cuts, scrapes, or chapped skin.
- Wear rubber boots, coveralls or aprons, gloves, and splash protection (a disposable dust mask offers splash and dust protection at a very low cost).
- Do not ingest pathogens or other contaminants. Never eat or drink while sampling or put pencils or other items in your mouth, and do not store food or drink in sample coolers.
- Carry antibacterial soap; wash before leaving the site. Remember to wash again after unloading supplies.
- Disinfect all contaminated surfaces as soon as possible.
- Handle bacteria plates carefully and autoclave them before disposal. An aseptic technique for bacteria enumeration is described in Chapter A7.1 of this *National Field Manual*.

Alert colleagues and laboratory if samples could contain large concentrations of hazardous materials.

ENVIRONMENTAL CONDITIONS 9.8

Field work often is necessary under adverse atmospheric and other environmental conditions. Unpredictable occurrences, such as earthquakes, require event-response planning. Prepare for extreme conditions that might be experienced in your area of the country. Before leaving for the field, check the weather forecast using one or more of these options: the local television station, the national weather channel, the local land/marine weather band channel that constantly repeats current and future weather conditions, or computer networks such as the World Wide Web at http://www.intellicast.com.

TEMPERATURE AND SUN EXPOSURE 9.8.1

Extremes of air temperature occur in all parts of the country. The ideal comfort range for humans is between 16 to 32°C (60 to 90°F). Hypothermia and hyperthermia normally occur in temperatures outside this range.

Hypothermia is a condition of reduced body temperature caused by exposure to cold, and aggravated by wet clothes, wind, hunger, and exhaustion. Hypothermia in extremities can lead to frostbite. Hypothermia can occur with air temperature above 16°C (60°F) under wet and (or) windy conditions. The best way to avoid hypothermia is to dress warm and stay dry. Refer to Denner (Revised 1993) for information on cold-weather clothing.

The warning signals of hypothermia are uncontrollable fits of shivering, incoherence, listlessness, fumbling hands, frequent stumbling, drowsiness, and inability to get up after resting. Victims of hypothermia must be treated immediately by removing them from exposure to the elements, replacing wet clothes with dry ones, and giving them warm, non-alcoholic drinks. Seek emergency facilities as soon as possible.

To prevent hypothermia:

1. Put on rain gear before it starts to rain or snow.
2. Put on additional clothes before starting to shiver.
3. Seek shelter immediately if conditions become severe.

Always carry a complete change of dry clothes. This simple procedure could save a life!

Hyperthermia is a condition of increased body temperature caused by exposure to excessive heat. Contributing factors are physical exertion, clothing, humidity, lack of air movement, and temperature, but the most important factor is body hydration. The normal body requirement for fluids in temperate regions is 2 1/2 quarts per day; desert conditions require more fluid. Early warning symptoms of hyperthermia are chilling, a throbbing pressure in the head, unsteadiness, dizziness, nausea, dry skin (either hot and red or cool and pale), rapid pulse, and muscle pains and spasms.

Persons suffering from hyperthermia should seek medical attention immediately. First aid involves cooling down and rehydrating.

To avoid hyperthermia:

1. Drink water in moderate amounts on a scheduled basis—do not wait until you are thirsty.
2. Avoid alcohol, caffeine, and soda—these liquids are not water substitutes.
3. Wear lightweight clothing and a wide-brimmed hat.
4. Schedule activities that require the most exertion in early morning or late afternoon, if possible, and not when air temperature is at its highest.

Sun exposure can have painful and dangerous short-term and long-term effects. Regardless of the region in which you are working, take the proper precautions to protect your skin and eyes from excessive sun exposure.

To prevent excessive sun exposure:

1. Wear sunscreen on all exposed skin to avoid burning and skin cancer.
2. Wear sunglasses with polarized lenses to protect eyes, reduce glare, and improve vision, especially when working on water or snow.

THUNDERSTORMS, TORNADOES, AND HURRICANES 9.8.2

Thunderstorms, which can be accompanied by hail, are common throughout the United States. Some are predicted by weather forecasters. Others can move into an area with almost no advance warning. Watch the sky for signs of thunderstorms, and seek shelter before the weather deteriorates. Lightning is extremely dangerous and should be respected.

To protect yourself during thunderstorms, heed the following advice from Lockhart (1988):

- Seek shelter inside a vehicle or building; keep away from open doors and windows, plugged in appliances, and metal. Avoid contact with metal objects in a vehicle.
- Do not use a telephone.
- If outside, do not congregate. In case of a lightning strike, someone must be able to begin revival techniques immediately, such as cardiopulmonary resuscitation (CPR).
- Put on rubber boots or rubber-soled shoes.
- Do not work on electrical lines, pipes, cableways, or steel structures.
- Do not use metal objects such as wading rods, bridge cranes, and well-logging equipment.
- If caught in the open, crouch down low, but do not lie flat on the ground.
- Avoid standing near isolated trees.
- Avoid working on streams and lakes.
- Seek lower elevations such as valleys or canyons—avoid being on peaks or ridges.
- If you feel your hair standing on end and your skin tingling, this is a sign that lightning might be about to strike—crouch immediately (feet together, hands on knees).

Tornadoes sometimes accompany thunderstorms. Tornadoes are violently rotating columns of air that descend from the clouds in a funnel formation. A weather channel or weather-band radio will sometimes provide advance warning of possible tornadoes.

To protect yourself during a tornado, heed the following advice from Lockhart (1988):

- Seek shelter immediately if there is a sudden, violent change in weather involving wind, rain, hail, or funnel-shaped clouds.
- Avoid occupying vehicles or mobile homes.
- If you are caught outside, find a ravine, ditch, or culvert and lie flat.
- If inside, go to the basement or lowest interior reinforced part of the structure, such as a closet or bathroom. Stay away from windows.

Hurricanes are severe tropical cyclones with winds exceeding 74 miles per hour, and also can contain heavy rain. Stay informed as to the projected path of an approaching hurricane. Sampling activities should not be conducted until the hurricane has moved out of the area.

Get out of and off of water bodies if you are in or expect a thunderstorm, tornado, or hurricane.

FLOODS 9.8.3

Rain can fall at a rate of several inches per hour and rapidly create dangerous flash flood conditions, either in the area where you are working or several miles away. Weather forecasts will be helpful in planning your activities accordingly to ensure your safety. Maintain an updated copy of your district floodplan. Always be aware of rapidly rising stages in rivers and creeks. Beware of dry creekbeds that can become raging rivers in a short period of time.

EARTHQUAKES 9.8.4

Although earthquakes occur more frequently in tectonically active areas, an earthquake can occur anywhere and without warning.

- **Do not panic and run during an earthquake.** The greatest danger is from falling objects and walls (including rock formations). If possible, take cover under a solid structure, such as a table, to protect yourself from falling objects until the shaking stops. If you are out in the open, sit down to avoid losing your balance.
- If an earthquake occurs while driving, slow down and pull over to the side of the road, avoiding overhead structures such as bridges and signs. If on a bridge, try to drive onto solid ground.

9.8.5 FIRE

Fire can spread out of control rapidly—call 911 if you notice a brush fire or other type of threatening fire or smoke. Working inside your field vehicle or outside at your field site requires fire prevention measures. Do not smoke. Keep matches stored in a metal container. Keep fire extinguishers visible and accessible.

- Know how to operate fire extinguishers.
- Know the type of fire for which an extinguisher is designed (extinguishers are different for ordinary combustibles, flammable liquids, and electrical equipment).
- Never point an extinguisher at a person's face.
- **Recharge fire extinguishers according to the schedule provided with the extinguisher.**

9.8.6 SNOW AND ICE

Snow and ice are dynamic mediums that change quickly in structure and strength. Snow and ice can accumulate rapidly, hiding hazards, and creating slippery conditions. Heavy snowfall (white-outs) can be disorienting and can produce avalanche conditions in steep terrain. Working on ice requires experience, training, and knowledge of the water body over which the ice has formed. Wear layers of appropriate clothing and work in teams. Refer to USGS Handbook 445-1-H, chapters 14 and 15, for detailed information.

ANIMALS 9.9

Most sampling activities take place in and around areas inhabited by animals. Before a field trip, try to find out which species inhabit the area and how to deal with them. Table 9-1 summarizes guidelines on what to do if faced with dangerous animals. Note that such guidelines can vary from expert to expert; the right way to deal with encounters could well be what works at the time.

- Most animals will vigorously protect their young and should not be approached or disturbed.
- If a threat or an injury occurs, the most important action is to remain calm and focus on taking the appropriate steps to relieve, remedy, or rescue yourself or another victim. Call for medical advice before transporting the victim, if possible.

ARACHNIDS AND INSECTS 9.9.1

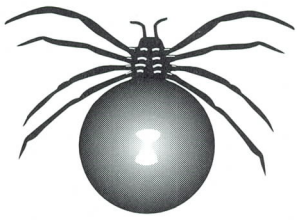
The most common remedy for bites and stings usually involves basic first aid, followed by immediate medical attention if symptoms warrant. If a member of the field team is allergic to insect bites or stings, this should be made known to all members of the team and noted in the emergency information section of the field folder. Treatment procedures should be reviewed before field activity begins. Persons with known allergic reactions to insects should wear or carry on their person medical alert identification, and carry sting kits for use in emergencies.

Scorpions, spiders, and ticks

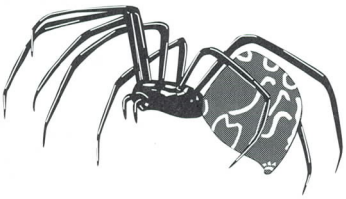
Arachnids such as scorpions, spiders, and ticks are cause for caution by the field team. Spiders and scorpions are known to inhabit enclosed, dark spaces; for example, inside shoes or the corners of well houses and shelters.

Scorpions. Scorpions are known to frequent the desert, but also have been found frozen in ice. Scorpions are not easily seen in the wild. They are nocturnal creatures that are sensitive to vibrations, either in the air or on the ground. When humans are stomping around, scorpions usually run for cover. Scorpion stings often involve an encounter between a big toe and a scorpion that has crawled into a shoe. Check shoes and boots left in the field vehicle before putting them on. **Beware of putting your hands and feet into small, dark spaces (table 9-1).**

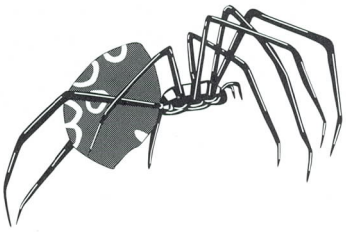
Spiders. Although few spiders in North America bite people, and the venom of most is harmless (Audubon Society, 1980), exceptions include the black widow and the brown recluse (fig. 9-3). The black widow (*Latrodectus mactans*) has a fairly large geographical range. Red and brown widow spiders are found mainly in the Gulf Coast region of the United States. The brown recluse (*Loxosceles reclusa*) frequents areas of human habitation and prefers dark spaces such as equipment shelters, as well as areas in the wild. It is advisable to be familiar with the area in which you are working and take care when walking and when reaching into small spaces.



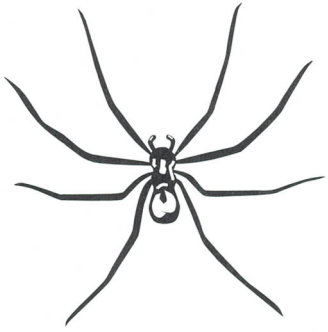
Southern black widow spider
(underside view)



Brown widow spider



Red widow spider



Brown recluse spider

Figure 9-3. Sketches of selected spiders found in North America. (From M.H. Cox, 1994, p. 38-39.)

Ticks. Ticks are found nearly everywhere in North America, and can transmit diseases such as Rocky Mountain spotted fever, Lyme disease, human ehrlichiosis, and human granulocytic ehrlichiosis (HGE). To reduce your chances of being exposed to ticks, wear long pants and tuck the pants legs into your socks; use a repellant containing the compound DEET (N-diethyl-meta-toluamide) on exposed skin, except for the face; check your body regularly for ticks, including inspection of the neck and scalp. Remove attached ticks immediately (table 9-1).

Bees and wasps

Venomous insects of common concern include bees and wasps. Bee stingers are equipped with barbs that should be scraped off if a person is stung—using forceps or tweezers to pull the stinger out can force more venom into the wound (table 9-1). A wasp stinger has no barb; the venom is injected and the stinger usually slides out. The yellow jacket (a vespid wasp) nests in the ground and will aggressively defend the nest if disturbed, particularly in the late summer and early fall. Stings in the mouth or throat sometimes result when a bee or wasp has flown into a can of soda. Seek medical attention if symptoms warrant.

Do not disturb bee hives or wasp nests.

9.9.2 SNAKES

DISTINGUISHING FEATURES OF POISONOUS AND NONPOISONOUS SNAKES OF NORTH AMERICA

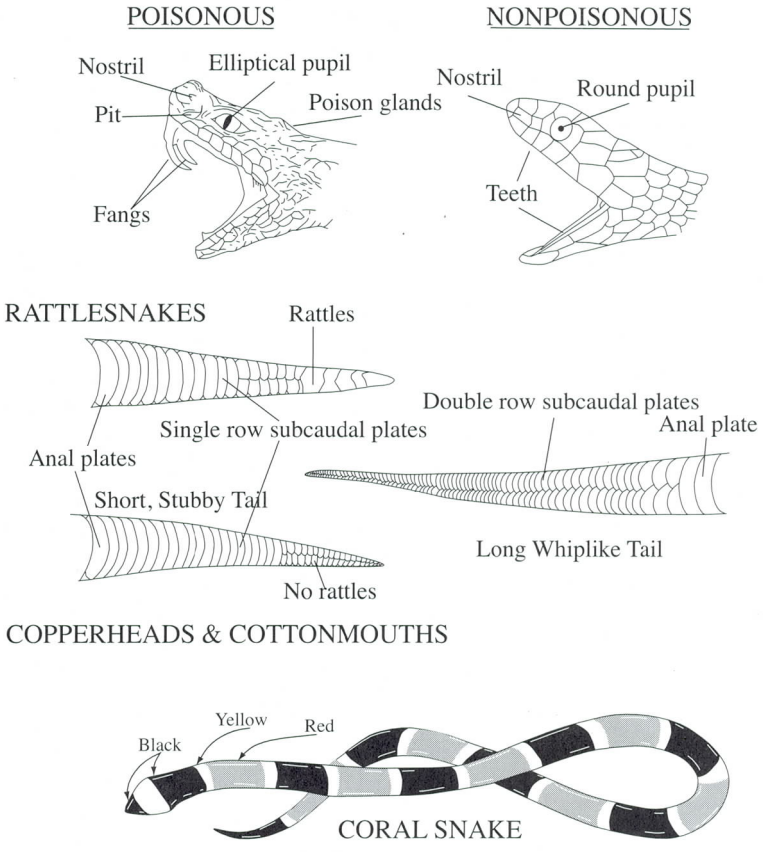


Figure 9-4. Sketches of selected poisonous and nonpoisonous snakes of North America. (From M.H. Cox, 1994.)

SNAKES 9.9.2

Snakes deserve our respect, but they do not have to be feared. Only about 10 percent of the approximately 3,000 species of snakes in the world are poisonous. Differences between poisonous and nonpoisonous snakes of North America are illustrated in figure 9-4.

In the event of snakebite, take the victim to the nearest medical facility as soon as possible. Call the medical facility first if time allows. Even a person who has been bitten by a nonpoisonous snake should be treated by medical personnel, because some people are allergic to the foreign protein in snake saliva. Refer to table 9-1 for procedures to follow if bitten. The best advice regarding snake bites is to prevent them in the first place.

Snake expert Maynard Cox (1994) recommends:

- Do not put your hands or feet where you cannot see.
- Never handle a snake unnecessarily, dead or alive, poisonous or nonpoisonous.
- If you come upon a poisonous snake, turn and run. A snake normally can strike up to one-half or two-thirds of its body length, but if provoked it can strike up to its full body length.

A common symptom of a poisonous snakebite from pit vipers (copperheads, cottonmouths or water moccasins, and rattlesnakes) is a burning, fiery, stinging pain at the bite site. Other symptoms could include swelling; skin discoloration; nausea and vomiting; a minty, metallic, rubbery taste in the mouth; sweating and chills. If the pain does not get any worse and remains localized, venom probably was not passed. If the pain becomes severe, venom was probably injected.

Copperheads (*Agkistrodon contortix*) have a wide distribution throughout the central, mid-Atlantic, and southern United States. They can be found on wooded hillsides or in areas near water. Although the bite of a copperhead can be painful, it is unlikely to result in an adult human death.

Cottonmouths or water moccasins (*Agkistrodon piscivoros*) are found in the southeastern United States and are never far from water. Cottonmouths usually swim with their entire body on top of the water (Huegel and Cook, undated). Cottonmouths might be seen in the daytime, but they are more active at night. They are an extremely aggressive snake and should not be approached.

Rattlesnakes have been found in every state except Alaska, Delaware, Hawaii, and Maine. All other states have at least one species of rattlesnake, and many have three or four. Arizona, for example, has 17 species or subspecies of rattlesnakes (Kauffeld, 1970). A rattling sound usually alerts that a nearby rattlesnake has been disturbed and can be preparing to strike, but if the snake is sufficiently disturbed, it might not rattle at all.

Coral Snakes. Symptoms are different for bites from coral snakes. The coral snake's venom is extremely toxic, but little or no pain may occur from the bite. Look for teeth marks at the puncture wound. Other symptoms could include euphoria, excess salivation, convulsions, weakness, and paralysis (Cox, 1994).

The **Eastern coral snake** (*Micrurus fulvuis*) is found in the southeastern United States. It is identified by wide red and black bands separated by a narrow, bright yellow band. The red and black bands never touch. The **Arizona coral snake** (*Micruroides euryxanthus*) is located in the southwestern United States. The red and black bands also never touch.

9.9.3 ALLIGATORS

The American alligator (*Alligator mississipiensis*) is found in swamps, rivers, and lakes, primarily of the southeastern United States. Alligators are fairly inactive in the winter months when the water temperatures are cool; their metabolism slows down and there is little need for food. The breeding season is mostly during April and May; male and female move around more during this time.

Treat alligators with extreme caution. Some can become a nuisance when they lose their fear of humans and usually have to be destroyed by licensed trappers. **Never approach an alligator, either on land or in the water.** Alligators can outrun humans for short distances. If your sampling involves fish collection, get the specimens out and away from the water as soon as possible.

BEARS 9.9.4

Bear behavior is unpredictable. According to *Guidelines for Safe Geologic Fieldwork in Alaska* (U.S. Geological Survey, May 1978), bears fiercely defend any carcasses and will often bury or partially cover such prizes for later. Contrary to popular belief, bears can see almost as well as people, but trust their noses much more than their eyes or ears.

Avoiding contact with a bear is the best defense:

- Avoid game trails that bears might use.
- Avoid carrion (dead and decaying flesh), fresh kill, or gut piles.
- Avoid berry patches, or other areas abundant with plants that bears use for food.
- Avoid willow and dry grass patches; bears sometimes use these areas for daybeds.
- Avoid areas with fresh bear tracks.
- Make noise or wear bells when moving through the woods so as not to surprise bears.
- Avoid carrying food that a bear can smell. Always keep food sealed and in a backpack, not in a pants pocket.
- Work in teams of two or larger groups to help deter a bear from attacking.

If you meet a bear on the trail, effective methods of defense can vary:

- If you see the bear before it sees you, decide on your route of escape and leave the area at once.
- If you find yourself close to a bear, give the bear all the room you can.
- Let the bear know you are human—talk in a normal voice and wave your arms. Try to back away slowly, but if the bear follows, stop and hold your ground.
- **Do not run!** Bears often make bluff charges, sometimes within 10 feet of their adversary, without making contact.
- If a bear actually makes contact, surrender! Fall to the ground and play dead. Typically, a bear will break off its attack once it feels the threat has been eliminated. If the bear continues to bite after you assume a defensive posture, the attack is predatory and you should fight back vigorously.

9.9.5 MOUNTAIN LIONS

Mountain lions (*Felis concolor*) are a species of larger cats found in North America (also called cougar, puma, and panther). The primary habitat for these members of the cat family is west of the Rocky Mountains and south of the Yukon, although Florida has a small population. Mountain lions are active during the day and night, and search a wide territorial range for food. The main food source is deer and smaller animals.

Be alert to reports of mountain lion attacks or sightings. Healthy mountain lions do not usually attack humans, but when this occurs, it is usually because the person panicked and ran. Turning and running can evoke a predatory response from mountain lions.

9.9.6 RODENTS AND OTHER SMALL MAMMALS

Rodents and other small mammals can be disease carriers as well as be a nuisance. The best policy is to avoid them; know what animals are in your particular area and take appropriate precautions. Two diseases of concern carried by such animals are hantavirus and rabies.

Mice, rats, and chipmunks are the primary hosts of hantaviruses (Center for Disease Control, 1994a and b). Known carriers include the deer mouse (*Peromyscus maniculatus*), piñon mouse (*P. truei*), brush mouse (*P. boylii*), cotton rat (*Sigmodon hispidus*), and western chipmunk (*Tamias*). Hantavirus does not cause apparent illness in the host, but the infected individual sheds the virus in saliva, urine, and feces for many weeks. Rabies infection is another hazard of contact with small animals, especially skunks, raccoons, foxes, coyotes, bats, cats, and dogs.

The best way to eliminate the chance of infection from rodents and other small mammals is to secure the areas in which you will be working against an animal population. In gage houses and recorder shelters, make sure all openings have been blocked before leaving the site. Subsequent inspections must be made on a routine basis to ensure that rodents have not found other means of access into the structure.

Structures with heavy rodent infestation must be treated with extreme caution and may require specific training to ensure proper precautions are used. Persons involved in cleanup should wear disposable coveralls, rubber boots or disposable shoe covers, rubber or plastic gloves, protective goggles, and appropriate respiratory protection, such as a half-mask air-purifying (or negative pressure) respirator with a high-efficiency particulate air (HEPA) filter or a powered air-purifying respirator (PAPR) with HEPA filters (Center for Disease Control, 1994b). Immediately after the clean-up operation, this personal protective equipment should be decontaminated or discarded using appropriate methods.

If the gage house or recorder shelter is suspected of being inhabited by rodents, the following steps are to be followed before entering the structure:

1. Open the door or shelter lid and allow to air out for at least 30 minutes before entering.
2. Wear rubber or plastic gloves when working in the previously enclosed area.
3. Spray dead rodents, rodent nests, droppings, or other potentially tainted areas with a general-purpose household disinfectant. Soak the materials thoroughly with disinfectant and place in a plastic bag. Seal the bag and place it inside another plastic bag and then bury or burn. If this is not possible, contact the local or State health department for alternative disposal methods.
4. After removing the above items, disinfect the area with a solution of water, detergent, and disinfectant. Do not vacuum or sweep dry surfaces prior to disinfecting with a liquid solution.

DOMESTIC ANIMALS 9.9.7

Sampling often involves working in urban or rural areas where cats, dogs, cows, horses, and other domesticated animals can be carriers of disease or exhibit unpredictable and aggressive behavior. Before entering private property, contact the owner and obtain permission to enter. Ask about any animals that might be on or around the property. Do not pet, feed, or otherwise contact these animals.

Table 9-1. Guidelines on potentially dangerous animals

[mm, millimeter; in., inch; cm, centimeter; ft, foot; lb, pound; mph, mile per hour]

Animals	Description/ Characteristics	Procedure
Arachnids and Other Insects		
Black widow spiders (Black, brown and red widow spiders are illustrated in figure 9-3.)	Female (only one that bites) is black with abdomen almost spherical, usually with red hourglass mark below or with 2 transverse red marks separated by black. Spiderling is orange, brown, and white, gaining more black at each molt. Habitat among fallen branches and under objects, such as well shelters, furniture, and trash.	**If bitten, seek medical attention as soon as possible.**
Brown recluse spiders	Orange-yellow thorax with dark violin pattern. Bases of legs orange-yellow, rest of legs grayish to dark brown. Abdomen grayish to dark brown with no obvious pattern. Habitat outdoors in sheltered corners, among loose debris; indoors on the floor and behind furniture in houses and outbuildings.	
Scorpions	Nocturnal, sensitive to vibrations. Field boots are a favorite hiding place.	
Ticks	Small, less than 3 mm (<1/8 in.). Clamps to host using a dart-like anchor located just below the mouth.	**Do** • Check for ticks during and after field work. • Remove with tweezers within 24 hours. **Don't** • Leave the head imbedded. • Extract using matches or applying petroleum jelly or other coating.
Bees	Bees vary in size from 2 mm (0.08 in.) long to 4 cm (1.6 in.) long; divided into a number of family classifications which are determined by mouthparts and other characteristics that are difficult to see without dissection.	**Do** • Avoid all bee hives and wasp nests. • Scrape off the bee stinger with a knife or other flat object. • Use an over-the-counter sting ointment or a solution of baking soda, meat tenderizer, and ammonia. **Don't** • Use forceps or tweezers to pull the bee stinger out.
Wasps	Wasps vary in size from minute up to 5 cm (2 in.) long; adults distinguished by a narrow waist between the first and second abdominal segments.	
Snakes and Alligators		
Copperhead snake Cottonmouths or water moccasin snakes Rattlesnakes Eastern coral snakes and Arizona coral snakes	Elliptical eyes; short, stubby tail. Elliptical eyes; short, stubby tail. Usually swim with their entire body on top of the water. Never far from water. Most active at night. An extremely aggressive snake. Elliptical eyes; short, stubby tail. The rattle is a sign of fear, but if the snake is sufficiently disturbed, it might not rattle at all. Wide red and black bands separated by a narrow, bright yellow band; the red and black bands never touch; round pupils; short, stubby tail.	**Do not confront a snake—turn and run** **If bitten:** **Do** • Reassure victim. • Treat for shock. Keep victim lying down; elevate feet 10 to 12 in. • Seek medical attention as soon as possible. Call medical facility while en route, if possible. **Don't** • Cut and suck affected area. • Apply ice or a tourniquet. • Leave victim unattended.

Table 9-1. Guidelines on potentially dangerous animals–*Continued*

Animals	Description/ Characteristics	Procedure
Snakes and Alligators—*Continued*		
Alligators	Fairly inactive when water is cool. Most active during breeding season (mostly April and May). Alligators can run quickly for short distances.	**Don't** approach an alligator.
Mammals		
Polar bears	White, 8-10 ft in length, male 600-1,200 lb, female 400-700 lb, carnivores (primarily).	**Do** • Make your presence known (sing, talk, tie bells to pack). • Travel with a group. • Give bears plenty of room. • Play dead if attacked. Lie flat on stomach or curl up in a ball with hands behind neck. Remain motionless as long as possible, until the bear is gone. If bear continues attack long after you play dead, it is probably a predatory attack. FIGHT BACK VIGOROUSLY! **Don't** • Run. Bears can run up to 35 mph. • Imitate bear sounds or make a high-pitched squeal.
Black bears	Brown to black, white patch in front of chest, 5 ft in length, male 150-400 lb, female 125-250 lb, herbivores (primarily).	
Brown bears	Dark brown to blonde, 7-9 ft in length, male 400-1,100 lb, female 200-600 lb, herbivores (primarily).	
Mountain lions	Active during the day and night. Healthy mountain lions do not usually attack humans.	**Do** • Stand your ground. • Shout and wave your arms. • Throw rocks at the animal. **Don't** • Turn your back. • Panic and run.
Rodents and small mammals: mice, chipmunks, rats, skunks, squirrels, raccoons, bats, foxes, coyotes	Animals infected with hantavirus show no signs of illness. Virus is transmitted from being bitten, or when infective saliva or excreta are inhaled as aerosols produced directly from the infected rodent, or when dried or fresh material contaminated by rodent excreta are disturbed, directly introduced into broken skin, introduced onto the conjunctivae (mucous membrane covering the eyeball), or possibly ingested in contaminated food or water. Signs of an animal infected with rabies are nervousness, aggressiveness, excessive drooling and foaming at the mouth, abnormal behavior, such as wild animals losing their fear of humans or nocturnal animals being seen in the daytime.	**Do** • Wash the wound from a bite or scratch thoroughly with soap and water. • Seek medical attention. • Notify game warden or health department. **Don't** • Capture animal. • Pet or feed wild or domestic animals.
Domestic animals: cats, dogs, cows		

9.10 PLANTS

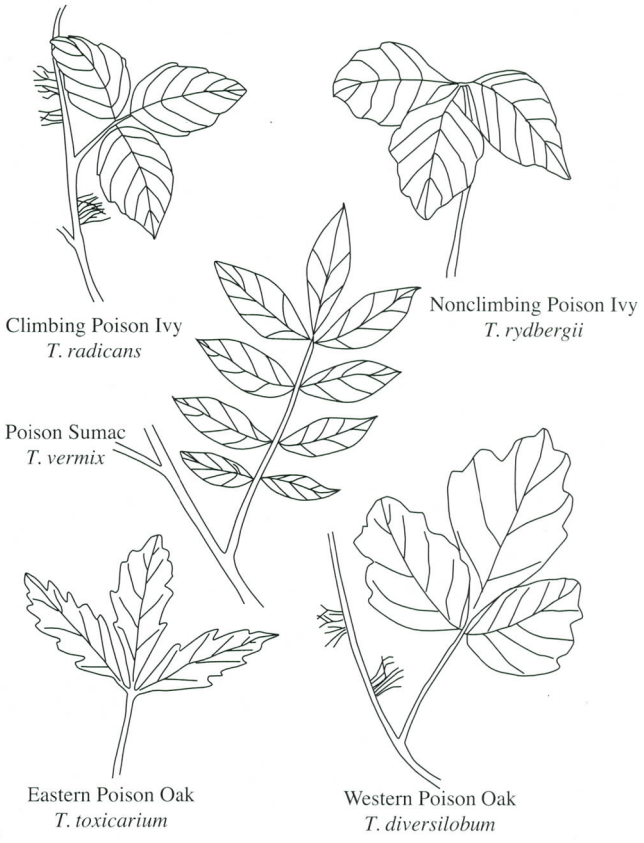


Figure 9-5. Shapes of leaves in five species of *Toxicodendron* found throughout the continental United States (except Alaska and Nevada). (From Frankel, 1991.)

PLANTS 9.10

The most common poisonous plants are the *Toxicodendrons*, or poison ivies, and include climbing and nonclimbing poison ivy, eastern and western poison oak, and poison sumac (fig. 9-5). Resins and secretions from these species are capable of inflicting a mild to serious skin rash on susceptible individuals (Frankel, 1991).

The best defense against *Toxicodendrons* and other poisonous plants is proper clothing. Long pants and sleeves will protect you in most cases, but plant poisons have been known to penetrate clothing. In the field, always wear shoes that protect your whole foot.

The oily resin of the plant is only slightly soluble in water, and the best treatment is to flush the area of skin contact with copious amounts of cold water (table 9-2). A little water spreads the poison; lots of water washes it away. Soap can remove natural skin oils that protect against penetration of the resins; warm water can also hasten the absorption.

Table 9-2. Guidelines on poisonous plants

Plant	Description/Characteristics	Procedure
Poison ivy *(Toxicodendron rydbergii)*	• Climbing poison ivy has alternate, trifoliate leaves, tiny greenish-white flower clusters or white berries, and aerial roots that grow straight and are fuzzy. Ubiquitous in most environments (seldom found in deep, dark forests or at heights above 4,000 ft) (Frankel, 1991). • Non-climbing poison ivy lacks aerial roots. The leaves are larger and broader than the climbing variety, but the pattern is still alternate and trifoliate.	**In case of skin contact:** **Do** • Flood the affected area with copious amounts of **cold** water as soon as possible. **Don't** • Use soap. • Use warm water.
Eastern poison oak *(Toxicodendron toxicarium)*	Prefers the sandy soil of the Atlantic and Gulf coasts. Distinguished by trifoliate fuzzy leaves, fuzzy fruits, and leaflets with rounded tips.	
Western poison oak *(Toxicodendron diversilobum)*	Strictly a Pacific coast species. Usually grows as a short shrub but can grow as a vine, due to aerial roots. Trifoliate leaves.	
Poison sumac *(Toxicodendron vernix)*	A tree that prefers a moist habitat such as bogs or swamps. Ranges in height from 6 to 20 feet. The alternate leaves are compound with 7 to 13 lobeless, toothless leaflets arranged in a featherlike fashion with a single leaflet on the end. Can have white berries. The fruits of poisonous varieties of sumac droop downward.	

9.11 CHECKLISTS FOR STANDARD SAFETY EQUIPMENT

Checklists are helpful for ensuring that personnel have the appropriate safety equipment available during field trips. Each study team needs to consider the specific needs for their work and should customize these checklists as necessary.

9.11.1 CHECKLIST FOR PERSONAL PROTECTIVE EQUIPMENT

✓	Personal Protective Equipment[1]
	Chemical and disease protection
	Aprons
	Eye/Face splash guards
	Gloves (vinyl and/or latex or nitrile). Sizes: S M L XL
	Protective suits. Sizes: S M L XL
	Respirators (certification required for use)
	Climatic and UV protection
	Boots
	Fluids (for example, water and sports drinks)
	Hat, wide-brimmed
	Insect repellent (unscented)
	Rain gear
	Sunglasses
	Sunscreen
	Temperature-modifying clothing
	Flotation and reflective protection
	Orange flotation vests and jackets
	Safety harness
	Protection for working around heavy objects and machinery
	Back belt
	Hardhat
	Hearing protection
	Safety glasses
	Steel-toed safety boots
	Work gloves

[1] PPE must be selected based on the hazards likely to be encountered. The USGS is required to supply appropriate PPE, and field personnel are required to use it.

CHECKLIST FOR VEHICLES AND VEHICULAR LABORATORIES 9.11.2

✓	Items for Field Vehicles
	Chemical protection and storage
	Chemical spill kit
	Eye wash kit (replace old or expired wash solution)
	Material Safety Data Sheets (MSDS)
	Chemical reagents (stored in appropriate area)
	Flammable solvents (stored in appropriate dedicated area)
	Pressurized gases (stored in appropriate area)
	Communications and instructions
	Field folder (including maps, emergency phone numbers for medical facilities, office contacts, family contacts)
	Cellular phone/communication equipment (check that the service is operational for the area to be traveled)
	First aid and protective equipment
	Complete change of clothes (stored in dry area)
	Fire extinguisher (safely secured)
	First aid kit and manual (check for missing or old, expired items and replace if necessary)
	Orange reflective vest
	Miscellaneous equipment
	Bungie cords (to secure loose articles)
	District flood plan (most current version)
	Flagging
	Flares
	Flashlight (including fresh batteries)
	Flexible hose (to vent exhaust away from vehicle)
	Safety cones
	Tool kit

9.11.3 CHECKLIST FOR WATERCRAFT

✓	Watercraft Items
	Instructions and navigation
	Field folder, with float plans
	Charts and maps
	Compass (in working order)
	Depth finder (if appropriate)
	Dead-man's switch
	Navigation lights
	Ring buoy with line
	Distress and external communication
	Radio (VHF, AM, FM, and WEATHER)
	Special lighting/flagging (if boat activities might pose a hazard to the public, such as tag line measurements)
	Visual distress signals (Coast Guard approved)
	Whistles or horns
	Type IV throwable rescue device
	Personal flotation devices for each passenger (Coast Guard approved)
	Anchor and lines (spare)
	Bucket for use as a bailer
	Paddle (extra paddle for each canoe or rowboat)
	First aid kit (Coast Guard approved)
	Flashlights and batteries
	Fire extinguishers
	Spare parts (anchor, fuel, propeller, extra lines)
	Tool and repair kits
	Extra clothes (hat, foul-weather gear)
	Food and water
	Sunscreen

CONVERSION FACTORS AND ABBREVIATIONS

CONVERSION FACTORS

Multiply	By	To obtain
milligrams (mg)	3.52×10^{-5}	ounce
millimeter (mm)	0.03937	inch
centimeter (cm)	0.3937	inch
square centimeter (cm^2)	0.155	square inch
liter (L)	0.2642	gallon
meter (m)	3.281	foot
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
square foot (ft^2)	2.590	square kilometer
mile	1.609	kilometer
pound, avoirdupois (lb)	0.4536	kilogram
quart	0.9464	liter

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:

$$°F = 1.8\ (°C) + 32$$

ABBREVIATIONS

CFR	Code of Federal Regulations
CPR	Cardiopulmonary resuscitation
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
MSDS	Material Safety Data Sheet
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
PFD	Personal flotation device
PPE	Personal protective equipment
TWRI	Techniques of Water-Resources Investigations
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
WRD	Water Resources Division of the USGS

SELECTED REFERENCES AND INTERNAL DOCUMENTS

SELECTED REFERENCES FOR SAFETY IN FIELD ACTIVITIES

American Red Cross, 1988, American Red Cross Standard First Aid—Workbook, 1988: American Red Cross, 180 p.

Anonymous, Fall 1992, Well aware: Ormond Beach and Flagler, Fla., Memorial Hospital, p. 1-4.

Audubon Society, 1980, The Audubon Society field guide to North American insects and spiders: New York, Alfred A. Knopf, Inc., 989 p.

_____1986, The Audubon Society encyclopedia of animal life: New York, Portland House, 606 p.

Boy Scouts of America, 1984, Fieldbook (3d ed.): Irving, Tex., Boy Scouts of America, 630 p.

_____1990, Boy scout handbook (10th ed.): Irving, Tex., Boy Scouts of America, 661 p.

Cahalane, V.H., ed., 1970, Alive in the wild: Englewood Cliffs, N.J., Prentice-Hall, 236 p.

Center for Disease Control, October 21, 1994a, Fax Information Service 310031—Hantavirus Illness SW-USA.

_____October 21, 1994b, Fax Information Service 310032—Hantavirus—Prevention Info.

Cox, M.H., Revised September 1994, Protocol for emergency room procedures and hospital management of snakebites: 198 Venus Lane, Orange Park, Fla. 32073-2431, Maynard H. Cox, 36 p.

Denner, J.C., Revised 1993, A primer on clothing systems for cold-weather field work: U.S. Geological Survey Open-File Report 89-415, 16 p.

Florida Game and Fresh Water Fish Commission, April 1991, American Alligator (pamphlet).

_____April 1991, Living with Alligators (pamphlet).

Frankel, Edward, 1991, Poison ivy, poison oak, poison sumac, and their relatives: Pacific Grove, Calif., The Boxwood Press, 93 p.

Harper and Row, 1981, Complete field guide to North American wildlife—eastern edition: New York, Harper and Row, 714 p.

_____1981, Complete field guide to North American wildlife—western edition: New York, Harper and Row, 809 p.

Horowitz, A.J., Demas, C.R., Fitzgerald, K.K., Miller, T.L., and Rickert, D.A., 1994, U.S. Geological Survey protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water: U.S. Geological Survey Open-File Report 94-539, 57 p.

Huegel, C.N., and Cook, D.G., undated, Florida's nonvenomous snakes: Florida Game and Fresh Water Fish Commission, Tallahassee, Fla., 6 p. [brochure]

J.J. Keller & Associates, Inc., 1993, Driver's pocket guide to hazardous materials (1st ed.), A guide to U.S. Department of Transportation regulations in U.S. Code of Federal Regulations, Title 49, Parts 171-180 and 390-397: P.O. Box 368, Neenah, WI 54957-0368, J.J. Keller & Associates, 386 p.

Joseph, Jack, 1957, Don't die with your boots on: Outdoor Life, v. 119, no. 4, p. 70.

Kauffeld, C.F., 1970, The rattlesnake, *in* Cahalane, V.H., Alive in the wild: Englewood Cliffs, N.J., Prentice-Hall, p. 42-49.

Lockhart, Gary, 1988, The weather companion: New York, Wiley Science Editions, 215 p.

Maughan, J.J., and Puddicombe, Ann, 1981, Hiking the backcountry: Harrisburg, Pa., Stackpole Books, 226 p.

National Institute for Occupational Safety and Health, June 1994, Pocket Guide to Chemical Hazards, Publication No. 94-116, 398 p.

Nichol, John, 1989, Bites and stings—the world of venomous animals: New York, Facts On File Publications, 185 p.

Tidball, R.R., 1984, Field-safety guidelines for the U.S. Geological Survey, central region (2d ed.): U.S. Geological Survey Geologic Division Central Region Committee on Safety, U.S. Government Printing Office 776-041/4015 Region No. 8, 56 p.

U.S. Department of the Interior, 1991, Safety and health handbook (485 DM), Departmental Manual: Washington, D.C., U.S. Department of the Interior, Office of the Secretary [variously paged].

U.S. Department of Labor, 1995, Occupational Safety and Health Administration: U.S. Code of Federal Regulations, Title 29, Chapter 17, Parts 1900 to 1910, revised as of July 1, 1995, 948 p.

U.S. Department of Transportation, 1990, Emergency response guidebook: U.S. Department of Transportation, DOT P 5800.5, 76 p.

_____1995, Other regulations relating to transportation: U.S. Code of Federal Regulations, Title 49, Parts 171-177, revised as of October 1, 1995.

U.S. Environmental Protection Agency, 1995, U.S. Code of Federal Regulations, Title 40, Parts 260-272, 355, 370, 372, 710 p.

U.S. Geological Survey, May 1978, Guidelines for safe geologic fieldwork in Alaska: U.S. Geological Survey Geologic Division, Branch of Alaskan Geology, Committee on Safety, 20 p.

_____1988, Geological Survey manual, 370.792.1.1, Preventive medical treatment: Reston, Va., Administrative Division/Personnel, 3 p.

_____August 1989, Safety and environmental health handbook—Handbook 445-1-H: Reston, Va. [variously paged].

_____December 1993, USGS occupational hazards and safety procedures handbook—Handbook 445-2-H: Reston, Va., Administrative Division [variously paged].

_____July 1994, USGS diving safety manual: Reston, Va., Bureau Safety Manager, National Center [variously paged].

_____December 1994, USGS environmental/hazardous waste compliance guide: Reston, Va., Bureau Safety Manager, National Center [variously paged].

Wagner, C.R., 1991, Streamgaging cableways: U.S. Geological Survey Open-File Report 91-84, 89 p.

Yobbi, D.K., Yorke, T.H., and Mycyk, R.T., 1996, A guide to safe field operations: U.S. Geological Survey Open-File Report 95-777, 29 p.

INTERNAL DOCUMENTS

Water Resources Division Memorandums and Office of Water Quality Technical Memorandums are available electronically on the Internet through the USGS Home Page on the World Wide Web. The site address (URL) is

<http://water.usgs.gov/cgi-bin/geturl?TECHMEMO>

Water Resources Division (WRD) Memorandums

Plan for insuring the safety of cableways, June 1991: WRD Memorandum No. 91.42, 12 p.

Requirements for Water Resources Division personnel performing electrofishing, February 1993: WRD Memorandum No. 93.19, 2 p.

Storage, transportation, handling, and disposal of formaldehyde (FORMALIN) solution, July 1993: WRD memorandum No. 93.44, 4 p.

Storage, transportation, handling, and disposal of hydrochloric acid, November 1993: WRD Memorandum No. 94.06, 5 p.

Storage, transportation, handling and disposal of methyl alcohol, December 1993: WRD Memorandum No. 94.07, 5 p.

Plan for insuring safe work in gaging station stilling wells, April 1994: WRD Memorandum No. 94.30, 11 p.

Managing safety and health hazards when working in and around streamgaging stations: a lesson learned from an incident in the Iowa District, December 1994: WRD Memorandum No. 95.06, 5 p.

Traffic control plan for field operations from bridges and along roadways, February 1995: WRD Memorandum No. 95.17, 21 p.

Bureau-administered specialized safety programs, August 1995: WRD Memorandum No. 95.47, 2 p.

Aircraft safety: lesson learned from a recent Colorado helicopter accident, August 1995: WRD Memorandum No. 95.49, 4 p.

New watercraft safety requirements, May 1996: WRD Memorandum No. 96.25, 7 p.

Water Resources Division immunization program, June 1996: WRD Memorandum No. 96.29, 3 p.

Office of Water Quality (OWQ) Technical Memorandums

Return of spent mercury and dichromate ampoules to the National Water Quality Laboratory, July 16, 1992: OWQ Technical Memorandum 92.11, 3 p.

Discontinuance of field use of mercury liquid-in-glass thermometers, November 22, 1993: OWQ Technical Memorandum No. 94.02, 5 p.

New preservation techniques for nutrient samples, August 5, 1994: OWQ Technical Memorandum 94.16, 11 p.

PUBLICATIONS ON TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS

The U.S. Geological Survey publishes a series of manuals describing procedures for planning and conducting specialized work in water-resources investigations. The material is grouped under major subject headings called books and is further divided into sections and chapters. For example, Section A of Book 9 (Handbooks for Water-Resources Investigations) pertains to collection of water-quality data. The chapter, which is the unit of publication, is limited to a narrow field of subject matter. This format permits flexibility in revision and publication as the need arises.

The reports listed below are for sale by the U.S. Geological Survey, Branch of Information Services, Box 25286, Federal Center, Denver, CO 80225 (authorized agent of the Superintendent of Documents, Government Printing Office). Prepayment is required. Remittance should be sent by check or money order payable to the U.S. Geological Survey. Prices are not included because they are subject to change. Current prices can be obtained by writing to the above address. When ordering or inquiring about prices for any of these publications, please give the title, book number, chapter number, and "U.S. Geological Survey Techniques of Water-Resources Investigations."

Book 1. Collection of Water Data by Direct Measurement

Section D. Water Quality

1-D1.Water temperature—influential factors, field measurement, and data presentation, by H.H. Stevens, Jr., J.F. Ficke, and G.F. Smoot: USGS—TWRI Book 1, Chapter D1. 1975. 65 pages.

1-D2.Guidelines for collection and field analysis of ground-water samples for selected unstable constituents, by W.W. Wood: USGS—TWRI Book 1, Chapter D2. 1976. 24 pages.

Book 2. Collection of Environmental Data

Section D. Surface Geophysical Methods

2-D1.Application of surface geophysics to ground-water investigations, by A.A.R. Zohdy, G.P. Eaton, and D.R. Mabey: USGS—TWRI Book 2, Chapter D1. 1974. 116 pages.

2–D2.Application of seismic-refraction techniques to hydrologic studies, by F.P. Haeni: USGS—TWRI Book 2, Chapter D2. 1988. 86 pages.

Section E. Subsurface Geophysical Methods

2–E1.Application of borehole geophysics to water-resources investigations, by W.S. Keys and L.M. MacCary: USGS—TWRI Book 2, Chapter E1. 1971. 126 pages.

2–E2.Borehole geophysics applied to ground-water investigations, by W.S. Keys: USGS—TWRI Book 2, Chapter E2. 1990. 150 pages.

Section F. Drilling and Sampling Methods

2–F1.Application of drilling, coring, and sampling techniques to test holes and wells, by Eugene Shuter and W.E. Teasdale: USGS—TWRI Book 2, Chapter F1. 1989. 97 pages.

Book 3. Applications of Hydraulics

Section A. Surface-Water Techniques

3–A1.General field and office procedures for indirect discharge measurements, by M.A. Benson and Tate Dalrymple: USGS—TWRI Book 3, Chapter A1. 1967. 30 pages.

3-A2.Measuement of peak discharge by the slope-area method, by Tate Dalrymple and M.A. Benson: USGS—TWRI Book 3, Chapter A2. 1967. 12 pages.

3-A3.Measurement of peak discharge at culverts by indirect methods, by G.L. Bodhaine: USGS—TWRI Book 3, Chapter A3. 1968. 60 pages.

3-A4.Measurement of peak discharge at width contractions by indirect methods, by H.F. Matthai: USGS—TWRI Book 3, Chapter A4. 1967. 44 pages.

3-A5.Measurement of peak discharge at dams by indirect methods, by Harry Hulsing: USGS—TWRI Book 3, Chapter A5. 1967. 29 pages.

3-A6.General procedure for gaging streams, by R.W. Carter and Jacob Davidian: USGS—TWRI Book 3, Chapter A6. 1968. 13 pages.

3-A7.Stage measurement at gaging stations, by T.J. Buchanan and W.P. Somers: USGS—TWRI Book 3, Chapter A7. 1968. 28 pages.

3-A8.Discharge measurements at gaging stations, by T. J. Buchanan and W. P. Somers: USGS—TWRI Book 3, Chapter A8. 1969. 65 pages.

3-A9.Measurement of time of travel in streams by dye tracing, by F.A. Kilpatrick and J.F. Wilson, Jr.: USGS—TWRI Book 3, Chapter A9. 1989. 27 pages.

3-Al0.Discharge ratings at gaging stations, by E.J. Kennedy: USGS—TWRI Book 3, Chapter A10. 1984. 59 pages.

3-A11.Measurement of discharge by the moving-boat method, by G. F. Smoot and C.E. Novak: USGS—TWRI Book 3, Chapter A11. 1969. 22 pages.

3-A12.Fluorometric procedures for dye tracing, Revised, by J.F. Wilson, Jr., E.D. Cobb, and F.A. Kilpatrick: USGS—TWRI Book 3, Chapter A12. 1986. 34 pages.

3-A13.Computation of continuous records of streamflow, by E.J. Kennedy: USGS—TWRI Book 3, Chapter A13. 1983. 53 pages.

3-A14.Use of flumes in measuring discharge, by F.A. Kilpatrick and V.R. Schneider: USGS—TWRI Book 3, Chapter A14. 1983. 46 pages.

3-A15.Computation of water-surface profiles in open channels, by Jacob Davidian: USGS—TWRI Book 3, Chapter A15. 1984. 48 pages.

3-A16.Measurement of discharge using tracers, by F.A. Kilpatrick and E.D. Cobb: USGS—TWRI Book 3, Chapter A16. 1985. 52 pages.

3-A17.Acoustic velocity meter systems, by Antonius Laenen: USGS—TWRI Book 3, Chapter A17. 1985. 38 pages.

3-A18.Determination of stream reaeration coefficients by use of tracers, by F.A. Kilpatrick, R.E. Rathbun, Nobuhiro Yotsukura, G.W. Parker, and L.L. DeLong: USGS—TWRI Book 3, Chapter A18. 1989. 52 pages.

3-A19.Levels at streamflow gaging stations, by E.J. Kennedy: USGS—TWRI Book 3, Chapter A19. 1990. 31 pages.

3-A20.Simulation of soluble waste transport and buildup in surface waters using tracers, by F.A. Kilpatrick: USGS—TWRI Book 3, Chapter A20. 1993. 38 pages.

3-A21.Stream-gaging cableways, by C. Russell Wagner: USGS—TWRI Book 3, Chapter A21. 1995. 56 pages.

Section B. Ground-Water Techniques

3-B1. Aquifer-test design, observation, and data analysis, by R. W. Stallman: USGS—TWRI Book 3, Chapter B1. 1971. 26 pages.

3-B2.Introduction to ground-water hydraulics, a programed text for self-instruction, by G. D. Bennett: USGS—TWRI Book 3, Chapter B2. 1976. 172 pages.

3-B3.Type curves for selected problems of flow to wells in confined aquifers, by J. E. Reed: USGS—TWRI Book 3, Chapter B3. 1980. 106 pages.

3-B4.Regression modeling of ground-water flow, by R. L. Cooley and R. L. Naff: USGS—TWRI Book 3, Chapter B4. 1990. 232 pages.

3-B4.Supplement 1. Regression modeling of ground-water flow—Modifications to the computer code for nonlinear regression solution of steady-state ground-water flow problems, by R.L. Cooley: USGS—TWRI Book 3, Chapter B4. 1993. 8 pages.

3-B5.Definition of boundary and initial conditions in the analysis of saturated ground-water flow systems—An introduction, by O. L. Franke, T. E. Reilly, and G. D. Bennett: USGS—TWRI Book 3, Chapter B5. 1987. 15 pages.

3-B6.The principle of superposition and its application in ground-water hydraulics, by T. E. Reilly, O. L. Franke, and G. D. Bennett: USGS—TWRI Book 3, Chapter B6. 1987. 28 pages.

3-B7.Analytical solutions for one-, two-, and three-dimensional solute transport in ground-water systems with uniform flow, by E. J. Wexler: USGS—TWRI Book 3, Chapter B7. 1992. 190 pages.

Section C. Sedimentation and Erosion Techniques

3-C1.Fluvial sediment concepts, by H. P. Guy: USGS—TWRI Book 3, Chapter C1. 1970. 55 pages.

3-C2.Field methods for measurement of fluvial sediment, by T.K. Edwards and G.D. Glysson: USGS—TWRI Book 3, Chapter C2. 1998. 80 pages.

3-C3.Computation of fluvial-sediment discharge, by George Porterfield: USGS—TWRI Book 3, Chapter C3. 1972. 66 pages.

Book 4. Hydrologic Analysis and Interpretation

Section A. Statistical Analysis

4-A1.Some statistical tools in hydrology, by H. C. Riggs: USGS—TWRI Book 4, Chapter A1. 1968. 39 pages.

4-A2.Frequency curves, by H.C. Riggs: USGS—TWRI Book 4, Chapter A2. 1968. 15 pages.

Section B. Surface Water

4-B1.Low-flow investigations, by H.C. Riggs: USGS—TWRI Book 4, Chapter B1. 1972. 18 pages.

4-B2.Storage analyses for water supply, by H.C. Riggs and C.H. Hardison: USGS—TWRI Book 4, Chapter B2. 1973. 20 pages.

4-B3.Regional analyses of streamflow characteristics, by H.C. Riggs: USGS—TWRI Book 4, Chapter B3. 1973. 15 pages.

Section D. Interrelated Phases of the Hydrologic Cycle

4-D1.Computation of rate and volume of stream depletion by wells, by C.T. Jenkins: USGS—TWRI Book 4, Chapter D1. 1970. 17 pages.

Book 5. Laboratory Analysis

Section A. Water Analysis

5-A1.Methods for determination of inorganic substances in water and fluvial sediments, by M.J. Fishman and L.C. Friedman, editors: USGS—TWRI Book 5, Chapter A1. 1989. 545 pages.

5-A2.Determination of minor elements in water by emission spectroscopy, by P.R. Barnett and E.C. Mallory, Jr.: USGS—TWRI Book 5, Chapter A2. 1971. 31 pages.

5-A3.Methods for the determination of organic substances in water and fluvial sediments, edited by R.L. Wershaw, M.J. Fishman, R.R. Grabbe, and L.E. Lowe: USGS—TWRI Book 5, Chapter A3. 1987. 80 pages.

5-A4.Methods for collection and analysis of aquatic biological and microbiological samples, by L.J. Britton and P.E. Greeson, editors: USGS—TWRI Book 5, Chapter A4. 1989. 363 pages.

5-A5.Methods for determination of radioactive substances in water and fluvial sediments, by L.L. Thatcher, V.J. Janzer, and K.W. Edwards: USGS—TWRI Book 5, Chapter A5. 1977. 95 pages.

5-A6.Quality assurance practices for the chemical and biological analyses of water and fluvial sediments, by L.C. Friedman and D.E. Erdmann: USGS—TWRI Book 5, Chapter A6. 1982. 181 pages.

Section C. Sediment Analysis

5-C1.Laboratory theory and methods for sediment analysis, by H.P. Guy: USGS—TWRI Book 5, Chapter C1. 1969. 58 pages.

Book 6. Modeling Techniques

Section A. Ground Water

6-A1.A modular three-dimensional finite-difference ground-water flow model, by M.G. McDonald and A.W. Harbaugh: USGS—TWRI Book 6, Chapter A1. 1988. 586 pages.

6-A2.Documentation of a computer program to simulate aquifer-system compaction using the modular finite-difference ground-water flow model, by S.A. Leake and D.E. Prudic: USGS—TWRI Book 6, Chapter A2. 1991. 68 pages.

6-A3.A modular finite-element model (MODFE) for areal and axisymmetric ground-water-flow problems, Part 1: Model Description and User's Manual, by L. J. Torak: USGS—TWRI Book 6, Chapter A3. 1993. 136 pages

6-A4.A modular finite-element model (MODFE) for areal and axisymmetric ground-water-flow problems, Part 2: Derivation of finite-element equations and comparisons with analytical solutions, by R.L. Cooley: USGS—TWRI Book 6, Chapter A4. 1992. 108 pages.

6-A5.A modular finite-element model (MODFE) for areal and axisymmetric ground-water-flow problems, Part 3: Design philosophy and programming details, by L. J. Torak: USGS—TWRI Book 6, Chapter A5, 1993. 243 pages.

6-A6.A coupled surface-water and ground-water flow model (MODBRANCH) for simulation of stream-aquifer interaction, by E.D. Swain and Eliezer J. Wexler: USGS—TWRI Book 6, Chapter A6, 1996. 125 pages.

Book 7. Automated Data Processing and Computations

Section C. Computer Programs

7-C1.Finite difference model for aquifer simulation in two dimensions with results of numerical experiments, by P.C. Trescott, G.F. Pinder, and S.P. Larson: USGS—TWRI Book 7, Chapter C1. 1976. 116 pages.

7-C2.Computer model of two-dimensional solute transport and dispersion in ground water, by L.F. Konikow and J.D. Bredehoeft: USGS—TWRI Book 7, Chapter C2. 1978. 90 pages.

7-C3.A model for simulation of flow in singular and interconnected channels, by R.W. Schaffranek, R.A. Baltzer, and D.E. Goldberg: USGS—TWRI Book 7, Chapter C3. 1981. 110 pages.

Book 8. Instrumentation

Section A. Instruments for Measurement of Water Level

8-A1.Methods of measuring water levels in deep wells, by M.S. Garber and F.C. Koopman: USGS—TWRI Book 8, Chapter A1. 1968. 23 pages.

8-A2.Installation and service manual for U.S. Geological Survey manometers, by J.D. Craig: USGS—TWRI Book 8, Chapter A2. 1983. 57 pages.

Section B. Instruments for Measurement of Discharge

8-B2.Calibration and maintenance of vertical-axis type current meters, by G.F. Smoot and C.E. Novak: USGS—TWRI Book 8, Chapter B2. 1968. 15 pages.

Book 9. Handbooks for Water-Resources Investigations

Section A. National Field Manual for the Collection of Water-Quality Data

9-A6.Field measurements, by F.D. Wilde and D.B. Radtke, editors: USGS—TWRI Book 9, Chapter A6. in press [variously paged].

9-A7.Biological indicators, by D.N. Myers and F.D. Wilde, editors: USGS—TWRI Book 9, Chapter A7. 1997 [variously paged].

9-A8.Bottom-material samples, by D.B. Radtke: USGS—TWRI Book 9, Chapter A8. 1998 [variously paged].

9-A9.Safety in field activities, by S.L. Lane and R.G. Fay: USGS—TWRI Book 9, Chapter A9. 1998 [variously paged].