A GUIDE TO SAFE FIELD OPERATIONS

U.S. Geological Survey
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By D.K. YOBBI, T.H. YORKE and R.T. MYCYK

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Water Resources Division Safety Officer
U.S. Geological Survey
Office of the Assistant Chief Hydrologist for Operations
Branch of Operational Support, MS 405
12201 Sunrise Valley Drive
Reston, VA 22092

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ACRONYMS USED IN THIS REPORT:

AC	Alternating Current
CPR	Cardiopulmonary Resuscitation
EF	Electrofishing
GFCI	Ground-Fault-Circuit-Interruptor
IRP	Installation Restoration Program
OSHA	Occupational Safety and Health Administration
PFD	Personal Flotation Device
PVC	Polyvinyl Chloride
RP	Redox Potential
TCP	Traffic Control Plan
TWRI	Techniques for Water-Resources Investigations
US	United States
USGS	United States Geological Survey
WRD	Water Resources Division

INTRODUCTION

Most functions of the U.S. Geological Survey (USGS), Water Resources Division (WRD) require employees to participate in numerous field activities ranging from routine meetings with cooperators, other federal and public officials, and private citizens to potentially hazardous assignments, such as making flood measurements and scuba diving to service underwater instruments. It is paramount that each employee be aware of safety procedures and operational policies of the WRD to ensure that (1) their activities avoid or minimize personal injury to the employee, coworkers, or anyone in the vicinity of the field activity, and (2) their conduct does not infringe on the personal or property rights of any individual or organization.

The purpose of the guide is to familiarize employees with the operational and safety procedures expected to be followed by each employee as a representative of the WRD. It is also intended as a training tool for all new employees and a document to be reviewed by each employee before undertaking a field assignment. It includes general procedures that are standard and applicable to all field operations, such as communication, vehicle operation, and adequate preparation for anticipated weather conditions. It also includes a discussion of specific procedures and safety considerations for most of the routine field assignments undertaken by hydrologists and hydrologic technicians of the WRD. The guide is not intended to be a technical handbook outlining step-by-step procedures for performing specific tasks or a comprehensive discussion of every possible activity that may be undertaken by a USGS employee. Employees are referred to the Techniques for Water-Resources Investigations (TWRI) series for specific technical procedures and to the U.S. Geological Survey Safety and Environmental Health Handbook 445-1-H (USGS, August 1989), USGS Occupational Hazards and Safety Procedures Handbook 445-2-H (December 1993), the WRD notebook on Safety Policy and Guidance Memoranda, and other references for procedures and safety issues related to nonroutine activities, such as operations on large vessels and aircraft.

YOUR ROLE AS A USGS EMPLOYEE

The Bureau and Division are mandated through Executive Order 12196 and Occupational Safety and Health Administration (OSHA) 29 CFR 1960, to establish policies, procedures, and requirements of managers and supervisors to provide training, a safe working environment, and proper equipment for employees to undertake field assignments with minimal chance of personal injury or infringement on the rights of others. However, once you have received training and have been assigned an activity, most of the responsibility for personal safety and that of others is yours. The same applies to infringing on another person's personal or property rights. You will be in the field alone, in most cases, and will have to make decisions based on your training, common sense, judgment, and experience.

Your first responsibility is to think for yourself. Most supervisors have previously undertaken most, if not all, of the activities that you will be assigned; however, each individual is much more aware of his or her own experience, skills, and limitations. Therefore, before you undertake an assignment, review the tasks required and then think about what you need to do and prepare yourself accordingly. If you have questions or concerns about your assignment and equipment, whether it is a policy or safety issue, be sure to request advice or consultation from your supervisor. For instance, if you feel that your equipment is inadequate to accomplish the assigned tasks in a safe manner, you have the right to request that adequate equipment be provided. If you are already in the field and your equipment becomes unsafe to operate, it may be appropriate to make an emergency purchase in order to outfit yourself properly.

Once you have prepared yourself and have begun your assignment, your safety is largely dependent on your attitude. You do not want to be approaching a task with the notion that you can do anything and that you can rely on your strength and ability to avoid personal injuries. Instead, think about each step that you must take to accomplish a task, think about the risks involved, and plan each step to minimize the risks. A "Job Hazard Analysis" would be most helpful. This might, for example, include taking a circuitous route to the field site to avoid backing into or turning across heavy traffic with your vehicle. Also be ready to alter your plan if you are confronted with a potential risk

due to changes in situation. For example, do not go ahead with a wading measurement when the stage is too high just because you have already carried all your equipment to the normal wading section; instead, find a safe wading section or make plans for an alternative measurement. Remember, if you want to complete your assigned tasks free of personal injury, you must be thinking constantly about safety.

As a representative of the USGS, you also need to be aware of how your activities may affect the rights of others and the Division's relations with property owners, cooperators, and the general public. A flippant comment, inappropriate attire (for example, a tee shirt with a vulgar phrase), or driving a vehicle off a designated trail may seriously damage a good relationship or trust built through years of mutual respect between the affronted individual and your office. It also might jeopardize a long-term investigation and federal and cooperator funds that support you and other employees. Once again, think before you act; know why and how you are undertaking an activity, be willing to answer reasonable questions posed to you, be respectful, ask permission before entering private property, and use common sense.

Finally, you are entrusted with a considerable amount of equipment and specialized instruments that were purchased with dollars provided by yourself and other taxpayers. This equipment should be secured and properly maintained not only to minimize loss and damage, but also to reduce the risk of injuries to yourself and others. For example, if you keep a vehicle well maintained, it will have a longer useful life and be less costly to the government; however, more importantly, the vehicle will be much safer and dependable for both you and your fellow workers to operate. Proper use and care of hand and power tools will save on replacement costs, ensure that tools are available, and ensure that they are safe to use.

GENERAL OPERATIONAL AND SAFETY PROCEDURES

This section of the guide discusses policies, procedures, and safety issues that are common to most of our field activities or assignments. It includes training and responsibilities of supervisors, maintaining adequate communication, field preparations, transportation, field situations, operation and maintenance of tools, and safety inspections.

Training for New Employees

Since many of the field activities that hydrologists and hydrologic technicians are asked to undertake are unique to our Division, it is incumbent on the Division to provide proper safety training for new employees and refresher courses for all employees. The USGS Handbooks, 445-1-H and 445-2-H, outline the training requirements for managers, supervisors, and employees. Training will include a combination of formal classroom training, reading assignments, discussions with the supervisor, and on-the-job training. The employee's immediate supervisor has the primary responsibility of ensuring that adequate training is provided.

Training begins with discussions between the supervisor and the employee on the mission of the Division, activities assigned to individual offices, and what is expected of the employee. The supervisor needs to assess the employee's capabilities and maturity, determine his or her previous safety record, determine the type of training and previous field experience, and discuss a specific training plan for the individual. The employee also will need to accurately state his or her previous experience and training, ask questions about the nature of potential assignments, and be confident that the instructions and training will be adequate for the employee to begin field activities.

The training plan for each employee will consist of at least the following elements:

- Orientation for the new employee by the supervisor, administrative officer, safety officer, and office manager.
- Reading assignments—Handbook for New Employees, (USGS, 1990), Field Safety Guidelines for the U.S. Geological Survey, Central Region (Tiball, 1984), excerpts from the USGS Safety Handbook (USGS, August 1989) and appropriate TWRI's.
- Formal initial training and refresher courses—Defensive driving, first aid and cardiopulmonary resuscitation (CPR), boating and water safety, and swimming, if employee is a nonswimmer.

- Supervisory instruction and on-the-job training—Communication with office and others, vehicle operation and maintenance, care and use of instruments and specialized equipment, proper care and use of hand and power tools, hazardous situations in the field, safety inspections, and specific technical procedures to be followed.
- Level I training on ground-water, surface-water, and water-quality principles.

Depending on the nature and location of assignments, other special training may be appropriate including wilderness survival, advanced boating, navigation, scuba diving, techniques for off-road/back-road driving, driving in adverse weather, and aircraft operation.

Communication

Communication, as defined in the American Heritage Dictionary (William, Morris, ed., 1976), is the exchange of thoughts, messages, or the like, as by speech, signals, or writing. Thus, if we are to accomplish our mission and do it efficiently without any personal injury or property damage, we must exchange our thoughts and ideas with each other. Communication is a two-way street: it includes instructions and questions and answers if clarification is needed, it includes letting people know where you are going and why and checking to make sure of safe returns, and it includes contacting others to explain our plans and receive permission to enter on or use the property of others.

Making assignments and conveying instructions for accomplishing assigned tasks is the responsibility of the supervisor; making sure the assignments and instructions are understood is the responsibility of both the supervisor and the employee and this constitutes an effective two-way communication. In addition to specific instructions, the supervisor needs to explain the purpose of the assignment and how it relates to our overall mission. The employee will be in a better position to accomplish the tasks if he or she understands the importance of the assignment and its relation to the other work that we do; the employee will be able to think about the assignments, make plans, and make adjustments to get the job done. On the other hand, the employee needs to be thinking why and how. Why is this task important and how am I going to get it done? If the employee doesn't know, he or she needs to ask questions and gets answers from the supervisor. Supervisors prefer spending extra time repeating instructions and answering questions rather than having an employee return from the field without completing the assigned task.

Communication also is critical (second only to thinking) for safety. Employees must be made aware of potential risks, how to avoid them, and how to get help if an accident does occur. Supervisors need to know where employees are going and when they will return to provide information to searchers and rescuers in case the employees do not return from an assignment. Special communication equipment, such as two-way radios or cellular telephones, are necessary if assignments are in remote locations. Remember to think, communicate, and consider the following procedures to ensure your safety:

- Prepare an itinerary and discuss it with your supervisor, including a list of field sites, a route-of-travel log, motel reservations, and a schedule for "check in" telephone calls to your home or office.
- If going to a remote area, use mobile or portable radios or a cellular telephone if coverage is adequate. Always have fully charged batteries and an extra set of batteries.
- Before entering a remote area, confirm that your communication equipment is operating properly.
- Whether using telephones or radios, keep to your prearranged check in schedule and provide update information or adjustments to your itinerary.

Another important aspect of communication is conveying plans for hydrologic data-collection activities to cooperators and landowners. Almost all field activities are conducted on land or water that is in private ownership or under the jurisdiction of local, state, or federal agencies. Before starting an assignment, contact the appropriate individuals,

discuss plans, and receive permission. Give them a schedule of planned activities and keep them posted on progress. Time spent talking with a public official or landowner may help avoid problems or gain their cooperation for activities in the future. We can do our job only if we have access to collect the needed data.

Preparing for the Field

Adequate preparations before beginning a field assignment will help ensure that you complete assignments, avoid accidents, and return safely. Prepare yourself, plan specific activities and tasks, and check both your personal protection gear and tools and instruments needed for the job.

In preparing yourself, consider the following elements:

- Many of the tasks assigned to USGS employees require strenuous exercise, sometimes under adverse weather conditions. It is recommended that each employee maintain physical fitness through a regular program.
- Learn how to swim, or be prepared to wear a personal floatation device (PFD) if near water.
- Maintain a schedule of physical examinations, as appropriate for your age, with your personal physician or a health clinic. Periodic examinations are available through the U.S. Public Health Service.
- Seek medical advice if you have a limiting medical condition; have an adequate supply of medication on hand for field trips.
- If you have severe allergic reactions to insect bites or stings, carry appropriate serum and instruct colleagues on administering it in case you are incapacitated.
- Learn modern first aid procedures and CPR.
- Learn wilderness survival techniques if you will be working in remote areas.
- Learn to drive off-road 4-wheel-drive vehicles.
- Learn about hazards associated with confined space.
- Recognize hazards associated with field installations.

Adequate planning for field assignments includes:

- Discussing the assignment thoroughly with your supervisor to ensure that you understand what is expected, why it needs to be done, and how it should be accomplished.
- Know where the nearest emergency medical facilities are located; make plans on how to contact these facilities if you are alone and severely injured (cellular phone).
- Reviewing maps, property descriptions, and notes made by yourself and others on previous visits to ensure that you are aware of site conditions and potential hazards that may exist.
- Reviewing technical manuals, memoranda, previous field inspection notes, and safety procedures.
- Preparing a schedule for completing individual tasks and making a list of required instruments, tools, and supplies.
- Contacting landowners and public officials to inform them of your plans and receive permission for access.
- Having your plans and schedule reviewed by your supervisor or another individual with substantial field experience.
- Checking weather forecasts.

Appropriate personal gear may include:

- Adequate clothing for weather conditions.

- Proper foot gear that you will need for field work, including hiking boots, steel-toed safety shoes, hip boots, and waders. Too many people wear shoes with no heels to climb ladders and descend steep slippery slopes.
- Hats appropriate for weather conditions; a light-weight hat with a visor for warm, sunny conditions and a wool stocking cap for cold weather. A hard hat is recommended while working on bridges, inside gaging stations, and during all construction activities.
- Safety goggles, work gloves, dusk masks or respirators, and earplugs.
- A PFD is required when working on bridges, boats, cableways, or while wading streams.
- An orange fluorescent vest is required while working on bridges or surveying on or adjacent to highways.
- Avoid field work during hunting season or in intensively hunted areas. If work is required, always wear hunter orange clothing. Know when hunting season is scheduled and where it is permitted.

A list of required tools, instruments, and supplies should be made when planning your trip, and these items should be checked to ensure they are in good operating condition before you start your trip. Bring along a first aid kit, flashlight, compass, PFD, matches, cellular phone, insect repellant, suntan lotion, drinking water, machete, and a triangular-shaped reflector device.

Transportation

The common means of transportation for hydrologists and hydrologic technicians involved in field activities are passenger cars, vans, light trucks, and small boats. The operation and maintenance of these vehicles will be discussed in this section. Individuals using aircraft, all-terrain vehicles, snowmobiles, and horses are referred to references in the back of this guide for guidance and instruction. Specialized training is recommended before using any of the atypical means of transportation.

Accidents involving cars and light trucks account for most of the serious injuries among field personnel. Therefore, it is incumbent on the managers and supervisors to provide training for safe vehicle operation and to ensure that operating and maintenance procedures are adhered to. Instructions on appropriate use and care of vehicles, and a defensive driving course should be scheduled for each employee as soon as they enter on duty. It is USGS policy to report personal injuries and property damage promptly and accurately. Any work-related accident must be reported to your supervisor within 3 workdays that results in damage to Government-owned or leased property of greater than $50 and/or personal injury.

The first step in safe vehicle operation is an inspection of a vehicle before beginning a trip. This inspection will include:

- Checking for adequate fuel supply, engine oil, and coolant.
- Testing of headlights, tail lights, and turn signals.
- Checking all belts and hoses.
- Checking windshield washers and wipers.
- Testing brakes and checking tires
- Checking to be sure that all equipment is properly stored and secured. Any piece of equipment or tool could become a flying projectile during a sudden stop or accident.
- Checking and adjusting rear-view mirrors.
- Ensuring vehicle is equipped with adequate safety and emergency equipment.

Another step required for a safe trip in your vehicle is a preplanned schedule and route to save time and avoid known road hazards. Plan your trip to allow for a mix of driving and rest or other activity. For long trips, plan on rotating drivers. Also, plan your route to avoid potentially dangerous situations, such as having to

back out onto a busy highway or traversing a flooded section of highway. A few guidelines for highway and back road travel follow.

- Wear safe seat belts.
- Always drive defensively.
- Obey the speed limit and traffic signs.
- Be aware that road surfaces are very slippery after a brief rain and heavy rains may cause excessive accumulation of water on the road surface and hydroplaning of the vehicle. Adjust your speed accordingly.
- Do not ford a stream or flooded road section without first checking for deep holes or washouts.
- Test brakes after fording a stream or any deep water; they probably will be wet and not as responsive as normal.
- Be aware of weather conditions. A dry road or track going into a field site may become wet and impassable coming out after changes in weather conditions.
- Be especially cautious on logging and mining roads. Logging trucks have the right-of-way on a logging road. Expect loaded logging, ore, and coal trucks to take up the inside of curves even when traveling on an outside lane.
- Be especially aware of wild animals and open-range livestock while driving at night when animals tend to be on the move and transfixed by headlights.
- Avoid traveling during snow and ice storms. If you must travel, maintain a safe speed and test for traction frequently. Learn how to drive safely and handle your vehicle in severe weather conditions. Use proper equipment (i.e. snow tires and chains).
- Drive only on existing, well-established back roads or trails. Avoid driving on agricultural fields, open pasture, fragile desert, alpine, or other unsafe areas.
- Always attempt to park your vehicle completely off the road surface and shoulder. If this is not possible, use orange pylons, traffic cones, reflectors, emergency flashers, etc., to warn approaching motorists.

In the Field

Whether you are on a one-day trip to measure observation wells or an extended trip to run indirect measurements of flood discharges, you will be subjected to many natural and manmade dangers. These include varying weather conditions, rough terrain, animals, and manmade structures such as flood control and drainage structures, overhead power lines, cableways, stream gage houses and stilling wells. Many of the structural dangers related to our work will be discussed later in this report in the sections dealing with specific field procedures and related safety issues. The natural dangers likely to be encountered in the field are discussed thoroughly in the report, "Field-Safety Guidelines for the U.S. Geological Survey, Central Region," (Tiball, 1984). The most common risks faced by hydrologists and hydrologic technicians of the WRD are summarized below.

Weather

Normal comfort temperature range for man is between 60 and 90˚F. Beyond these limits various precautions become necessary, depending on tolerance and adaptation to extremes. Most cases of **hypothermia** (condition of reduced body temperature that results in rapid mental and physical collapse) develop in air temperatures between 30 and 50˚F. Hypothermia is aggravated by wet clothes, wind, hunger, and exhaustion. The best way to avoid hypothermia is to take more clothes than will be needed and to dress appropriately with layers of clothing and adequate headgear. Layers of clothing can be removed or added as the temperature changes. Prepare yourself for working in cold environments by:

- Acclimating yourself to conditions by scheduling moderate exercise outdoors with frequent breaks in sheltered areas.
- Carrying a sleeping bag, blanket, and a small stock of food in the field vehicle.

- Carrying replacement clothing, particularly for items that may become wet.
- Carrying good rain gear and using it before clothes get wet.
- Being aware of the conditions that lead to hypothermia.
- Leaving a detailed travel plan before venturing into remote or untraveled territory.
- Keeping informed of local weather conditions. Don't get caught in severe weather.
- Learning and practicing cold weather survival techniques.

The opposite physiological condition is **hyperthermia**, in which heat in excessive amounts can create a life threatening situation. Temperature, humidity, and physical exertion all contribute to this condition, but body hydration is the most important factor. Prepare yourself for working in hot environments by:

- Wearing light-weight, light-colored clothing.
- Wearing a wide-brimmed hat.
- Acclimating yourself to conditions by scheduling moderate exercise in the direct sunlight with frequent breaks in a shaded area.
- Drinking a moderate amount of water on a regular schedule. Normal water requirements in temperate regions is about 2-$^1/_2$ quarts per day; desert conditions will require more.
- Scheduling the most physically demanding activities in the early morning and late evening to avoid the heat of midday.
- Being aware of the warning symptoms that lead to heat exhaustion, heat cramp and heat stroke induced by heat.

Sun exposure can cause first and second-degree burns, and you should be aware of your susceptibility to burning. It is recommended that you wear protective clothing and cover exposed skin with sunscreen. Remember that the intensity of radiation is greater at high elevations and exposure is increased where light is both direct and reflected from light surfaces, such as snow and sandy areas.

Thunderstorms are a serious danger while working in the field. Lightning is the storm's worst killer, but the intense rains, hailstorms, and wind associated with these storms can create dangerous conditions. Frequent monitoring of weather reports is important for scheduling your activities to avoid extreme weather conditions. While working in the field, keep an eye on the weather and notice whether towering cumulus clouds that mark the location of thunderstorms are approaching your work area. The safest place to be during a thunderstorm is in the field vehicle with doors and windows closed. General guidelines for avoiding dangerous conditions during thunderstorms are:

- Stop making wading, bridge, or cableway measurements and seek shelter in a structure or your vehicle.
- Do not use the telephone or work on electrical lines or steel structures, such as bridges or cableways, because a lightning strike some distance away could affect you.
- If you are on a ridge or peak, get down to a lower elevation, preferably a level bench.
- Avoid isolated trees; seek shelter in dense stands or clumps of young trees.
- Sit on your feet in a crouched position or sit on some insulating material, such as wood, rubberized material, or a wool shirt.
- Be aware of flash floods, avoid stream crossings, and move vehicle and equipment to higher ground.
- Seek shelter from high winds and tornadoes; avoid high trees and find a sheltered draw. If you feel a sudden violent wind or sight a funnel-shaped cloud, seek shelter immediately by lying flat in a depression, ditch, or culvert.

Additional information on thunderstorms and lightning can be found in National Weather Service NOAA/PA 83001 (June 1985).

Terrain

Working in and around streams and rivers will subject you to many conditions in which the local terrain may cause slips and falls that could result in serious injury to you and your coworkers. You can't avoid all potential dangers, but you can minimize the risk of accidents by considering the following guidelines.

- Wear shoes or boots that provide good arch and ankle support instead of low-cut sneakers.
- Inspect the area before beginning work and locate gopher, muskrat, or other holes; isolated rocks and boulders; fallen logs; loose and slippery rocks; and other obstacles.
- Select a level work area and remove debris that could cause you to trip and fall. It may be necessary to cut tall vegetation to be sure the site is free of obstacles. Carry a machete in a sheath to cut vegetation instead of plowing through dense vegetation or taking another route over treacherous terrain to avoid dense vegetation.
- If you must travel some distance from your vehicle, avoid taking shortcuts across treacherous terrain; consider the time lost by an accident than by going the longer and safer way around.
- Avoid steep slopes with loose rocks and boulders that could come loose and tumble down the slope.
- Select sites for wading discharge measurements very carefully; keep in mind both the hydraulic characteristics required and safe conditions for accessing and wading the stream.
- Traverse streams carefully and use a wading rod or stout stick to probe the bottom in advance. If you find deep holes or a highly irregular bottom, look for another section.
- Be careful while walking on rocks and boulders in streams; they are usually very slippery. Consider wearing some type of sole gripper to give you additional traction.
- Wear a PFD when working in and around streams, rivers, and lakes.

Animals

There are numerous animals that may represent a risk. Snakes and insects are probably the most common nuisances that you will face, but other reptiles and domestic and wild animals can cause serious injury, illnesses, and fatalities.

There are four snakes in the United States that are poisonous and should be avoided: rattlesnakes, cottonmouth, copperhead, and coral snakes. There are numerous species of rattlesnakes throughout the U.S. Cottonmouths and coral snakes generally range from the Carolinas through Florida, westward to Texas, and up the Mississippi Valley. Copperheads are found in much of the eastern U.S. and parts of Missouri, Arkansas, Oklahoma, and Texas. The most effective defense against snakes is to avoid being bitten. The following precautions should be taken to minimize the risk of snakes while working in the field:

- Familiarize yourself with the description and habits of all poisonous snakes indigenous to the work area.
- Wear protective clothing, including boots and knee-high or full-length leggings in prime snake terrain.
- Be observant and look before you step or reach for something.
- Use existing trails and use a walking stick to clear vegetation ahead of you. Don't step over logs without looking on the other side first.
- Don't climb among rocks where you have to reach above your level of sight for a handhold.

- Don't pick up rocks or other objects that might conceal a snake. Turn the object toward you with a stick or shovel. This could shield you from being bitten.

Insects generally are a nuisance while working in the field, but they can be dangerous depending on the type of insect and your reaction to their sting or bite. Stinging insects, which include honey bees, killer bees, wasps, yellow jackets, hornets, and ants, are painful and can be dangerous to individuals that are allergic to the venom. The yellow jacket and hornet are the most dangerous because they are aggressive and can inflict multiple stings. You may be allergic to venom or you may develop an allergy with each new attack. Reactions can range from fever, light-headedness, hives, and painful swelling to a sudden drop in blood pressure and breathing difficulties. Biting insects, such as mosquitoes, chiggers, ticks, and various flies, are generally of less immediate hazard than stinging insects, but they may be carriers of disease. Ticks are the major carrier of disease in the U.S., transmitting Rocky Mountain spotted fever, Colorado tick fever, tularaemia, and relapsing fever or tick paralysis, and Deer ticks-Lyme disease.

Members of the spider family are another concern in both the field and office in certain parts of the country. Those of most concern are the black widow and brown recluse spiders and the scorpion. The spiders range widely in the temperate region and tend to seek dark hiding places. Scorpions range from the Gulf States to California and north into the dry areas of the west. Scorpions tend to seek shelter under bark, litter, sand, or rocks and may crawl into shoes, gloves, etc.

Keep in mind that there is just as much danger of falling off ladders and cableway platforms from trying to avoid bee stings as from the actual sting.

Common precautions against members of the spider family and insect bites and stings are:

- Wear clothing that makes access to the skin difficult.
- Avoid tramping through heavy vegetation if another choice is available.
- Be observant of wasp nests, hornet hives, and ant hills.
- Use insect repellants on exposed skin and at openings in your clothing. Spraying pants cuffs and socks is a good preventative for chigger bites.
- In the case of ticks, inspect clothing and exposed skin periodically during the day, and disrobe completely and inspect your skin at the end of the day.
- Obtain immunization in advance if you are allergic to stings or will be working in an area with infestations of disease carrying insects.
- Carry appropriate medication for allergic reactions and inform your coworkers about how to administer it.
- Watch out for characteristic dense webs of spiders.
- Avoid reaching into dark places where you can't see and be careful picking up rocks and clothing that have been lying on the ground.

Other animals may be a dangerous depending on whether you surprise them or represent a threat to their young, food, or territory. Most wild animals will be frightened away at sight, but the more domestic they are and the more familiar they are with humans, the less likely they will run from you. Because of this, dogs probably represent the greatest threat while in the field.

Significant animal threats also come from bears, moose, bulls some domestic livestock. These animals may actually chase people, so don’t challenge them. Expect animals to defend their territory. Refer to the discussion of bear behavior by Brew and others (1978). Numerous smaller mammals are likely to be afraid of humans, but don’t count on it. For instance, beware of porcupines and skunks that cease to flee and raise their tails vertically. They fight with their tails and the field person may become a target for flying quills or noxious excretions. The following guidelines are recommended to avoid animal attacks while in the field.

- Avoid surprising animals by making noise while traversing a trail or open country.
- Choose open terrain with good visibility.

- Make a wide detour around any animals with young, or over a fresh kill.
- Avoid walking in pastures or fields with domestic bulls.
- Avoid any animals acting abnormally. Many smaller mammals, including the coyote, fox, badger, raccoon, skunk, and squirrel may bite and transmit rabies.
- Carry a walking stick to fend off attacks from domestic dogs.
- Watch out for rodent nests. New rodent nests must be noted for future removal.

Poisonous Plants

The most common problem with poisonous plants is the allergic reaction that individuals have to the sap of poison ivy, poison oak, and poison sumac. The sticky sap of each plant can cause an allergic skin reaction of varying intensity depending on the amount of contact and the degree of susceptibility of the individual. The sap can be transferred directly by brushing against or handling the plants and indirectly from tools or clothing and from smoke of burning plants.

Avoid allergic reactions to poisonous plants by:

- Learning to identify poisonous plants and avoiding contact.
- Wear gloves and protective clothing when contacting plants cannot be avoided.
- Remove contaminated clothing as soon as possible and wash immediately to avoid contact by other individuals.
- Wash affected skin with abundant soap and water.

Some plants are poisonous to eat, and it is advisable not to eat any wild plants unless you have knowledge of safe plants and plant parts.

Equipment

Each hydrologist and hydrologic technician usually is equipped with and expected to handle a wide variety of tools and instruments. This equipment represents a potential risk to the user if it is improperly maintained and mishandled. It also represents a considerable investment to the government and each employee is entrusted with maintenance security, and proper use.

A fully-equipped field vehicle will include a tool box with screwdrivers, wrenches, pliers, hammers, and other small tools. Other standard items in a vehicle may be axes, saws, digging bars, shovels, and tools for making minor repairs to field installations. None of these tools are dangerous if they are used properly, but they need to be used with care and only for their intended purpose.

- Keep tools in a tool box and stow the tool box and larger hand tools securely in your vehicle.
- Keep all tools clean and free of excess oil and grease. A greasy handle could cause a tool to slip out of your hand and cause injury.
- Use a tool belt to carry small, sharp tools instead of your pocket.
- Wear goggles or safety glasses when using hammers, axes, and saws.
- Keep all cutting tools sharp. This will make the job easier and safer.
- Store and carry cutting tools with sheaths covering the sharp edges.
- When using a cutting tool such as an axe, make sure that you have a clear area to swing both above and behind. Do not swing in a direct path toward someone else.
- Replace any splintered handles of hammers, axes, etc.
- Count your tools before starting work and check to be sure all tools have been returned to the vehicle and secured before leaving a work site.

Power tools are a great convenience and can increase our efficiency dramatically, but they probably represent one of the greatest risks for severe injuries. Be careful with power equipment, and this is true particularly while working at remote field sites because of the lack of medical facilities. A deep cut caused by a

power saw that may result in a temporary disability from an accident at home, could result in a death at a remote location.

- Keep all power saws, generators, pumps, and other gas-engine equipment clean and properly lubricated. Always check the lubricant level before starting a gas engine.
- Fill the fuel tank before starting engine, using a funnel or a gas can with a built in funnel. Wipe excess gas off the engine housing before starting. When refueling, allow the engine to cool first.
- Consider using an air compressor and air-driven tools when working at a gaging station to avoid electrical shock.
- Use generators with ground-fault circuit interrupters (GFCI) when working in the field, particularly at streamside or other wet sites.
- Inspect all extension cords and the cords of individual tools to be sure the insulation is intact.
- Always keep the ground continuous. Do not remove ground lug from power tool plug. Never use the ground side for switching.
- Never use a chain saw or circular saw without reading the instructions or receiving instructions from an experienced user. These are probably the two most dangerous pieces of equipment that you will use during routine field activities.
- Keep chains and blades of saws sharp, and replace when frequent sharpening is required.
- Carry a chain saw suspended at your side with the sheathed guide bar pointing to the rear.
- Start a chain saw by setting saw on a clear, level spot on the ground. Do not carry a chain saw with the engine running.
- Wear personal protective equipment, especially goggles, gloves, hearing protection, and safety shoes when operating any power equipment.
- At the end of each work day, close gas valve on all gas-powered tools to burn the gas out of the carburettor. This will prevent a build-up of gum in the carburettor and minimize the possibility of a gas leak in the vehicle. It also will insure easier starting after storage.
- Stow all power tools securely in your vehicle and return them to their assigned storage place upon returning from the field after emptying fuel.
- Do not transport gas-powered tools, with gas left in the fuel tank in a vehicle that does not have a separate compartment from driver and passengers.

A wide variety of instruments in our assigned field tasks ranging from small hand-held levels to sophisticated electromagnetic data loggers and data storage devices are used by WRD field personnel. While the use of these instruments usually do not represent a risk, they are expensive and irreplaceable is some cases, and they should be secured and protected from damage or theft. Instruments and other sensitive equipment should be stored and transported in protective cases to avoid damage. Levels, pH meters, and other instruments should not be routinely stored in vehicles—they should be stored in an assigned and locked storage area in the office or warehouse. Storage of instruments in cabinets in vehicles provides additional protection from being damaged and also keeps them out of sight of would-be thieves. Locking your vehicle at all times will provide security for the valuable equipment assigned to you.

Maintenance and Storage

One of the activities that is least adhered to because of other pressing tasks is the proper maintenance and storage of equipment and instruments. Many times personnel are rushed when returning from a field trip and do not take time to clean, service, and return equipment to the appropriate storage area. Often, work

is postponed until the next day, but many times it never gets done, and then it may become someone else's problem. This can lead to hard feelings between co-workers, safety risks, and inefficiency. Some actions that may eliminate some of these problems are:

- Prepare an itinerary that includes time for cleaning and resupplying vehicle and cleaning and servicing equipment after the field trip.
- Schedule time during the trip to clean and service equipment after use each day.
- Note any equipment problems on field notes or personal diary as a reminder to get the equipment repaired upon return from the field.
- Inform supervisor or the person responsible for field equipment of the problems or personally insure that the equipment is repaired. At the very least, attach a note to the equipment indicating the problems encountered while using the equipment.
- Maintain a log for each piece of equipment which includes instructions and a schedule for servicing.
- Provide an assigned storage place for each piece of heavy equipment, such as centrifugal pumps, generators, and air compressors, and sensitive instruments. Return this equipment to storage area rather than leaving it in vehicles, loading dock, hallways, or office space.

Safety Inspections

The inspection of all operations, equipment and facilities is a continuous part of each employee's responsibility. The identification of hazards require the routine review of facilities, equipment, and operations by every employee as part of the daily work routine. To maintain a safe work environment, a formal safety inspection of all facilities, equipment, and operations must be made each year to identify potential hazardous or substandard conditions. The inspections must be made by qualified personnel who are knowledgeable of the appropriate safety standards and procedures. Any condition identified as not meeting established standards or creating a risk to the safety or health of the employee, or other employees, or to the public must be reported and brought to the attention of the responsible supervisor for corrective action.

Annual safety inspections are required of all areas of every building occupied by USGS employees. High hazard areas such as machine shops and laboratories with chemicals should be inspected semi-annually or more frequently. Areas and items requiring at least once a year inspections include: office and building areas, storerooms and warehouses, streamgaging stations, cableways, and vehicles.

A detailed discussion on safety inspection procedures and suggested check-list for areas and items
can be found in U.S. Geological Survey Handbook 445-1-H (USGS, August 1989).

SPECIFIC PROCEDURES AND SAFETY ISSUES

This section of the guide discusses specific procedures and safety considerations for most of the routine field assignments undertaken by hydrologists and hydrologic technicians of the Division. It includes discussions on safety guidelines that need to be observed when undertaking surface-water, ground-water, and water-quality activities.

Surface-Water Activities

Procedures and guidelines to avoid personal injury during wading measurements, bridge measurements, cableway measurements, boat measurements, measurements under ice cover, indirect flood discharge, maintenance of streamgages, and scuba diving are discussed in this section.

Wading Measurement

Discharge measurements using current meters are best made by wading. Wading measurements have a distinct advantage over measurements made from bridges, boats, or cableways in that it is usually possible to select the best available cross sections for the measurement. However, wading measurements represent one of the greatest potential sources of

accidents in the Division. The wide range of conditions, combined with the relatively large number of measurements made by wading, creates the high potential for accidents. Constant awareness of wading dangers and weather conditions needs to be maintained to avoid accidents and potential injury. Listed below are some safety guidelines that need to be observed:

- Review the field folder to determine the best section for making wading measurements. Also determine if any potential risks are noted and the maximum velocity and depths that may be encountered.
- Determine whether the river stage is rising or falling. Beware of rapid rises in river stage when wading and anticipate and allow for changes in flow conditions at the end of the measurement. It is a good idea to select an object (rock, stump, mark along bank, etc.) that is just above water surface and keep watching it to determine if the river stage is rising or falling.
- Always probe the stream bed ahead with a rod when moving from bank to bank. Keep your feet spread apart and alignment of legs parallel to the flow for better stability.
- If the velocity becomes too great for safe wading do not turn around, because when the greater area of the front or back of the body is exposed to the current, you may be swept downstream. Back out carefully, bracing yourself with the wading rod.
- Don't try to break the station discharge record for the maximum wading measurement.
- Wear a PFD when wading and conducting discharge measurements. Tie the tagline securely so that you may pull yourself out, if necessary.
- Don't wear boots or waders that are too tight or too loose.
- Beware of sand channels where pot-holes, quicksand, and scour can be hazardous.
- Beware of slick, steep banks, and swampy areas.
- Watch for debris and ice drifting.
- Beware of streams with partial or thin ice cover and especially of ice-covered streams at the time of incipient breakup. To venture out on such ice, tie yourself to some stable object ashore or overhead, if available. Otherwise, stay off and return on another day.
- At controlled or regulated streams, consult recorder or instruction for pattern of regulation. Contact dam, reservoir or gate operators before entering stream.

Bridge Measurements

Bridges are often used for making discharge measurements of streams that cannot be waded. Equipment needed in making bridge measurements differs from that used in wading measurements in that a portable metal crane is often used to mount a reel and suspend the meter, sounding weights, and cable over the bridge. Power equipment, which may be mounted on vehicles, is used for large rivers. Some bridges are not adaptable for cranes, and bridge boards must be used. On some foot bridges a special rod or handline is used.

Bridges are inherently dangerous because of vehicular traffic. The following safety procedures are recommended when making discharge measurements from a bridge:

- Review field folders to determine any hazards that are noted and maximum depths and velocities that have been observed.
- Know how to use the equipment. Make a dry run with new equipment or unfamiliar equipment at the office with someone who knows how it operates.
- Check the operation of the equipment before leaving the office to make sure that cranes, meters, reels, and motors

are in good operating condition. Perform a visual inspection of batteries used with power cranes. Replace if unusual wear or cracks in the casing are observed.

- Follow the procedures outlined in the Traffic Control Plan (TCP) for each bridge site for placing traffic control devices, and keep a copy in the field folder. The plan must meet Federal standards as a minimum, or State or local standards, whichever prevails.
- Park the vehicle on the shoulder and use colored, revolving beams and emergency flashers on vehicle to warn oncoming traffic, as stated in the TCP.
- Set "caution" signs and plastic cones around work area and assign a person, when necessary, to watch for traffic and debris in the river and shout warnings as appropriate.
- Wear an orange-colored PFD and work gloves.
- Using a reel and crane, either hand operated or power, can be dangerous because of the possibility of getting fingers caught under the cable or having the cable break and fly wildly. If at any time you lose your grip on the hand crank, make no attempt to grab the handle. Let it go! The flying handle can severely bruise an arm or even break a bone.
- When measuring at night, use adequate lights, especially if drift is running.
- Keep a sharp look-out for drift when measuring. Have a pair of heavy duty wire cutters handy to cut loose if drift is snagged.
- Work from upstream side of the bridges if at all possible, so that debris can be spotted moving downstream.
- Provide some device to alert boat operators that a cable is in the water.
- When working from a bridge that has hazardous power lines, provide a permanent warning sign on some part of the bridge directly above or below the hazard to alert the field person of the danger.

Cableway Measurements

Cableways have been used for many decades by the Division in making discharge measurements. Cableways provide a track for the operation of a cable car from which the hydrographer makes a current-meter measurement. Cable cars also support the sounding reel and other necessary equipment. Cable cars are moved from one point to another on the cableway by means of cable-car pullers. Power-operated cable cars are available for extremely long spans.

Properly constructed and maintained cableways and properly operated cable cars are dependable and convenient. The following safety procedures are recommended to be followed when making cableway measurements:

- Review and adherence to the new manual "Streamgaging Cableways" (USGS Open-File Report 91-84 (1991) and WRD Memo No 9142 ("Plan for Insuring the Safety of Cableways") for information on construction, inspection, and maintenance of cableways.
- Review field folder and note any special conditions or procedures to be used at the site.
- Before starting to assemble measuring equipment in the cable car undertake a close inspection of A frames, all cables, cable connectors, and all bolts **at both** banks, if possible. It is especially important that all cable cars be equipped with the necessary safety equipment, such as car pullers, and braking system, and that towers or A-frames supporting the cable should be provided with suitable means of access to the cable such as ladders, climbing bolts, and landing platforms.

- Inspect all areas of the cable car for weak or missing parts, also check operation and condition of the braking system.
- After completing cableway inspection, proceed with setting up necessary measuring equipment in the cable car. When carrying sounding reel and weight, use proper lifting techniques. Caution must be taken in climbing A-frames and towers and getting into the cable car to avoid falling.
- Avoid personnel working under cableway platform when assembling measuring equipment in cable car.
- The cable car, when not in use, must be locked to the cable support by a bar hook. Then the car can be unlocked from the platform without danger of its getting loose. Once the field person is aboard, the car can be easily released without danger.
- A cable-car puller must fit the cable which is positive in its action and grip and which will release the cable readily and without undue effort.
- Before departing the bank where cable car is parked, inspect and take inventory of safety and operational equipment and inspect car for insect nests and cable for fishing lures.
- Wear PFD, hard hat, and work gloves. Carry extra cable-car puller, heavy duty cutting pliers for emergency cutting, sounding reel, insect repellent, and necessary tools for repairing measuring equipment.
- Keep your hands off the cable when the car is moving to prevent possible injury.
- If the river is used by boats, some warning device must be used to alert the boat operators that there is a cable in the water ahead.

Boat Measurements

Measurements made from boats require special equipment not used for other types of measurements. Generally, a cross-piece reaching across the boat is clamped to the sides of the boat and a boom attached to the center of the cross-piece extends out over the bow. The cross-piece is equipped with a guide sheave and clamp arrangement at each end, to attach the boat to the tag line and make it possible to slide the boat along the tag line from one station to the next. Power-operated equipment, which may be mounded on boats, is used for large rivers. The following safety procedures are necessary to prevent accidents or damage to equipment:

- Review field folders to determine potential risks and maximum depths and velocities.
- Select the proper boat and motor for the particular job and maintain them in good, workable condition.
- Follow all safety precautions during trailering, towing, and launching boat.
- After arriving at boat measuring site, locate launching area for the boat. Check this area for snakes and clear any brush.
- Unload boat from top of truck or trailer. Remember to use proper lifting techniques.
- At least two people on board and one on bank
- Boat trailer must have lights rather than reflector
- Operators of boats must be trained in CPR and have completed an approved boating skills and seamanship course.
- Assemble all equipment associated with the boat measurement. Carry spare paddles, horn, cutting pliers, bailing devices, PFD’s, and water jug.
- Stretch a tagline (with white or red flagging attached) across the river and secure it to a tree or stake with a cable grip. Wear a PFD, work gloves, and be observant for boat traffic. Provide an

advanced warning to the boaters such as a compressed air horn, buoys, or flashing lights. Warning devices should be positioned $^1/_4$ mi upstream and downstream of tagline. Remember, the only practical way to avoid tagline accidents is to engage a tagline release person and provide them with equipment to release the tagline quickly.

- Avoid or take special precautions in the vicinity of canal siphons, pumping intakes, bridge piers, docks, locks, and dams.

The essence of boating safety is keeping out of trouble rather than getting out of trouble after you get into it. The operator of the boat is responsible for knowing all equipment requirements and safety procedures for the craft. Employees are referred to U.S. Coast Guard Auxiliary (1986) for detailed boating information and regulations. Some general boating safety guidelines are:

- Distribute weight evenly when loading your boat.
- Know emergency procedures and distress signals.
- In addition to the equipment required by law, carry a first aid kit, flashlight, distress flares, paddle or oars, extra shear pins, bailor or bucket, extra anchor and plenty of anchor line, mooring lines, a good tool kit, compass, reserve fuel and extra spark plugs, emergency water and food, and a transistor radio capable of receiving on the marine band.
- Call for weather report for the area you will be in prior to each trip. Beware of weather, currents, and tide conditions.
- Know and obey state and federal rules.
- Leave a float plan.
- Follow all safety precautions when fueling the craft. Portable fuel tanks should be lifted out of the boat and placed on the dock to be fueled. Don't forget to secure the tank and wipe up and wash down any spillage.
- Pay attention to your boat's handling characteristics and know its capabilities for all types of weather conditions.
- Keep clear of fixed objects and watch out for overhead power lines.
- Keep the boat in good condition.
- Where possible, have the boat safety checked by U.S. Coast Guard.

Discharge Measurements Under Ice Cover

Current-meter measurements, made under ice cover require special equipment for cutting holes in the ice through which to suspend the meter. Holes of 6-inch diameter are most often cut with a power ice drill. Where impossible to use an ice drill, ice chisels are used to chop the holes. The most dangerous task of ice measurements is determining whether or not the ice is strong enough to support the hydrographer and the equipment. If the ice thickness is questionable for safety, no measurement will be made. Discharge measurements under ice cover are usually made under conditions that range from uncomfortable to severe.

A few reminders that might prevent accidents or damage to equipment are:

- Review field folder and study previous available field notes on hazards experienced at the measuring sites.
- Use appropriate ice drilling and measuring equipment. Power augers must have a dead man switch to stop the auger when the operator lets go. Be sure to have enough sharpened blades for ice drill that could be replaced when needed.
- A minimum of two people must be assigned to make a measurement under ice cover. Especially, when testing the strength of the ice, they should work as a team and observe all safety precautions. PFD’s will be worn at all times during the measurement.
- After arriving at the site, first select the cross section that is most suitable for existing flow condition. This will require crossing the stream; the

hydrographer should test the strength of the ice with solid blows using a sharp ice chisel.

- Ice creepers, strapped on the shoes of boots or waders, are especially recommended for use on steep or icy streambanks.
- After selecting a cross section, stretch a tag line across the stream. Start cutting holes with an ice drill. Be careful, avoid hitting rocks or logs.
- Dress according to the weather conditions; always carry extra clothing for emergencies.
- After holes are cut, start discharge measurement. The meter should be exposed as little as possible to the cold air so that its operation will not be impaired by the formation of ice on exposed parts. When taking velocity counts from hole to hole, avoid slipping on freshly formed glazed ice.

Indirect Flood Discharge Measurements

The measurement of flood discharges at field sites may be impossible or impractical, due to road conditions or high streamwater velocities. Fortunately, technology exists that enables hydrologists to measure peak flood discharges after the fact by indirect methods. These methods require the field surveying of water-surface profiles, from flagged high-water marks, and the geometry of the stream channel which carried the flood.

The field surveying is performed in a timely manner after the flood peak occurrence, and is performed under commonly difficult field conditions. The high-water marks are generally flagged within 24 hours of the crest, when seed lines are fresh. Field conditions can be hazardous and require extreme caution by field people. These conditions can include dead and decaying animals, broken sewer lines, foul humid air, downed power lines and trees, and snakes up in trees. Additional information can be found in Benson and Dalrymple (1967) or Rantz and others (1982).

Electrofishing

Some WRD programs require that biological information on fish be collected to help assess the water quality of a stream. A technique which is commonly used by biologists to collect fish is electrofishing (EF). In this method, an electrical charge in the water stuns the fish so they can be captured and examined.

Electrofishing is an inherently hazardous activity in which safety is the primary concern. The electrical energy used in EF is sufficient to cause electrocution. To protect the safety of the employees involved in EF, the WRD has issued Memorandum 93.19 ("Requirements for WRD Personnel Performing Electrofishing") that presents policy on training, immunization, and procedures and responsibilities.

Construction, Repair, and Maintenance of Streamgaging Stations

There are many hazards associated with the construction and repair of streamgaging stations. By using common sense and by taking proper precautions, most accidents can be prevented. This can be accomplished by reading instructions and asking questions related to the job, including planning of work, research for information in field folders, and reading previous field notes of adjacent sites. The type of structure or repair that is needed should be determined and, if necessary, detailed plans for the construction or repair of gages must be prepared. Construction permits and inspections may be required and you must consult your local building department for up-to-date information. On occasion, contractors may be required to complete the work.

The maintenance of gages needs to be conducted on a regular basis. If maintenance is scheduled and carried out properly, it will result in fewer safety risks and less costly repairs. All manufacturer's recommendations must be closely followed when servicing or trouble-shooting equipment. Instructions associated with equipment operation in the field must be filed in the field folder. All specific information related to the maintenance of the gage must be available prior to technician's departure to the field. The following safety procedures relating to gaging stations are recommended.

- Identify all potential hazards before the construction or repair of the gage. Assemble the list of hazards from hazard elimination logs, and provide it to the field crew.
- Clear away the brush, vegetation, or debris from around the structure using a brush hog, keeping a sharp eye out for poisonous snakes. Hip boots or high-top leather shoes provide some protection against snake bites.
- During construction of gage houses, the excavation must be properly shored to eliminate any danger of cave-ins. Scaffolding should be well constructed and checked before using.
- Before any excavation is started, the location of underground utility lines must be identified. These lines include electric, oil and gas, telecommunications, water, and sewer.
- When doing construction or repair work on the gage structure, precautions must be taken against falls. Portable ladders used to gain access to the roof of a gage house must be well positioned to prevent slippage.
- When doing construction or repair work to the gage structure attached to bridges, precaution must be taken to insure employees safety as well as the safety of the motoring public while working from the bridge. Wear PFD's at all times. Check atmosphere in well before entering and have an assistant and retrieval system available for emergencies.
- When working in a well, be sure that tools are in a safe place where they cannot be knocked into the well. When buckets are lowered or raised, the person below, should wear a hard hat and stand in the farthest side from the trap or well door.
- When entering a well (confined space), proper ventilation in the well is necessary. Some wells may have little or no oxygen. Use a gas monitoring instrument to check for the presence of harmful gases and low oxygen levels. Do not strike a match in a well because of the danger posed by the possible presence of explosive or flammable vapors. Do not work in the well until the deficiency is corrected.
- Carry plenty of rope and complete set of bridge traffic control safety equipment to warn motorists.
- The walkaways, steps, etc., to the gage houses must be checked frequently. Any parts that are decayed, broken, loose, etc. must be replaced promptly. Never paint a wooden walkaway, use a wood preservative.
- Flooring, trap doors, and shelves within the gage house must be checked frequently for safety. Wooden parts will often become weakened by decay and must be replaced.
- Ladders and ladder rungs must be properly secured to and spaced from the gage house walls. Those under water can rust so badly that they become unsafe. When descending or ascending ladders, employees should make sure of their footing and always have one hand gripping the siderails.
- Check for evidences of rodents as a prevention of hantavirus and other infectious diseases. Respirators must be worn during removal of rodent nests and excreta. The inside of the gage house must be sprayed with a chlorine solution (1 cup Chlorox to 1 gallon of water). Access holes for rodents must be found and plugged.

Gage Inspection and Records Removal

It is required to visit the streamgaging stations at scheduled intervals for record removal and discharge measurement. The field folders provide the specific pertinent information associated with each station. All instructions and notes that are related to the particular station must be left in the field folder and transferred

from year to year. Hazards must be well documented in a log and made available to anyone that visits the station.

Upon arrival at the station, one should clear away the brush, vegetation, or debris from around the structure, keeping a sharp eye for poisonous snakes before beginning the inspection and records removal. Open the gage house door carefully and look for unusual conditions that might exist inside. If the station was vandalized, equipment in the gage house may be left in a dangerous condition. Also, look for insects that could be a hazard to you during your work inside the gage house. Brace the door or lid of the shelter so it will not close by strong wind while you are working inside of the gage house. In gage houses with wells or equipped with monitoring manometers, check if there is a supply of oxygen and maintain proper ventilation. The house door should be kept open for at least a few minutes before servicing the equipment. This is because mercury vapor may be present even in ventilated houses.

Do not work inside a gage house with the door closed. Gage house doors are often targets for gun practice. People may not be aware that someone may be behind the closed door.

Share information on any hazard that you discover by leaving a note in the field folder and inside the gage house, and list all hazards on a hazard elimination log. Any problem that field personnel encounter in the field must be corrected immediately, if possible. A problem left unresolved could become a serious hazard.

Keep the inside of the gage house clean.

Scuba Diving

Occasionally it is necessary for Survey personnel to conduct scuba diving activities in support of data collection and environmental studies. Scuba diving is a potentially high risk operation and therefore requires special control and procedures to protect employees from accidents. Compliance with OSHA regulations is required as specified for scientific diving. No scuba operations are permitted without meeting every requirement of the OSHA regulations.

Safety considerations include:

- Always dive with another person; use the buddy system. Stay together continuously.
- Avoid decompression, dive within your limits.
- Make the deepest dive first.
- Control buoyancy; don't overweight yourself.
- Always display the dive flag while diving.
- Avoid strong currents and begin dive against current.
- Equalize pressure early and often.
- Develop and use methods to communicate underwater.
- Limit depth to 100 feet or less.
- Breathe regularly and be aware of the hazards of breath holding.
- Stay aware of air supply while diving.
- Ascend carefully and slowly.
- Leave water when shivering, tired, or injured.
- If diving in an area where gates are being moved using electrical power, coordinate the dive with the gate tender to avoid movement of the gates while the diver is in the water.

Ground-Water Activities

This section of the guide discusses safety issues that are common to most of our ground-water activities. It includes procedures and guidelines to avoid personal injuries when conducting well inventory, collecting water-level data, instrumenting and repairing observation wells, drilling observation wells, conducting aquifer tests, geophysical logging of wells, and conducting surface-geophysical measurements.

Well Inventory

Wells are the primary source of ground-water data. Well inventories, either for project investigations or for basic data collection networks, usually require an intensive search for a large number of wells in a localized area. Data collection in most project wells are discontinued in a few years upon completion of the

project. Wells included in the basic data collection network are selected to represent regional coverage and various ground-water conditions and are usually operated for long periods of time.

Private landowners, their dogs, and some of their livestock (bulls, horses, certain breeds of cattle, buffalo, boar, hogs, etc.) must be recognized as potential risks while conducting well inventories. Consider the following recommendations:

- Contact property owners beforehand and obtain permission to access the property. Obtain as much information as possible from the owner about possible hazards. If the site will be visited regularly, make notes on potential dangers so that subsequent field personnel will be forewarned.
- Minimize disturbing livestock and fowl.
- Stay on roads or trails with vehicles to avoid damage to vehicles, pastures, crops, etc. Catalytic converters can start grass fires. Leave all gates as found (open or closed).
- Be careful of wells with pumps in operation and avoid contact with moving parts and electrical wiring.
- Carry a clipboard as protection from small hostile animals and for keeping data while at the field site. Carry a large crescent wrench or walking stick to ward off larger hostile animals.
- Survey the site watching for snakes, animals, insects, water, and other hazards.
- List all the hazards on a hazard elimination log.

Collecting Water-Level Data

Fluctuations of water-levels in aquifers are obtained primarily from direct measurements with a steel tape, battery powered electric tapes, air lines equipment with pressure gages, and graphical or punch tape stage recorders. In recent years, electronic pressure transducers and data recorders have been used to measure water levels.

Collecting water-level data with a steel or electric tape is a relatively safe activity, but a few simple procedures must be followed to minimize personal injury and property damage. If the well is pumping, special precautions must be taken.

- Determine as much as possible about the types of pumps you will be working with and the position of the pump intake. Take care not to have the tape pulled into the pump intake.
- Stay clear of unprotected rotating drive shafts or belt drives.
- Avoid using weights attached to tape. The weights could lodge in the pump column or well casing. Be sure that the weights are attached with a hook or wire mesh weak enough to be snapped off if it should become lodged in the well.
- Watch for low doorways and beams in well houses. As you enter the well house, check for rotten or loose floor boards, snakes, biting or stinging insects, slick pump house floors, and inadequate lighting.
- If the pump is electrically driven, check for exposed wires, electrical panels without protective covers and any other possible electrical hazards which might be encountered while working near the pump.
- During measurement of non-pumping water levels, disconnect or open the electrical switch on the pump motor to prevent the pump from starting during the measurement. This will eliminate the chance of the tape becoming pulled into the pump intake. Close the switch when measurement is complete.

Instrumentation and Repairing Observation Wells

Observation wells usually are equipped with digital, punched-tape recorders and are used to monitor changes in water levels and to provide long-term statistics for assessing the impacts of climatic and man-induced changes. Another method uses a data logger with pressure transducers capable of recording very

frequent fluctuations of the water levels in wells. This method is used for short-term projects such as measuring drawdowns during aquifer tests.

Installing instruments and repairing observation wells are relatively safe activities, but a number of procedures listed below must be followed to avoid personal injury or infringing on someone's rights.

- Obtain permission and property access agreement from owner to access site and to install instruments or repair observation wells.
- Read and follow instructions for materials to be used for instrumentation or repairing the well.
- Prepare instrument shelter and attach all fittings in the shop so that the shelter can be positioned into the well casing in the field. Be sure to wear work gloves and goggles when operating power tools.
- Stay on roads or trails with vehicle to avoid damage to vehicle, pasture, crops, etc., and to avoid getting stuck. Leave all gates as found (open or closed)
- After arriving at well site, unload shelter by using proper technique for lifting and moving heavy objects.
- If a generator and power tools are required, be sure they are operated away from grass or brush to avoid a fire or away from water that could cause an electrical shock to the operator. Install Ground-Fault-Circuit-Interrupter (GFCI) when required to prevent shock.
- Clear vegetation, cut tall grass around the well site, and remove all trash from site at each visit, or as needed, to discourage the nesting of snakes, rodents, and insects.
- Be careful while using polyvinyl chloride (PVC) solvents and adhesives. Avoid skin contact and breathing vapors.

Drilling Observation Wells

To obtain information on the subsurface and hydrology of an area, it is often necessary to drill test wells, to collect drill cuttings of formations penetrated by, or to make borehole geophysical studies involving the use of specialized logging equipment. Field personnel assigned to such projects are exposed to dangers when working around heavy machinery, and must have a thorough understanding of the drilling equipment and its operation. The following guidelines must be followed to avoid accidents while working at well drilling sites.

- Obtain written permission for entry to land.
- Plan access to minimize damage to private property.
- Be familiar with the drilling equipment and its operation procedures.
- Drill rig should be fitted with an all around shut down switch bar.
- Before any drilling is started, a site must be selected that is free of any overhead wires, underground cable, pipes, tanks, or buried wastes. Research the historical use of a site and, if warranted, use surface geophysical techniques such as resistivity or EM-31 profiling to indicate potential problems from buried tanks or wastes.
- If it is necessary to set up a drilling rig on a public road, use proper signs, reflectors, and/or flag persons to warn oncoming traffic.
- Be sure to wear the proper clothes and use safety equipment, such as hard hats, gloves, safety glasses, steel-toed shoes.
- Never wear loose-fitting clothes that can be entangled in open rotating gears or belt drives.
- One should be prepared for accidents by being trained on the principles and procedures of first aid and fire fighting, and be equipped with adequate first-aid kits and fire extinguishers.

- Keep the site clear of excess pipe, casing, tools, cables, and rope.
- Be aware of potential dangers such as pinching fingers between lengths of pipe, casing, etc.; tangling hands and feet in ropes or chains, slipping on drilling mud; and touching a hot compressor, generator, etc.
- Never use equipment that is not safe. If a breakdown or problem arises that constitutes a safety risk, the equipment must be shut down until necessary repairs or changes have been made.
- Never allow a drill rig to be operated by only one person.
- Never do repair work on the equipment without first shutting it off.
- Allow a gasoline or diesel engine to cool before refueling.
- Clean up site after drilling and repair any damage to property.
- Drilling at hazardous waste sites such as air bases. Installation Restoration Program (IRP) requires specific training and medical surveillance of the personnel according to OSHA regulations.
- When lightning is observed, discontinue operation.

Conducting Aquifer Tests

Aquifer tests are routinely conducted as part of subsurface hydrologic project activities. An aquifer test involves pumping a well at a constant rate to stress the aquifer. The rate of water-level depletion is measured in the pumped well and nearby monitoring wells and the data are used to determine the hydraulic properties of the aquifer. The fluctuations in water levels are measured either electronically, mechanically, or manually. The hydraulic characteristics of the aquifer are determined graphically or analytically.

The following points need to be considered when conducting aquifer tests:

- Permission must be obtained from the agency, organization, or private person owning or controlling the land. Remember to maintain cordial relations and respect the right of the landowner. Be specific in your communication about the purpose of work and locations where work will be done.
- Manpower and equipment must be able to reach the site safely.
- Protective gloves should be worn during pump installation and removal because the discharge pipe may be slippery or the woven wire cable may be frayed.
- Protect against rotating shafts.
- If a portable generator is used, be sure to use caution when storing and handling gasoline.
- In using electrical motors, care must be exercised to see that the motor voltage, frequency or cycles and phase correspond with those of the power lines. To ensure proper performance of the pump motor, have a licensed electrician connect it to the service line.
- Transport the water away from the site to an area that will not be damaged or flooded. This also will reduce the potential for electrical shocks.
- During long-term tests, schedule adequate personnel. Avoid extreme fatigue; it can impair judgement and physical capability. Recuperate as needed and maintain communications between personnel.
- After test is completed, clean up the site and repair any property damage.

Occasionally, project work calls for aquifer testing with a high-capacity pump. A pump contractor is usually hired to install the pump, maintain it in running condition throughout the test, and remove it when the test is completed. The responsibility of the employees assigned to the site is to:

- Stand clear of the site while the pump is being installed or removed.

- Wear a hardhat at all times.
- Use earplugs.
- Insure that the contractor cleans up the site and repairs any property damage.

Geophysical Logging of Wells

Geophysical logging sometimes provides the only means of obtaining subsurface information. Geophysical logging can be used for determining geologic formations, aquifer characteristics, and physical properties of wells. Most geophysical logging equipment used by the USGS is permanently mounted on heavyweight carryall trucks. The equipment includes a single or multi-conductor cable and a pen and ink recorder and solid-state recorders. Data are collected by lowering sensing devices in the borehole and recording the data on a graphic chart and magnetic tape. The logger also is useful for collecting water samples at different depths by lowering a sampler into the well. The logger is generally powered by a generator, and the cable is raised and lowered with a power winch.

To minimize the potential for accidents, consider the following guidelines.

- Contact the well owner and request permission to log the well. Keep the owner informed of your plans and schedule.
- Use common sense around logging equipment. Be aware that you are working around water and 120 volts of electricity. To avoid electrical shock, wear rubber boots.
- Check probes and generator before leaving office. Inspect cable and connectors for rust and wear.
- Wear fitted clothing and stay clear of the winch and pulleys when probes are being lowered or raised to avoid getting clothing caught. A helper often must attend to the cable to work the probes past tight spots and to clean the cable as it comes out of the hole.
- Handle cable with heavy gloves to prevent burns and cuts from cable.
- Tension on cables must be monitored at all times. Particular care must be exercised when pulling probes out to avoid breaking line if tool becomes stuck.
- When lightning is observed, discontinue operation and remove probes from well.
- Be aware of radiation risks and take the necessary precautions when logging with a nuclear source. In order to operate a nuclear-source tool, the operator must be trained and certified. The greatest danger may be to an untrained helper who may get long-term exposure.

Surface Geophysical Measurements

Surface geophysical methods are often used to study the subsurface without the expense of drilling wells. These methods include electrical resistivity measurements, electromagnetic, seismic, magnetic and ground-penetrating radar surveys, and gravity techniques. The electrical resistivity, electromagnetics, and seismic methods are the most widely used for ground-water exploration. Electrical resistivity measurements require an electrode array to detect zones of high or low subsurface resistivity. The seismic surveys use an energy source such as explosives or hammers and an array of receivers to detect velocity difference between different earth materials.

Personnel who conduct surface geophysical surveys must have a thorough understanding of the equipment and its operation. General guidelines to follow are:

- Contact all property owners and obtain permission to conduct the surface geophysical surveys. Keep owners informed of your plans and schedule.
- Make sure all equipment is in good operating condition. Check all equipment and power source prior to leaving the office. Replace any frayed, cut, or damaged cords or plugs.
- Follow all instructions when operating the equipment. Incorrect connection of wires could be dangerous to the operator and the equipment.

- Respect the energy source and properly ground all instruments. Discontinue use of any equipment that causes an electrical tickle or shock. Use GFCI's in the lines.
- When working along roadways, use caution, place cones around work areas, stay off the roadway if possible.
- Use special caution when operating equipment with high-voltage output. Never tamper with the equipment during operation and only service it when the unit has been properly discharged.
- Any use of explosives is potentially dangerous and requires special training and preparation. Employees must not work around a site where explosives are being used without receiving training on specific operation and associated hazards. Check to see if permits are required from local jurisdictions. Adequate communication between the explosives operators is essential—they should be properly trained in use of hand signals and hand-held radios.

WATER-QUALITY ACTIVITIES

Water samples are collected under a wide range of conditions and the work can be dangerous. A knowledge of the hazards involved and means by which they can be minimized should be helpful in preventing accidents and in providing greater safety for sample collectors. It is the responsibility of every field person to take proper precautions to insure their own safety and the safety of others while collecting water samples. Follow normal field safety precautions regarding weather, insects, heat, dehydration, etc., and follow the recommended procedures and precautions for wading, boat, bridge, cableway, or ice measurements. Especially, pay attention to dangers present in the vicinity of the sampling site. List all specific instructions in field files for safety procedures according to TWRI's or established standards.

Collecting Samples from Streams, Rivers, and Lakes

Taking samples from streams, rivers, and lakes for water-quality analysis has unique safety risks. The inability to swim and difficulty in freeing oneself of burdensome equipment or waders if suddenly plunged into deep water are perhaps the most serious risks in taking samples. Remember to always wear your PFD and make sure it is in good condition. Keep your feet spread apart and body aligned parallel to the flow and don't fight the water. At cableways, remember to inspect anchorages at both banks, if possible, and look for signs of excessive wear, vandalism, or accidental damage to the equipment. At bridge sites, follow all State laws for blocking traffic, wear high visibility vests with reflective strips, post appropriate signs at each end of the bridge, and be alert for wide loads and large trucks which may extend over the walkway. Develop a plan for each bridge site for placing traffic control devices. When working on ice, there is no substitute for experience. When possible, work with someone who is experienced working on ice. Be aware of the temperature, whether the stage is rising or falling, and whether the ice is strong enough to support your body and equipment.

Water is a carrier for many disease-producing organisms. Appearance alone is no way to judge the safety of the water. Water-born hazards may come from material dissolved in the water, suspended in the water, or in sediment of the stream bottom. Infections or disease can enter the body through accidental ingestion by mouth or through skin broken by injury or another infection. The following guidelines must be used for protection of personnel working around polluted water:

- Assume the water is polluted.
- Wear rubber gloves to avoid contact with water, especially if it is suspected of being contaminated.
- Obtain immunizations for known hazards.
- Equipment for each personnel should include separate supplies of drinking water, wash water, soap, and a disinfectant.

- Wash water, soap, and disinfectant should be used after all sampling even if the sampled water appears to be uncontaminated.
- Protect feet with waders while in mud or water. Remove waders before washing hands; remember, they may be more contaminated than the current meter or sampler.
- Protect wounds on hands with rubber or plastic gloves.
- Avoid contamination of water, places, or people with your equipment or waders.
- Avoid carrying a pencil in the mouth while sampling or stream gaging.
- Avoid rubbing eyes.

Sampling Wells

There is no single sampling method that will work best for all wells. A number of methods are currently in use for sampling wells. The equipment ranges from simple to refined, including bailers, gas-driven samplers, bladder pumps, syringe devices, electric submersible pumps, suction-lift pumps, air-lift samplers, and gas-driven piston pumps. In selecting a sampling method for a well, a number of details must be considered. Among the considerations are the portability of the equipment, depth to water, well diameter, water volume, ease of cleaning the equipment, method by which the sampling device brings the water to the surface, and reliability of the equipment.

Due to the great variety of physical equipment and field situations in well water sampling, it is impracticable to list a detailed set of safety rules and standards applicable to this activity. Collecting ground-water samples has its own special risks. Follow normal field-safety precautions and procedures for ground-water activities. General guidelines to follow are:

- All routine field safety and equipment and procedures must be followed at all times.
- Know as much as possible about the types of pumps you will be working with.
- Follow specific instructions on instrument operations provided by the manufacturer.
- Make sure all equipment is in good operating condition. Check all equipment and power sources prior to leaving the office.
- Before using any pump, be familiar with its operation, and for installed pumps, review procedures in the field folder for the site.
- Electrical sources are potential hazards. Electrical sources, batteries, generators, or existing AC can cause shocks. Respect the energy source and properly ground all instruments.
- Gasoline is a source of potential contamination, fire, and fumes; gasoline must be stored in approved containers. Pumps and generators must be fueled and oiled away from the area of operation.
- If the site is in a well house or spring house, watch for low doorways and beams inside. As you enter, check for rotten or loose floor boards, slippery floors, snakes, and biting or stinging insects.
- Check for exposed wiring, open electrical panels, and any other possible electrical hazards which might be encountered while working near the pump.

Sample Preservation and Shipment

Chemicals, supplies, and equipment used in the collection and preservation of water-quality samples may be dangerous to both field personnel and to passers-by if precautions are not followed. Most preservatives are either corrosive or poisonous and contact with them must be avoided. Buffers, standards, and filling solutions also are potentially harmful and it is a good general rule to also avoid contact with them. The following safety rules must be practiced when handling preservatives:

- Protective gloves, clothing, and eye wear must be worn when handling hazardous chemicals.
- Carry a sufficient volume of water and antiseptic washes to rinse any accidental spills. Baking soda is a good all purpose substance to absorb acid spills in trucks.
- Avoid spillage and personal contact and have appropriate clean-up kits.
- Wash gloved hands thoroughly with disinfectant soap after sampling and discard gloves properly.
- Be careful when handling acid ampoules to avoid cuts splashes, and breathing fumes. Wear eye protection devices (goggles or face shield).
- Dispose of each empty ampoule and tip immediately following use and before filling a bottle for the next sample. It is recommended that the two parts of the ampoule be placed in either a wide-mouth glass screw jar or a steel disposal can. The disposal container should be filled to $^1/_4$ volume with tap water to minimize shock breakage to the used ampoule.
- Concentrated acid used to preserve samples should be carried in the smallest volumes possible and practicable.
- If ampoules are used, they should be carried in their original shipping container.
- If a larger volume of acid is needed, it should be carried in a container with non-flammable packing which will absorb spills. The container must be secured in the vehicle so that even if the vehicle is involved in an accident or upset, the acid will not leak out of the container and packaging.
- Avoid rapid heating and cooling of glassware, because it can cause breakage. Do not pick up broken glass with hands. Sweep or scoop the glass up.
- Avoid contact with contaminated water. If contact is unavoidable, wash hands and equipment frequently.
- Special care must be used with syringes. The used syringe must be packaged for disposal so that no one handling the wastes will be cut or gouged.
- Alcohol or other flammable chemicals must be transported in the smallest practical volumes and in closed containers that are secured in the vehicles so they will not leak or break.
- Cylinders of compressed gasses must always be tightly secured in a vehicle and while in use. Gas cylinders must never be allowed to stand upright without being secured.

Follow established procedures for shipping samples to the laboratory and observe proper lifting procedures when transporting water and ice-filled coolers. It is recommended that shipping containers be lined with appropriate water-proof materials to prevent water leakage from melting ice. Use sufficient packing material in containers to avoid breakage of sample bottles.

Operating Field Parameter Meters

A wide variety of meters are commercially available for measuring water-quality field parameters. Parameters commonly measured in the field include alkalinity, dissolved oxygen, pH, specific conductance, and temperature. A less commonly measured parameter is RP (redox potential). Usually parameters are measured independently using separate meters. However, multi-parameter meters also are available.

Standards are used to calibrate the meters both in the office and in the field. All meters must be recalibrated at each site. This means, if the meter is packed up and moved, it must be recalibrated.

Standards should be at ambient water temperatures for accurate calibration. When the air temperature is radically different from water temperature, standards should be placed in a circulating bath of sample water until they are close to the water temperature. Remember, good field data depends on proper care, calibration, and maintenance of field equipment.

The operation of field meters is generally a relatively safe activity. A few reminders that may prevent accidents or damage to the equipment are:

- Keep meters in good operating condition and routinely clean, repair, or replace dirty or corroded connections, cells, probes, or sensors.
- Read and follow instrument manual and become familiar with its operation.
- Protect yourself from electrical shock. Replace or repair any broke, weak, exposed, or frayed wiring. Replace batteries that show any unusual wear or cracks in housing.
- Store and transport meters, probes, and sensors carefully. Equipment and tools should be kept separate as much as possible and carried in such a manner as to minimize damage from vibrations and jostling.
- Meters and probes should not be stored in vehicle over night, if possible. Return meters and probes to the office or lab at the end of each field day.

Installing and Operating Water-Quality Monitors

In recent years, equipment to record measurements of various water-quality parameters every few minutes has been developed and can be installed on stream banks, bridges, or wells. These data are often needed to determine short term and in some cases real time fluctuations in the concentration of these water quality parameters. In many cases, data are needed at remote sites, which have no electrical utilities.

Personnel who install and operate water-quality monitors must have a thorough understanding of the equipment and its operation. General guidelines to follow are:

- Follow all instructions when operating the equipment.
- Make sure all equipment is in good operating condition. Check all equipment and power sources prior to leaving the office.
- When working on bridges, follow the safety procedures discussed in the section on surface-water procedures.
- Follow all safety precautions in the construction and repair of gage structures that may house the equipment.

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