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1.0 What is Texas Stream Team?

Recognizing the size and complexity of the water environment, the time and expense of monitoring water quality, and the significant role that each one of us has in protecting Texas waters, the Texas Commission on Environmental Quality (TCEQ), the U.S. Environmental Protection Agency (EPA), and Texas State University–San Marcos have formed a cooperative partnership to support Texas Stream Team. Texas Stream Team (formerly known as Texas Watch) is an environmental education and monitoring program funded through an EPA Nonpoint Source Pollution (NPS) grant under section 319 of the Federal Clean Water Act.

Texas Stream Team emphasizes communication about the environment, which is based on the premises that water issues are inextricably linked with air, biological, land, and human resource issues, and that the protection of the environment requires the active, positive, cooperative participation of all Texans. Texas Stream Team involves the participation of volunteers, students and faculty, the TCEQ and Texas Stream Team Partners such as river authorities, regional councils, businesses, universities, and other agencies.

Texas Stream Team encourages everyone to ask:

- What questions do we want to answer about the environment?
- What part of the environment are we most concerned with?
- What can I do to help preserve and protect the environment?

For those people whose concerns are centered on water quality, Texas Stream Team helps them to design water quality monitoring programs to address those concerns.
1.1 Water Quality Monitoring and Environmental Education

This monitoring manual presents methods and procedures for volunteers to become Texas Stream Team Certified Water Quality Monitors (CWQMs). Certification enables volunteers to collect water quality data that meet the requirements of the EPA-approved Texas Stream Team Quality Assurance Project Plan (QAPP).

Texas Stream Team has developed this monitoring program with input from the EPA and TCEQ to address the following goals and benefits:

- Standardized training and quality assurance procedures help the volunteer to collect accurate information that can be used in making environmentally sound decisions.
- As recognized by the EPA and TCEQ, volunteer collected, quality assured data can serve to enhance professionally collected data.
- Collection of quality assured data improves understanding of environmental issues and promotes communication and positive cooperation between citizens, professional monitors, and the regulated community.

The Texas Stream Team water quality monitoring manual was first developed not only to provide volunteers with clear instructions on how to collect water quality data, but also to educate volunteers about the importance of the tests and why they are relevant to understanding water quality. This manual also features an educational section on nonpoint source pollution. Texas Stream Team encourages new and veteran monitors to develop a solid grasp of such key concepts as watersheds, stream order, and eutrophication. By bringing nonpoint source pollution into the foreground of sampling projects,

Texas Stream Team directs volunteer monitors to more effective strategies for protecting water resources and for resolving water quality problems that originate at the community level.

Another important development in the Texas Stream Team program is its increasing emphasis on middle school and high school education. To support this emphasis, Texas Stream Team has developed a companion volume that adapts the information in this manual for the classroom. This Curriculum Companion and others can be found on the Texas Stream Team website in the Publications section. These education tools provide teachers with the option of effectively conveying to students Texas Stream Team oriented environmental concepts and skills, either in the classroom or in the field.
### Key Concepts

**What is a watershed?**

Everyone lives in a watershed, or drainage basin, which is defined as a geographic area in which water, sediments, nonpoint source pollutants, and dissolved materials drain into a common body of water. The body of water can be a stream, lake, playa, estuary, aquifer, or ocean. A watershed can be large or small, depending on the water body that is chosen to define it. In a city, the gutters that run along the curb on your street are the drainage outlets for your street’s watershed. The water in your gutters, which drain the small watershed of your neighborhood, flows into the storm drain system and empties into a nearby stream, which drains several neighborhoods in a larger watershed. That stream, in turn, flows into a larger stream or river.

Another example is the Colorado River watershed, which contains thousands of smaller watersheds and is one of the largest watersheds in Texas. All of the smaller watersheds and their corresponding streams flow downhill and converge with each other, forming a tree-like network with the Colorado River as the trunk and its tributaries as the branches. All of the streams, from the smallest branch of Bee Creek to large tributaries such as the Llano River, constitute the river system of the Colorado River watershed.

### Stream Order

Water quality professionals have developed a simple method to categorize the streams of a river system. Streams that have no tributaries flowing into them are called first order streams.

Small headwater streams, also called first order streams, flow into larger streams. The network of streams in a single watershed is known as the river system.
Streams receiving the flow from only first order streams are second order streams. When at least two second order streams combine, the result is a third order stream. This continues until all the streams merge into the largest river, which ultimately drains into a lake or ocean. The order of the stream at the watershed outlet is the watershed order.

**Texas River Basins**

The state of Texas consists of 23 major river basins (watersheds) and has approximately 191,228 miles of streams and rivers. All of these streams drain into the Gulf of Mexico. Of the total stream mileage, 144,603 miles (76 percent) have intermittent flow during some part of the year, which means these streams have portions that are completely dry some of the time. Texas also has approximately 5,700 reservoirs, each with a surface area of 10 acres or larger, for a total coverage estimated at 3,065,600 acres.
1.3 Nonpoint Source Pollution

Getting to the Point

To a large extent, water quality within a watershed is linked to the actions of the people who live, work, and play within its boundaries. Water quality problems caused by human activities can be a result of either point source or nonpoint source (NPS) pollution (see box). A **point source** is a single, identifiable source of pollution such as a discharge from a municipal or industrial wastewater treatment plant. Point sources are regulated under the Federal Clean Water Act and Texas state law and are subject to permit requirements. These permits specify effluent limits, monitoring requirements, and enforcement mechanisms. Even though effluent discharges are permitted and regulated, many of these point sources contribute to water quality degradation.

**Nonpoint sources** of pollution are largely unregulated and have not been evaluated in the same rigorous manner as point source pollution. NPS pollution originates from many different locations. We’ve all seen trash in our waterways following a storm. Other contaminants, not so easily seen, enter our waters in much the same way. NPS pollution occurs when rainfall runoff transports contaminants on the surface of the land into adjacent water bodies. Contaminated storm water can cause impairment to the beneficial uses of streams, reservoirs, estuaries, and oceans. Pollutants carried by water percolating through the soil and aquifer recharge features can contaminate groundwater. Land management activities associated with agriculture, forestry, and residential and urban development can increase NPS pollutants.

| Nonpoint Source (NPS) Pollution: Pollution from sources which are diffuse and do not have a single point of origin or are not introduced into a stream from a specific outfall. The pollutants are generally carried off the land by stormwater runoff. |
| Common NPS Pollutants |
| **Sediment** from croplands, forestry activities, construction sites, and streambank erosion. |
| **Nutrients** from croplands, lawn and gardens, livestock operations, septic systems, and land waste application; sediments from erosion can reduce clarity and sun penetration in bodies of water, harming aquatic plant life and fish. Nutrients can also be carried by runoff from over-fertilized areas or decaying leaves and lawn clippings. Excessive nutrients in waterways can cause excess plant and bacteria growth, resulting in eutrophication (oxygen depletion) and fish kills. |
| **Bacteria** from livestock, seepage from improperly maintained septic systems, leaking sewer lines, wildlife, and urban runoff. |
| **Man-made chemicals**, including pesticides from roadways, croplands, lawns, gardens, and forestry operations; toxic materials, such as improperly applied pesticides or automotive products such as motor oil, engine degreasers and antifreeze; these toxins can wash from city streets and other areas or can result from illegal dumping. |
| **Surface trash**, such as plastic containers or cigarette butts; this trash is not only aesthetically unappealing, but residue from discarded containers can be washed into water bodies. |
NPS Pollution’s Effects on Aquatic Ecosystems

Dissolved oxygen (DO) is a basic requirement for a healthy aquatic ecosystem. Most fish and beneficial insects breathe oxygen dissolved in the water. Some fish and aquatic organisms (such as gar and sludge worms) are adapted to low DO concentrations, but most desirable fish species (such as largemouth bass and darters) suffer if DO concentrations are below 4 mg/L. Insect larvae and juvenile fish are more sensitive and require even higher concentrations of DO to function in a healthy way.

Oxygen concentrations in the water column fluctuate under natural conditions, but severe depletion may be the result of human activities that introduce large quantities of biodegradable organic materials into surface waters. Biodegradable organic materials which include lawn clippings, raw and treated sewage, food processing wastes, rice field drainage, and pulp paper wastes, are some examples of oxygen depleting organic materials that enter surface waters. As these wastes decompose and break down into essential nutrient enriched building blocks, many chemical and biological processes are directly affected. Nutrients are fundamental building blocks for healthy aquatic communities, but excess nutrients (especially nitrogen and phosphorus compounds) may over stimulate the growth of aquatic plants and algae. Excessive growth of these plants, in turn, can clog waterways and interfere with boating and swimming. In addition, these plants will out-compete native submerged aquatic vegetation, and with excessive decomposition, lead to oxygen depletion. Oxygen concentrations often fluctuate widely, increasing during the day as aquatic plants conduct photosynthesis (produces oxygen) and falling at night as plants continue to respire, consuming oxygen.

Fertilizers, malfunctioning septic systems, detergents and organic materials in treated sewage, and manure in agricultural runoff are examples of nutrient sources often responsible for water quality degradation. Rural areas are susceptible to groundwater contamination from nitrates found in fertilizer and manure. Nutrients are difficult to control because they typically recycle among the water column, algae, and bottom sediments. For example, algae may
temporarily but significantly reduce phosphorus from the water column, but the nutrients will return to the water column when the algae die and are decomposed by bacteria. Gradual inputs of nutrients tend to accumulate over time rather than leave the system.

**Detecting and Tracking NPS Pollution**

Nonpoint source pollution is episodic. This means it typically enters our rivers and lakes during episodes of rainfall, during isolated events such as incidences of illegal dumping, or in a random fashion, as when a sewer line overflows or breaks. It is difficult and expensive to monitor nonpoint source pollution using a fixed monitoring schedule and employing tests for only a few chemical variables. Analyzing data for trends and correlations provides an effective strategy to investigate NPS pollution.

Running chemical tests on water quality is like taking a snapshot of the river or lake at that moment. Trend analysis based on DO concentrations, secchi depth measurements, and fluctuations in conductivity levels provides additional clues in assessing NPS pollution. Looking at this information over an extended period of time provides a strong foundation to infer the corresponding DO values (oxygen concentrations will correspond to plant production and decomposition), rainfall contributions (conductivity values will change with runoff), and nutrient fluctuations (secchi measurements can be used to determine the productivity status of a system, which is influenced by nutrient loading).

Looking at the living organisms in a stream or lake can tell you a lot about what has happened there over time as well. For example, if you monitor a stream that has good habitat and good chemical water quality but no living organisms, something may have happened there prior to your sampling to account for this lack of biodiversity. Perhaps a heavy rain storm washed a lot of water through your site and dislodged all the organisms. Perhaps an episode of NPS pollution lowered the DO level, causing the organisms to die or move downstream. There are many possible explanations, but by looking at the biological community of the stream over time, the monitor knows more about the long-term conditions of the stream than if they performed only chemical tests.

Sources of water pollution from the nonpoint sources are less obvious than those from point sources and are not as easy to control through traditional treatment strategies. The variability of rainfall events and the complexity of the landscapes and geologic strata lead to nonpoint source pollution phenomena which are highly variable and intricate. The lack of a single identifiable source of pollution makes it difficult to establish specific cause-and-effect relationships but reinforces the importance of analyzing trends and correlations drawn from consistent, extended monitoring efforts.
1.4 Texas Stream Team
Core Variables

Under the Texas Stream Team Core monitoring program, volunteers monitor water temperature, pH, dissolved oxygen, conductivity or salinity, and water clarity. These variables are documented in an approved monitoring plan that is recommended for all individuals, groups, or organizations engaged in monitoring in conjunction with Texas Stream Team. An approved monitoring plan identifies the objectives of monitoring and specifies the sites and variables monitored and monitoring procedures. A monitoring plan is unique to the conditions and needs of a site. In addition to providing information on monitoring techniques, this manual also provides extensive information on safety procedures in the classroom and in the field, along with data management procedures and proper cleanup and storage of equipment.

The monitored variables and their significance are described below. An *E. coli* sampling and analysis method is also available (see section 4 for *E. coli* testing information).

**Water Temperature**

Temperature affects feeding, reproduction, and the metabolism of aquatic animals. In addition, temperature affects the solubility of compounds in water, distribution and abundance of organisms living in the water, rates of chemical reactions, density inversions and mixing, and current movements.

Temperature preferences among species vary widely, but all species can tolerate slow, seasonal changes better than rapid changes. Thermal stress and shock can occur when temperatures change more than 1 to 2 degrees Celsius in 24 hours.
pH

An indication of the water’s acidity, pH measurements run on a scale of 1.0 to 14.0 standard units (su). A pH measurement of 7.0 is considered neutral. Solutions with a pH below 7.0 are considered acids, those above 7.0 are considered bases.

The pH scale is logarithmic, so every one-unit change in pH actually represents a ten-fold change in acidity. This means that pH 6.0 is ten times more acidic than pH 7.0, and pH 5.0 is 100 times more acidic than pH 7.0.

A range of pH 6.5 to pH 8.2 is optimal for most organisms. Rapidly growing algae and submerged aquatic vegetation remove carbon dioxide from the water during photosynthesis. This can result in significant increases in pH levels. Drastic changes in pH can affect aquatic life indirectly by changing other aspects of the water chemistry. For instance, toxic metals trapped in sediment are released into the water at lower pH levels, and the level of ammonia that fish can tolerate varies tremendously within a small range of pH values.

Dissolved Oxygen

Dissolved oxygen (DO) is the oxygen freely available in water. DO is vital to fish and other aquatic life. Oxygen is transferred from the atmosphere into surface waters and is produced by aquatic plants, algae and phytoplankton as a by-product of plant photosynthesis. Once dissolved in water, oxygen diffuses very slowly and distribution depends on the movement of aerated water from turbulence and currents caused by wind, water flow and thermal upwelling.

Traditionally, the level of DO has been accepted as the single most important indicator of a water body’s ability to support desirable aquatic life. The amount of oxygen required varies according to species and stage of life. Usually, DO levels of 5.0 to 6.0 milligrams per liter (mg/L), or 5.0 to 6.0 parts per million (ppm), are required for growth and activity. DO levels below 3.0 mg/L, or 3.0 ppm, are stressful to most aquatic organisms. When levels fall below 2.0 to 1.0 mg/L, or 2.0 to 1.0 ppm, for an extended period of time, most fish will not be able to survive.

Total Dissolved Solids and Conductivity

Total dissolved solids (TDS) is defined as the quantity of dissolved material in water. Background TDS levels for a specific area depend mainly on the solubility of rocks and soils the water contacts. For instance, water that flows through limestone and gypsum dissolves calcium, carbonate, and sulfate, resulting in high levels of TDS. Fluctuations in TDS could indicate human-caused pollution. Discharges to water can change the conductivity depending on the effluent characteristics. A failing sewage system could raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity because oil does not conduct electrical current very well.

A convenient way to measure TDS is to test the conductivity of the water sample. Conductivity is a measure of the ability of water to pass an electrical current and is affected by the presence of dissolved solids. As the level of TDS rises, the conductivity will also increase.

Conductivity is measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µS/cm), equivalent units of measure that can be used interchangeably. Distilled water has a conductivity in the range of 0.5 to 3 µmhos/cm. The conductivity of rivers generally ranges from 50 to 1500 µmhos/cm.

Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µmhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates.
Salinity

Salinity is the total of all salts dissolved in water, usually expressed in parts per thousand (ppt). Salinity is a term that usually refers to waters receiving marine inflow such as bays and estuaries. In an estuary, the flow of fresh water from streams and rivers mixes with salty ocean water, producing a range of salinity from 0 to 35 ppt. The salt content of water affects the distribution of animal and plant species according to the amount of salinity they can tolerate.

Salt pollution can be caused by natural conditions intensified by drought, irrigation return flows, wastewater discharges that may be high in salts, brine waters from oil production activities, or the spreading of road salt during icy conditions. Salt pollution is a problem because it can cause the salt levels of drinking water supplies to rise above recommended levels for human consumption. In some areas, it can cause rivers or streams to become unsuitable for agricultural irrigation or industrial use. Increasing levels might also impair aquatic life in ways that are difficult to determine.

Fresh water and drinking water contain low salt concentrations and usually have a salinity of less than 0.5 ppt, while the salinity of seawater averages about 35 ppt.

Water Clarity

Materials mixed and suspended in water reduce its clarity and make the water turbid. Turbidity is a measure of water clarity, specifically, of how much the solid matter suspended in water decreases the passage of light through the water. In the deeper waters of lakes, ponds, rivers and estuaries the Secchi disk is often used to measure water clarity (refer to page 24 for further explanation).

Sources of turbidity are primarily sediment from disturbed or eroded soil. But microscopic plankton also contribute to high turbidity when their numbers are increased due to excess nutrients and sunlight. In addition to blocking out the light needed by submerged aquatic vegetation, suspended sediment can carry nonpoint source pollution such as nutrients and pesticides throughout the water system. Suspended particles near the water surface absorb additional heat from sunlight, raising surface water temperature. Settling sediment can bury benthic (bottom dwelling) creatures and fish eggs.

Moderately low levels of turbidity may indicate a healthy, well-functioning ecosystem in which plankton flourish at a reasonable level to form the foundation of the food web. High turbidity is an indicator of either runoff from disturbed or eroded soil or blooms of microscopic organisms due to high nutrient inputs. Very clear water is typical of the open ocean and lakes or reservoirs supporting only sparse plant and animal life.

Additional Water Quality Tests and Environmental Observations

Additional environmental information gathered during a monitoring event includes algae cover, water color, water clarity, flow level, water surface, water conditions, water odor, present weather and rainfall accumulation. These observations can be some of the most important information collected and can significantly contribute to the process of evaluating the site’s data. Close attention to detail will result
in familiarity with typical site conditions and a better record of any changes that occur.

Pathogens and *E. coli* in Texas freshwater streams and reservoirs continues to increase in importance across the state. Monitors may wish to test their site for contact recreation concerns through a newly adopted *E. coli* testing procedure. In addition to attending a “core” training, monitors can attend a two hour supplemental workshop. This training includes an introduction to *E. coli* monitoring, including its importance and relevance to contact recreation. Participants will gain an understanding of how and where to collect water samples. This hands-on training will use Coliscan Easygel methods and students will practice quantifying colonies on pre-prepared plates and also learn incubation, disposal procedures, results calculations and documentation.

As water quality monitoring tests are revised and new water quality monitoring procedures are adopted, Texas Stream Team will assist volunteer monitoring groups who want to add these tests to their program. Volunteers are encouraged to contact Texas Stream Team for information on equipment specifications, costs, and certification procedures.

### 1.5 Getting Started With Texas Stream Team

Please follow these steps to begin your monitoring project:

1. Select a monitoring site and request a site location number based on the guidelines included in this manual under Section 2.0 - Choosing a Monitoring Location.
2. Complete a Texas Stream Team Monitoring Plan for your volunteer monitoring program. The Monitoring Plan identifies the objectives of monitoring and specifies the sites, parameters, and monitoring procedures. A copy of the Monitoring Plan and instructions can be obtained on the Texas Stream Team website.
3. Schedule volunteer orientation and training sessions with your Texas Stream Team Partner. Texas Stream Team Partner contact information can be obtained by visiting the Texas Stream Team website or by calling toll free (877)506-1401. Training phases I and II are generally scheduled with a group.
Upon completion of Phases I and II, Phase III is scheduled to complete the water quality monitor certification. Phase III takes place at the volunteer’s monitoring site.

4. Acquire a monitoring kit. Monitors acquire kits in a variety of ways. They may pay for a kit with their own money or raise the money from another source such as a civic organization. Several Texas Stream Team Partners provide kits, and the Texas Stream Team Headquarters office at Texas State–San Marcos periodically has kits to loan volunteers.

5. Begin monitoring and send the data monthly to Texas Stream Team on the approved forms.

Please contact Texas Stream Team headquarters at Texas State University-San Marcos for information on equipment, completing a monitoring plan, scheduling a training, or any other issues related to your monitoring project.

Toll-free: (877) 506-1401
Email: txstreamteam@txstate.edu
Web: http://txstreamteam.rivers.txstate.edu

1.6 Training

This section includes information describing the various levels of certification and training offered in the Texas Stream Team environmental monitoring program. The longevity of the program is dependent upon the participation of our dedicated volunteers and we encourage you to continue increasing your level of involvement each year by completing the required training to become a certified Texas Stream Team Trainer and/or Quality Assurance Officer. See page 14 for more information.

Certified Water Quality Monitor

To receive certification as a Texas Stream Team Water Quality Monitor, all volunteers must complete the three-phase training program described below. Texas Stream Teamer Certification status can be earned by volunteers who intend to complete Phase I and II only, but do not intend to monitor regularly.

Phase I Training

Phase I training is a hands-on instructional classroom session covering approved methods of determining levels for the five Texas Stream Team core variables and/or other parameters. These methods are adapted from the TCEQ Surface Water Quality Monitoring Procedures Manual (RG-415 2008 or subsequent edition). Safety in both the laboratory and field settings is also discussed.

Each volunteer receives a Volunteer Monitor Training Packet for recording comments and training session results. The Volunteer Waiver and Acknowledgment form is included in the packet. Volunteers must read, understand and sign this form before they can be trained.

The training is led by a Texas Stream Team certified trainer who explains how the monitoring equipment should be handled and demon-
strates the water quality tests to the volunteers. The volunteers then perform the water quality tests under close supervision of the trainer, recording their results on the Phase I Monitoring Form. Adherence to safety procedures is emphasized.

After all tests are completed and the volunteers are comfortable with the monitoring procedures, the volunteer and trainer review and sign the Phase I Monitoring Form. This signed form signifies the volunteer’s successful completion of Phase I training for the parameters specified and indicates their understanding of the monitoring procedures and commitment to following all safety procedures. The Volunteer Training Packet with all signed forms is retained by the volunteer through their Phase III session.

**Phase II Training**

During Phase II, volunteers demonstrate the monitoring procedures they learned during Phase I training in the field. Safe monitoring procedures and selection of a site with safe access is emphasized. Whenever possible the water body used for Phase II testing should be similar to the sites the volunteers will eventually monitor. If the training location is appropriate the volunteers also learn how to measure water transparency using the Secchi disk.

During the Phase II training, volunteers conduct tests with the limited assistance of the trainer. The trainers carefully observe the volunteers’ procedures, answering any questions that the volunteers may have, and correcting any obvious mistakes. Assuring the quality of the monitoring information is also discussed.

After all questions have been answered and the volunteer finishes reporting information on the Monitoring Form, the volunteer and the trainer discuss the volunteer’s strong points and weak points with respect to testing procedures. The volunteer then signs the Phase II Monitoring Form and the trainer reviews and signs the Phase II Monitoring Form indicating completion of Phase II training for the parameters specified. The signed Monitoring Form is then returned to the Volunteer Monitor Training Packet to be retained by the volunteer for use at the Phase III training session.
Phase III Training

Phase III training takes place at the volunteer’s approved monitoring site (or a training site) within 6 months of completing Phase II training. The trainer and volunteer check to ensure the sampling site is the same location indicated in the Monitoring Plan. The trainer observes and conducts the tests from a trainers test kit as the volunteers conduct the monitoring tests at the site. By this time the volunteers should be able to work through the tests and complete the Monitoring Form with minimal direction from the trainer.

After the monitoring event, all safety and data quality assurance concerns are discussed. The volunteer and trainer then sign the Phase III Monitoring Form and complete the Phase III evaluation on the back of the Volunteer Monitor Training Packet. If the trainer believes the volunteer monitor has successfully completed the three training sessions for the parameters specified, the trainer signs the front page of the Volunteer Monitor Training Packet. When the Volunteer Monitor Training Packet is completed and includes a signed Volunteer Waiver and Acknowledgment form, signed Monitoring Forms from Phase I, Phase II and Phase III training sessions, and the Phase III trainer’s signature, the volunteer is then considered a Texas Stream Team Certified Water Quality Monitor. The packet is retained by the trainer and sent to Texas Stream Team for processing.

Texas Stream Team Quality Assurance Certification Program

Texas Stream Team Trainer:

Upon approval, Certified Texas Stream Team Water Quality Monitors may receive additional certification as a Texas Stream Team Water Quality Monitor Trainer after completing the requirements described below:

• Trainees must assist or coordinate a training session with a Certified Trainer
• Trainees must coordinate and lead a training session assisted by a Certified Trainer
To Perform Quality Control Site Visits Only:

Certified Trainers and Water Quality Monitors can be authorized to perform quality control (QC) site visits upon approval of a Texas Stream Team Quality Assurance Officer (QAO). Texas Stream Team suggests observing a field QC preformed by a QAO, followed by leading a field QC with a QAO present.

QAO Certification:

Upon approval, Certified Texas Stream Team Water Quality Monitors may receive additional certification to conduct both lab and field QC sessions as a certified Texas Stream Team QAO.

If the QAO trainee is a Texas Stream Team Certified Trainer the following QAO training standards will apply:

- Trainees must assist or coordinate a lab or field QC session with a Certified QAO that includes each of the parameters specified in the trainees training packet.
- Trainees must coordinate and lead a lab or field QC session assisted by a QAO that includes each of the parameters specified in the trainees training packet.
- All Trainees must demonstrate the ability to use and communicate the Data Quality Objectives Table (see page 26) with volunteer monitors.

If the individual is not a Certified Trainer, the following QAO training standards will apply:

- Trainees must assist or coordinate a lab QC session with a certified QAO that includes each of the parameters specified in the trainees training packet.
- Trainees must coordinate and lead a lab QC session assisted by a QAO that includes each of the parameters specified in the trainees training packet.
1.7 Quality Control

Certification

Once the training packets are completed, the Texas Stream Team Partner issues a Texas Stream Team Certificate and submits all the paperwork to Texas Stream Team. Once received by Texas Stream Team, the training information is processed and a file is established. All Texas Stream Team data are collected within an approved quality assurance project plan (QAPP). A QAPP document outlines the procedures a monitoring project will use to ensure that the samples and data are of high enough quality to meet project needs.

Texas Stream Team monitors currently collect data using the approved Integrative Quality Assurance Project Plan (IQAPP) or the Project-Specific Quality Assurance Project Plan (PSQAPP). The goals of the group and Texas Stream Team’s support capabilities determine which plan volunteers are monitoring within. IQAPP intended data uses include: education, research, screening and problem identification, and other uses deemed appropriate by resource managers and the TCEQ. PSQAPP intended data uses include: TMDL development, stream standards modifications, permit decisions, water quality assessments, education, research, screening and problem identification and other programs deemed appropriate by the TCEQ.

Because of intensive data validation techniques that must be utilized to document and approve PSQAPP data and monitors, Texas Stream Team has limited participation to a manageable number of sites. Generally, Texas Stream Team PSQAPP participants are veteran monitors who can commit to consistent monthly sampling for one year or more.

Quality Control Sessions

Texas Stream Team suggests that monitors attend one QC session per year after successful completion of their Phase III training. Volunteers participating in the PSQAPP must attend a field quality assurance session at their monitoring site at least once per year. All other volunteers participating in the quality assured program may attend either a laboratory session or field session.

Led by either a certified Texas Stream Team Trainer or QAO, these sessions are designed to ensure that data collected by the monitors accurately represent environmental conditions at the time of monitoring. Results of these reviews show how precisely and accurately the monitors make their measurements. Monitors must bring their monitoring kits and equipment to these QC sessions. The monitoring kits are checked to ensure all safety equipment, goggles and gloves are available, all reagents are up-to-date, and all other monitoring equipment is functioning properly.

At each QC session volunteers perform their routine sampling procedures and compare their values to those produced by a Certified Trainer or QAO for each of the parameters specified in their training packet. Completed Monitoring Forms are submitted to Texas Stream Team, and the Texas Stream Team database is updated to indicate successful completion of the QC session. This information is used to verify data quality.
1.8 Safety Considerations

General Precautions

1. Read all instructions to familiarize yourself with the test procedures before you begin. Note any precautions in the instructions.
2. Read the label on each reagent container before use. Some containers include precautionary notices or you may refer to material safety data sheets (MSDS), which provide important safety information. Copies of these MSDS sheets are located at the back of this manual.
3. Keep all equipment and chemicals out of the reach of young children.
4. In the event of an accident or suspected poisoning, immediately call the Poison Control Center at (800) 222-1222. Be prepared to give the name of the reagent in question and its manufacturer’s code number. LaMotte reagents are registered with POISINDEX, a computerized poison control information system available to all local poison centers.
5. Texas Stream Team recommends that you always sample with another person.

Protecting Yourself and Your Equipment

1. Avoid contact between chemicals and skin, eyes, nose, mouth and clothes.
2. Always wear safety goggles or glasses and rubber gloves when handling chemicals.
3. Use the test tube caps or stoppers, not your fingers, to cover test tubes during shaking and mixing.
4. When dispensing a chemical from a plastic squeeze bottle, hold the bottle upside-down in a vertical position (not at an angle) and squeeze it gently (if a gentle squeeze does not suffice, the dispensing cap or plug may be clogged).
5. Wipe up any chemical spills, liquid or powder, as soon as they occur. Rinse area with a wet sponge, then dry.
6. Thoroughly rinse sampling containers and vials before and after each test with deionized or distilled water (tap water is acceptable if the other two are unavailable). Dry the outside of the containers.
7. After use, tightly close all chemical containers. Do not switch caps.
8. Store the chemicals and equipment indoors at room temperature. Do not expose chemicals and equipment to direct sunlight for long periods of time and protect them from extremely high or low temperatures. Avoid storing your equipment in an automobile or truck.
9. Safely dispose of all out-of-date or waste chemicals by flushing them down a sanitary sewage system drain with plenty of water. Do not dispose of chemicals into a septic waste system, water body, or onto the ground.
Site Safety

1. Park your vehicle safely off roads and out of the way of traffic. Be cautious of traffic when unloading or loading monitoring equipment and accessing your site.

2. Sample your site from bridges with pedestrian walkways, from docks, or from stream banks whenever possible. If you must enter the water, always have a partner on the shore nearby and be certain to wear a life jacket if wading is necessary.

3. Approach your site carefully! Watch out for traffic on bridges and when crossing roads. Be on the lookout for snakes, fire ants, wasps, poison ivy, Africanized honey bees, wild animals, broken bottles, debris, or briars.

4. If using a boat to sample your site, learn and observe all U.S. Coast Guard and State of Texas regulations. Boat operators should complete a boating safety course.

2.00 Choosing A Monitoring Location

The location of a monitoring site should be based on the following Texas Stream Team site selection guidelines.

First, ensure that the proposed site is safely accessible year round. If the site is on private property, obtain the landowner’s written permission granting access prior to any monitoring activities taking place. A private property access form is available from Texas Stream Team for this purpose.

Texas Stream Team recommends selecting monitoring sites that best represent the overall water quality conditions of a water body. Sites should be free of backwater effects, and for monitoring in freshwater streams and rivers, sites should be suitable for conducting flow
estimates. Sites on streams with perennial (year round) flow are preferable to streams that flow intermittently. Lake and estuary sites should be in the major arms and/or near the dam (reservoirs). Coastal sites are best situated so that a representative sample can be collected, regardless of the tidal cycle.

Because historical water quality data are very useful in assessing impairments in water bodies, it is also preferable for volunteers to use existing monitoring sites when possible. Texas Stream Team can assist in determining if an established site is available in the volunteer’s area of concern.

Keep in mind that sites located at or immediately below major pollution sources may not accurately represent water quality conditions of that water body. Depending upon monitoring objectives, areas with significantly different contaminant sources or water quality problems may require additional sites to obtain a true representation of the water body.

2.01 Requesting a Site Location Number

Data cannot be used to assess water quality or entered into the Texas Stream Team database without latitude and longitude coordinates. To determine the exact location of your site, use Google maps, a U.S. Geological Survey topographic map (scale of 1:24000), a National Oceanic and Atmospheric Administration nautical chart with latitude/longitude coordinates, one of the several Street Atlas software systems that provide latitude/longitude coordinates or street address, or a calibrated global positioning system (GPS) unit.

Describe your site in detail and take photographs from different viewpoints. The photos will be your visual documentation of any future changes to your site. The photos will also help you and future monitors identify your exact sampling spot. Complete copies of the map(s) with your site indicated and photos (if possible) should be sent to Texas Stream Team with your Monitoring Plan.
2.02 Choosing A Sampling Time

Choose a convenient, regular time of the day and a day of the week or month for your monitoring. Your samples should be collected at regular intervals. For example, if you are sampling monthly, try to sample every 30 days. If necessary you may sample as early as 26 days after the last sampling event or as late as 34 days after the last sampling event.

Because water quality and environmental conditions can change throughout the day, monitoring at the same time and location helps to assure the data you have collected from different sampling days are comparable. If you have any questions as to whether or not to cancel, postpone, sample early, or change your sampling location, call your partner or Texas Stream Team.

SAFETY CHECK: If conditions are unsafe for any reason, do not sample.

2.03 Equipment List

- Armored thermometer, centigrade
- Conductivity meter
- DO titration kit
- Secchi disk with calibrated line (or turbidity octet comparator)
- Goggles for handling chemicals
- Gloves for handling chemicals
- Beaker
- Data forms
- Sealable container for collecting liquid reagent wastes in the field (empty conductivity solution cubitainer, or large plastic jars/containers work well)
- Bucket with rope (if necessary) for sampling off bridges
- Whirl Pak or another sterile container for E. coli sample collection

All equipment is inspected upon receipt from the manufacturer. Equipment is inspected for completeness, breakage, and to ensure it is operating correctly.

Monitoring Reagents

To ensure that the chemical reagents used during monitoring are always up to date, Texas Stream Team requires all reagents’ expiration dates be checked before each monitoring session and expired reagents replaced during QC sessions. The requested reagent expiration information should then be recorded in the appropriate blank on the Environmental Monitoring Form.

Shelf Life of Monitoring Reagents
Manganese Sulfate..................3 years
Alkaline Potassium Iodide Azide..3 years
Sulfuric Acid..............................3 years
Sodium Thiosulfate....................1.5 year
Starch Indicator..........................1.5 years
pH Wide Range Indicator...........2 years
2.04 Sampling Sequence

A typical sampling sequence might include the following steps:

1. Calibrate the conductivity and pH meters, and check and record reagent expiration dates. It is recommended that these procedures be performed before going into the field.
2. Prepare your *E. coli* testing supplies (if applicable) according to the procedures in section 4.
3. At your monitoring site, make careful observations about the condition of the water, weather and other pertinent facts.
4. Measure and record air temperature.
5. Collect water sample for *E. coli* (if applicable).
6. Measure water clarity with your Secchi disk.
7. If possible, also measure total depth with your Secchi disk.
8. Collect your water sample.
9. Measure and record water temperature.
10. Measure and record conductivity or total dissolved solids.
11. Collect your DO samples and add first two reagents.
12. Measure and record pH while waiting for the DO sample precipitate to settle.
13. Finish analyzing the dissolved oxygen samples.
14. Clean and store equipment.

**QC CHECK:** Meter calibration and reagent expiration checks (Step 1) can be performed up to 24 hours before sampling. It is recommended that these procedures be performed before going into the field.
2.05 Collecting Water Samples

Sample Depth

The standard sampling depth for most measurements is 0.3 meters (approximately one foot or about elbow deep). This is the depth at which most water quality measurements are made by the TCEQ’s professional monitors. If the depth of the water is less than 0.46 meters (1.5 feet), samples should be collected about one-third of the way from the surface to the bottom. Rinses of sample containers should always be done with water at the same depth as the sampling depth.

Accepted Methods for Collecting Water Samples

Bucket Grab:
Rinse your bucket twice with water to be sampled. Gently lower bucket 0.3 meters (about one foot) into the water, or to one-third of total depth (whichever is less) and fill.

Container Samples:
Rinse your water containers twice with the water from the same depth as sampling will occur. Lower your container (with container mouth facing down) vertically to a depth of 0.3 meters (or to one-third of total depth) and then turn the container upright. If there is a current, be sure you are standing downstream of your container. Do not drag the container on the bottom of the lake or stream, or kick sediment up into your sample.

**NOTE:** Review Section 4 (page 54) for more information on E. coli sampling procedures.

QC CHECK: Always throw the container rinse water far downstream or on the bank so that the rinse water will not contaminate your sample.

2.06 Field Observations

When you arrive at your sampling site, some of the most important information you can collect is a record of your observations. Look at the water and other things related to the water quality. Record how humans and wildlife are using the water.

When monitoring a site for the first time be very descriptive. Try to paint a word picture of your monitoring location. This close attention to detail will make you more familiar with the typical conditions of your site and allow you to better record any changes that may occur. As you become accustomed to your site, describe the changes occurring at the site.

In the Field Observations Section of the Monitoring Form record the following:

Flow Level:

Dry (6): When the stream is dry, a flow severity value of “6” is recorded for the sampling visit. This will indicate the stream is dry with no visible pools.

No flow (1): Only write in a value of “1” when the water body is not flowing downstream. You should also write this value if there are pools of water in a river or stream bed that are not connected by flowing water (in other words the river or stream bed is dry between pools). There should be no obvious subsurface flow in sand or gravel beds between isolated pools.

Low (2): Write in a value of “2” when the river, creek, pond or lake level is lower than normal. There are some visual clues to low flow: dry creek or lake bed between the water surface and the normal shore plants, or aquatic plants and algae that are now lying out of the water.

Normal (3): This is what, in your opinion, your monitoring site’s water level normally looks like. Write in the number “3”.

NOTE: Review Section 4 (page 54) for more information on E. coli sampling procedures.
High (5): Record a value of “5” when the water body is higher than normal. One of the best clues of high water is partially submerged shoreline vegetation, which is normally out of the water.

Flood (4): We do not expect you to sample when it is flooding. Simply record a value of “4” in the box.

**QC CHECK:** As you can see, the values are not sequential. However, the values for High Flow (5), Flood (4), and Dry (6) are based on established EPA protocols.

*Algae Cover:*

This observation of surface and substrate algae is important because of the relationship algae cover has with the DO in water. When large amounts of algae are present and the sun is out, providing the energy for photosynthesis, there will be a large amount of oxygen produced by the algae. The opposite is true at night. When the sun is not out, excessive algae growth (along with other plant life) can bring DO levels down low enough to stress or even kill some fish and other aquatic life. In addition, when algae die, aerobic bacteria may use enough oxygen in decomposing this material to deplete all available DO, thus contributing to anaerobic conditions.

Enter the appropriate value in the block for algae cover.

1. Absent: No algae apparent (0%)
2. Rare: Small patches, not readily apparent (1-25%)
3. Common: Substrate algae or surface mats noticeable (26-50%)
4. Abundant: Substrate and/or surface algae cover obvious and maybe thick in places (51-75%)
5. Dominant: The site is choked with algae. The entire substrate or surface is covered (76-100%)

**QC CHECK:** Don't mistake aquatic macrophytes, which are aquatic plants with vascular tissues (rigid, conductive tissues) for algae. These macrophytes will have roots, stems, and leaves. Any macrophytes present should be written in the comments section of the data sheet.
**Water Color:**

Check water color when you collect your water sample for conductivity/temperature, pH, or DO. Look at the water in the cup or bottle against a white background and indicate the most appropriate color on your Monitoring Form. If the water looks basically clear, write a value of “1” in the box. If it has a color not included in the given values, describe that color in the Comments sections at the bottom of the form. Be careful not to use direct observation of the water body itself as the indication of color. What may appear to be the water’s color is often just the bottom color, the reflection of trees or sky over the body of water, or a combination of all three.

**Water Clarity:**

Record the relative cloudiness of the water. This observation is especially important when you have noticed changes in clarity. Using the beaker or Secchi disk may help determine this value. Record “1” if the water is clear, “2” if the water is cloudy, and “3” if the water is very turbid, which would be very noticeable in the kit’s beaker.

**Water Surface:**

Record the appropriate value which describes the appearance of the water surface. For example, if the surface is clear, record a value of “1”. If scum is noticeable, record a value of “2” in the box. Record a value of “3” if there is foam on the water surface. If floating debris is present on the water, record a value of “4” in the box. Record a value of “5” if you notice sheen or oil on the water.

**Water Conditions:**

Although this is intended primarily for lakes, ponds and bays, you can record a value if you are sampling a river or creek. For example, if you are sampling in a rapids or riffle, you may want to write a value of “2” or “3” for ripples or waves. Increased aeration caused by ripples, rapids and waves can also increase DO levels in surrounding waters.

**Water Odor:**

Check water odor when you collect your samples for conductivity or pH by holding your nose over the sample cup (out of the breeze if possible) and taking a sniff.

**SAFETY CHECK:** If there seems to be a strong chemical odor or chemical appearance - do not do the sniff test!
**Present Weather:**

Write a value of “1” if the sky is completely clear. Write a value of “2” if there are clouds, but you can still see some blue sky. If you cannot see any blue between the clouds record a value of “3”. If it is raining, record a value of “4”.

**Days Since Last Significant Precipitation:**

Record the number of days since the last rainfall that occurred in the watershed upstream of your site.

**Rainfall Accumulation:**

Record the total rainfall (inches) that occurred in the last three days in the watershed and upstream of your monitoring location. A suggested way to get this information is to go online to www.weather.com, type your zip code into the “Search” box, and then click the “Month” tab at the far right of the page. Daily rainfall accumulations are listed there.

**QC CHECK:** Rainfall runoff can affect water quality. By tracking rainfall information on a calendar at home, you can better understand how the level of rainfall runoff affects your particular monitoring site. Just make sure that the rainfall you track is occurring in the watershed of your sampling location.

**Tide Stage:**

You should leave this box blank unless the body of water you are sampling is on the Gulf coast and influenced by the tides. Tidal conditions can greatly influence salinity levels. Record a value of “3” if the tide is in a slack stage (neither rising nor falling).

### 2.07 Additional Tests

The three spaces set aside for additional tests should be used if other variables are being added to the core variables.

**Stream Velocity:**

Where applicable, measure the stream velocity at your site by marking off a three meter (9.84 feet) section and measure the time it takes a float, such as an orange peel, to travel three meters (in seconds). Keep the float from being caught on any obstacles by choosing a clear path for it to travel. If it does get caught, start the procedure over. Fruit such as oranges or apples make good floats for determining velocity. Small sticks work well if you are sampling a stream that is too small for fruit. Record the velocity on the Monitoring Form under Additional Tests. Write in “flow” or “velocity” for the type of test, and in the reading block enter the distance “3m” and the time required for the float to travel that distance. For example 3m/8.5 seconds.
2.08 Measurement Comments

Record any explanatory information about your measurements or observations on these lines. For example, if you could not record temperature because your thermometer broke, you can mention it here. This is also the part of the form where you can describe the physical appearance of the water and surrounding area, the presence of any obvious pollutants, mudiness, or any other factors, which could also impact water quality. This is also the best place to describe:

- the biological conditions such as a plankton bloom, fish kill, presence and abundance of fish, aquatic insects, aquatic plants, and wildlife
- the lake and stream uses like swimming, wading, boating, fishing, irrigation pumps, navigation
- in stream or drainage basin activities or events that are impacting water quality - bridge construction, soil washouts, herbicide or pesticide use, livestock watering, dredging, or changes in stream bottom

2.09 Data Quality Objectives

The quality of Texas Stream Team data is verified through the procedures described within the Texas Stream Team Quality Assurance Program. At the heart of this Program are the Texas Stream Team data quality objectives (DQOs). DQOs are values, which are used to verify the accuracy and precision of the data collected by Texas Stream Team volunteer monitors (see the table below). For example, the Texas Stream Team DQOs prescribe a precision limit of .5 mg/L when analyzing two DO samples. This means that the sample values must be within .5 mg/L of each other to meet the Texas Stream Team DQOs. DQO values have also been established for the other Texas Stream Team variables in this manual. Please consult your trainer or QAO if you have questions about these values and how they are used.

**NOTE:** It is expected that volunteers committed to quality assured monthly sampling will submit data which meets all quality assurance objectives for 10 months of each calendar year.

### Texas Stream Team Quality Assurance Objectives

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>METHOD / RANGE</th>
<th>UNITS</th>
<th>DUPLICATE PRECISION</th>
<th>ACCURACY</th>
<th>METHOD SENSITIVITY</th>
<th>COMPLETENESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Thermometer -5.0 to 45.0</td>
<td>Degrees Celsius (°C)</td>
<td>+/- 0.5°C</td>
<td>+/- 1.0°C</td>
<td>0.5°C</td>
<td>90%</td>
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<tr>
<td>pH</td>
<td>Meter</td>
<td>Standard pH units (su)</td>
<td>+/- 0.1 su</td>
<td>+/- 0.2 su</td>
<td>0.1 su</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Color Comparator 3.0–7.0, 7.0–10.5</td>
<td>Standard pH units (su)</td>
<td>+/- 0.25 su</td>
<td>+/- 0.5 su</td>
<td>0.1 su</td>
<td></td>
</tr>
<tr>
<td>Specific Conductance</td>
<td>Meter 0–1990</td>
<td>µmho/cm (µS)</td>
<td>+/- 0.1 µS</td>
<td>Low +/- 30 Med +/- 130 High +/- 0.5</td>
<td>10 µS</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>0–19.90</td>
<td>mmho/cm (mS)</td>
<td>+/- 0.1 mS</td>
<td></td>
<td>0.1 mS</td>
<td></td>
</tr>
<tr>
<td>Salinity</td>
<td>Hydrometer 0.0 to 42.8</td>
<td>Parts per thou- sand (ppt)</td>
<td>+/- 1.0 ppt</td>
<td>+/- 2.0 ppt</td>
<td>0.1 ppt</td>
<td>90%</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Modified Winkler Titration</td>
<td>Milligrams per liter (mg/l)</td>
<td>+/- 0.5 mg/l</td>
<td>+/- 1.0 mg/l</td>
<td>0.1 mg/l</td>
<td>90%</td>
</tr>
<tr>
<td>Clarity</td>
<td>Secchi Disk</td>
<td>Meters (m)</td>
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<td>+/- 0.2 m</td>
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<tr>
<td>E. coli</td>
<td>Easy Gel 1–20,000</td>
<td>cfu/100 ml</td>
<td>NA</td>
<td>NA</td>
<td>1 cfu/100 ml</td>
<td>90%</td>
</tr>
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</table>
2.10 Temperature

Although temperature may be one of the easiest measurements to perform, it is probably one of the most important variables to measure. It dramatically affects the rates of chemical and biochemical reactions within the water. All biological, physical, and chemical processes are influenced by temperature. Some of the most common of these are the solubility of compounds in water; distribution and abundance of organisms living in streams, bays, lakes and bayous; rates of chemical reactions; density inversions and mixing; and movement of currents. For example, colder water holds more DO than warm water. Shallow streams and rivers, bays and bayous are much more susceptible to temperature changes because their capacity to store heat over time is also relatively small. Lakes, however, are much more resistant to temperature change because the volume of water over a certain area is relatively large.

Water temperature fluctuates considerably from one season to another. The temperature of the surface and subsurface waters often differs, with water generally becoming colder as depth increases. This results in thermal stratification of deeper water, and can lead to density differences. Remember that cold water is heavier than warm water. In some lakes it is as if there are really two separate lakes - one lake with warm water that receives sunlight on top and underneath it, another lake with cold water and little light. The water on top usually has enough oxygen for fish because it is in contact with air and it also receives sunlight for photosynthesis. The water near the bottom may lose much of its oxygen since there is no light to support plant production of oxygen and since it does not come in contact with the air.

In the fall, as the warming radiation from the sun begins to diminish, the surface water cools, increases in density, and becomes heavier. Once the surface water becomes nearly as heavy as the water toward the bottom, it begins to sink and vertical mixing, or destratification occurs. Wind may speed up the process as the mixing action brings nutrients from the bottom up into the surface water. The extra nutrients can sometimes cause an algae bloom that is indicated by the lake turning a darker greenish or brownish color. These bottom waters sometimes smell bad, perhaps with a rotten egg odor due to the presence of hydrogen sulfide.

Measuring Temperature

Temperatures are reported in degrees Celsius (°C). Although it is recommended that a thermometer calibrated to read in degrees Celsius be used for determining air and water temperatures, the following table provides Fahrenheit conversions to degrees Celsius.

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<th>°C</th>
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<td>35.6</td>
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<td>38</td>
<td>100.4</td>
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</table>

Temperature Test Procedure

Air Temperature:

Locate a place near your site to test the air temperature. Hang the thermometer on the dock, pier, or a tree out of direct sun and wind. Wait 2-3 minutes to allow the thermometer to equilibrate. You may conduct field observations while waiting. Record the value to the nearest 0.5 degree C on your data sheet. When reading
the thermometer, always hold the thermometer on the end that is opposite the thermometer bulb.

**QC CHECK:** Remember to measure air temperature before you measure water temperature. A wet thermometer will not accurately measure air temperature.

**Water Temperature:**

When you have collected the water sample in the bucket or beaker, remove the sample container from direct sunlight and wind. Do not hold the bucket or beaker in your hands because your hands might begin to warm the water. As soon as possible, put the thermometer in the bucket for one and a half minutes and record the value to the nearest 0.5 degree C. Read the thermometer while the bulb and lower part of the thermometer are underwater. Never take the thermometer out of the water to read the temperature. If your site is appropriate, you may place the thermometer directly in the stream or lake.

**QC CHECK:** The following are methods for reuniting a separated alcohol column in a thermometer:

**Cooling Method to Fix a Separated Thermometer:**

With the thermometer in an upright position, cool the bulb only in a solution of shaved ice and salt so that the alcohol column retreats slowly into the bulb. Remove and swing thermometer in a short arc forcing the entrapped gas to the top of the alcohol. Allow the bulb to warm slowly in the air.

**Heating Method to Fix a Separated Thermometer:**

Heat the thermometer bulb in warm water sufficient to allow the alcohol to rise slowly, until the separation and a portion of the main column enter the chamber. Tap the thermometer in palm of hand or on a padded surface reuniting the column. Allow to cool slowly.
Materials that become mixed and suspended in water will reduce its clarity and make the water turbid. Many materials contribute to turbidity. In the summer, plankton plays an important role. These microscopic organisms are growing and multiplying at a rapid pace in the warm, sunlit, nutrient-rich water. During periods of heavy runoff, silt-laden surface water can be seen running into the river, lakes, streams, bays and bayous. In shallow areas or near the shore, wind-generated waves and boat wakes interact with the bottom to stir up sediments. In some cases fish and other aquatic life, like turtles and carp that feed on the bottom, can stir up sediments.

The effects of turbidity on aquatic life can be significant. As described above, it interferes with the penetration of sunlight needed for the growth of algae and sea grasses. Second, suspended particles can transport heavy metals and other toxic substances into the habitat, which supports aquatic organisms. Fish cannot see very well in turbid water and may have difficulty finding food. On the other hand, high turbidity may make it easier for small fish to hide from larger fish or other predators.

Water clarity is also influenced by water color. In much of East Texas decaying plants, including dissolved organic acids like tannins and lignins, give the water a brown, tea-like color.

The Secchi disk provides an easy, convenient method for measuring how far light penetrates below the water’s surface, determining the limit of visibility of the water. Secchi disk transparency is the deepest point at which you can still see the Secchi disk. The less algae and silt in the water, the deeper the Secchi disk will be visible. More algae and silt limits how far down the Secchi disk can be seen.

### Measuring Transparency Using a Secchi Disk

The Secchi disk is usually a 20-centimeter diameter disk, with black and white quadrants. Before starting your Secchi disk measurements, make sure that your Secchi disk line is marked every 10 centimeters. You can mark your Secchi disk line using good quality, water proof markers and a meter stick. Holding the line attached to the middle of the disk straight, hold the meter stick against the line and place a black mark on the line every 10 centimeters from the top of the disk, place a blue mark at each half meter, and place a red mark on the line at every meter. The marks should go all the way around the line and be wide enough to be clearly visible from a distance of 3 meters (9.84 feet).

**QC CHECK:** Check line measurements yearly for inaccuracy due to stretching.

### Secchi Disk Procedures

**Step 1:**

Take the reading without sunglasses either in the shade or while standing with the sun to your back. If on a boat take the reading on the shaded side if possible.

**Step 2:**

Lower the disk into the water until the disk just disappears from sight and note the depth at which it disappears. (Hint: Grab the Secchi disk line at the water’s surface with your thumb and forefinger and hold onto the Secchi disk line as you do Step 3.)

**Step 3:**

Slowly raise the disk and note the depth at which it reappears (barely visible). (Hint: Grab the Secchi disk line at the water’s surface with your other thumb and forefinger. You should be holding the line at two different places.)
**2.12 Depth**

**Total Depth Procedures**

To use your Secchi disk to measure depth, lower the disk gently until you see or feel the line go slack. Pull up on the line gently to straighten it out. Read the measured line attached to the disk at the water level. Record the total depth of the water in meters.

In very shallow streams and water bodies, a tape measure, or a yardstick can often be used to measure total depth. Remember to convert measurement to meters before recording the information on the monitoring form.

**QC CHECK:** If your Secchi disk reaches the bottom and you can still see it, indicate this by recording the depth measurement in the Secchi disk transparency box on the monitoring form, and then placing a greater than symbol (>) in front of the value. For example, if your Secchi disk is on the bottom of the creek and the water depth at that point is 1.56 meters, the value you write in the box is >1.56.

**Step 4:**

Average the two depth readings obtained above. The average of the two readings is your Secchi disk transparency value and is considered to be the limit of visibility, or index of transparency. (Hint: The point on the Secchi disk line that is halfway between the two places you have grabbed the line is the average of the two depth readings. This is your Secchi disk transparency value.)

**QC CHECK:** If you are monitoring from a bridge or pier, use a fixed point on the bridge structure as a height reference point. Lower the Secchi disk until the surface of the disk is exactly even with the water’s surface. Record the distance from the bridge (or pier) height reference point to the water’s surface using the Secchi disk line. Lower the disk into the water until it disappears from view. At that point mark or grab the Secchi disk line at the bridge height reference point. Slowly raise the disk and grab or mark the line when the disk reappears. This mark should also be made on the line at the bridge height reference point. Calculate the average of the last two depths marked (when the disk disappeared and when it reappeared). Subtract the distance from the water’s surface to the bridge height reference point. The remaining value is the Secchi disk transparency value you record on the monitoring form.

**SAFETY CHECK:** Tie a wrist loop in the end of the disk line to prevent loss of the Secchi disk.

**QC CHECK:** For conversion purposes, 1 inch = 2.5 centimeters or 0.025 meters; 6 inches = 0.15 meters; 12 inches = 0.30 meters.
2.13 Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important indicators of water quality for aquatic life. It is essential for all plants and animals inhabiting a body of water. When oxygen levels in the water fall below about 3-5 parts per million (ppm), fish and other aquatic organisms may have difficulty successfully reproducing, feeding, or surviving. Oxygen is a particularly sensitive constituent because other chemicals present in the water, biological processes and temperature exert a major influence on its availability during the year.

Temperature plays a major role in influencing the amount of DO in water. Water at a temperature of 31°C (typical for Texas’ summer days) will only hold about half as much DO as the same water on a cold winter day at 1°C. Due to the physical and chemical properties of water, cold water generally contains more oxygen than warm water.

Oxygen is transferred from the atmosphere into the surface waters by the aerating action of the wind through a process called physical aeration or diffusion. It is also added as a by-product of plant photosynthesis. As a result, floating and rooted aquatic plants increase DO levels through the process of photosynthesis. Since the existence of plants also depends on the availability of light, the oxygen producing processes only occur near the surface or in shallow waters.

Oxygen levels may be reduced to harmfully low levels because high densities of bacterial or aquatic organisms use up the oxygen through the process of respiration. Respiration is a 24-hour a day process that nearly all aquatic plants and animals use to produce the energy they need. Through respiration, an overabundance of aquatic plants and animals can at times consume most of the oxygen in the water.

Too much aquatic plant or algal growth may occur when there are elevated concentrations of nitrogen and phosphorus (two nutrients essential for plant growth) in the water. This process

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>Solubility (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14.6</td>
</tr>
<tr>
<td>1</td>
<td>14.2</td>
</tr>
<tr>
<td>2</td>
<td>13.8</td>
</tr>
<tr>
<td>3</td>
<td>13.5</td>
</tr>
<tr>
<td>4</td>
<td>13.1</td>
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<tr>
<td>5</td>
<td>12.8</td>
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<tr>
<td>6</td>
<td>12.5</td>
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<tr>
<td>7</td>
<td>12.2</td>
</tr>
<tr>
<td>8</td>
<td>11.9</td>
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<td>9</td>
<td>11.6</td>
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<td>14</td>
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<td>30</td>
<td>7.7</td>
</tr>
<tr>
<td>31</td>
<td>7.4</td>
</tr>
</tbody>
</table>
is called over-fertilization. Over-fertilization may be caused by run-off from farmland, fertilized yards and golf courses, or partially treated wastewater effluent. Consumption of oxygen can be most damaging at night and on very cloudy days when the production of oxygen by photosynthesis does not occur. Respiration usually occurs at higher rates during the summer when higher temperatures increase plant and animal metabolism.

The DO test indicates how much oxygen is dissolved in the water, but it does not tell how much DO the water is capable of holding at the temperature, which it is tested. When water holds all the DO it can at a given temperature, it is said to be 100 percent saturated with oxygen. The table on the previous page shows the relationship between various temperatures and the solubility of oxygen in milligrams/liter (mg/L) or ppm.

The amount of oxygen that water can hold also decreases as the barometric pressure of the atmosphere decreases. Barometric pressure generally decreases as the altitude or elevation of the water body increases. For example, the barometric pressure in the mountains is less than the barometric pressure near the ocean.

The concentration of oxygen dissolved in water decreases as salt concentrations increase. For example, water from Corpus Christi Bay that is 100% saturated with oxygen at a temperature of 25 °C, and that has a salinity of 15 ppt (conductivity of 24,900 μmhos/cm), has a DO concentration equal to 7.6 mg/L. From the table on the previous page, you will see that freshwater that is 100% saturated with oxygen at a temperature of 25 °C, has a DO concentration equal to 8.4 mg/L.

**Measuring DO**

The DO test involves three stages: collecting the sample; fixing or stabilizing the sample; and titrating the sample to determine a DO value. Once the water sample is fixed, contact between the water sample and the atmosphere will not affect the test result, so it is not necessary to perform the titration procedure immediately.

Titrating the sample involves the addition of several chemicals to the fixed sample resulting in a DO value. Using this method, several samples can be collected, fixed in the field, and then carried back to a testing station or laboratory for titration. Fixed samples should be stored in the dark and away from hot or very cold temperatures. Titration should be completed no longer than 4 hours following fixation.

**Collecting the Sample**

*Step 1:*

Rinse the sample bottles and their caps twice from a depth of 0.3 meters (1.0 feet). If you are rinsing with water from a bucket, DO NOT throw the rinse water back into the bucket. If you are rinsing the bottles and caps directly from the water body, throw the rinse water downstream or up on the bank so the rinse water will not affect the water at your sample location.

*Step 2:*

Holding both bottles in one hand, vertically submerge them one foot with the mouth of the bottles facing down (this leaves the bottles full of air until inverted). Turn the bottles right side up and hold them at the sampling depth until they are filled (until they stop bubbling). Tap the sides of the submerged bottles to dislodge any air bubbles clinging to the insides of them. With both caps in one hand, invert and tap the caps to release bubbles. Cap the bottles under water. If the water is not deep enough, collect surface water by holding the bottles slightly submerged facing upstream. Fill the bottles to the brim and cap them while they are still submerged (see photo sequence on page 33).

*Step 3:*

Take the bottles out of the water. Turn the bottles upside down, tap them against the palm of your hand and examine them carefully to
Note: For demonstration purposes, the sequence is shown using only one bottle. When monitoring, the samples should be collected in both bottles simultaneously (see step 2).
make sure that no air bubbles are trapped inside. If air bubbles are present in one or both bottles, pour the water samples downstream or on the bank and repeat step two until no air can be detected in either bottle.

**SAFETY CHECK:** Put safety goggles and gloves on at this time and use until the end of the DO test!

### Fixing the Sample

**Step 4:**

Carefully uncap your sample bottles. Add 8 drops of manganese sulfate solution and 8 drops of alkaline potassium iodide azide solution to each sample. Hold the reagent bottles perfectly vertical above the sample bottle when adding the chemicals to the water. Do not let the reagent bottles touch the sample at any time. Cap the bottles. Mix by tightly holding the bottles and gently inverting them 25 times (do not shake).

A precipitate will form. Allow the precipitate to settle below the shoulder of the bottle. Invert the bottles ten more times and allow the precipitate to settle again below the shoulder of the bottle. You may have to allow up to 2 minutes for each settling.

**NOTE:** You may want to do other tests while the precipitate is settling.

**Step 5:**

Add 8 drops of sulfuric acid. Hold the reagent bottle perfectly vertical above the sample bottle when adding the chemical. Cap the bottles and mix the reagents by gently inverting the bottles for a minimum of three minutes, or until both the reagent and the precipitate have completely dissolved, whichever is longer. A clear-yellow to brown-orange color will develop, depending on the DO content of the sample. A dark yellow-brown color indicates high DO, while little or no color indicates low DO. Your sample is now fixed.
QC CHECK: Steps 1-5 are called fixing the sample. After step five, contact between the water sample and air will not affect the test result. Fixed samples should be stored in the dark and away from hot or very cold temperatures. Once the sample is fixed, the titration must be completed within 4 hours.

Titrating the Sample

Step 6:

Rinse the glass titration vial twice with a small amount of the fixed sample. Pour 20 mL of the fixed solution from the sample bottle into the glass titration vial, filling so the meniscus (dip in the water) rests on top of the 20 mL white line, and cap.

QC CHECK: Use only a small amount of fixed solution in rinsing the titration vial. You want to leave enough fixed sample to perform the titration a second time if necessary. (See Calculating DO Level).

Step 7:

Place the pink tip firmly onto the titrator. Fill the titrator with standard sodium thiosulfate solution. Do this by inserting the pink tip into the sodium thiosulfate bottle, inverting the bottle, and pulling back the plunger of the titrator. Be sure to expel any air bubbles from the titrator barrel by moving the plunger up and down repeatedly or by tapping the side of the titrator at the bubble with your finger. Fill the titrator until the top (not the bottom) of the ring of the green plunger tip lines up with the 0.0 mark (see photo). Check to ensure the plunger does not move. Remove the titrator from the reagent bottle and place it into the hole in the cap of the glass titration vial.
**QC CHECK:** Because the titrator never comes into contact with any other reagents, it should not be necessary to rinse the titrator EXCEPT when your sodium thiosulfate solution has become out of date OR if you think your titrator may have become contaminated. In these cases you should rinse the titrator twice with a small amount of sodium thiosulfate solution, disposing of the rinse directly into your waste container.

**Step 8:**

Add 1 drop of sodium thiosulfate solution from the titrator to the glass titration vial; swirl the glass titration vial gently but thoroughly to mix. Add another drop of the sodium thiosulfate solution and swirl again. Continue this titration process one drop at a time until the yellow-brown solution in the glass titration vial turns to a pale yellow color. Uncap the glass titration vial with the sodium thiosulfate-filled titrator still inserted in the cap of the glass titration vial. Keep the tip of the titrator suspended over the mouth of the titration vial (see photo).

**Step 9:**

Add 8 drops of starch solution to the glass titration vial while holding the reagent bottle vertically. Place the vial cap and titrator back onto the glass vial. Swirl the titration vial gently but thoroughly (do not shake) to mix. The solution should almost instantly turn from light yellow to dark blue.

**QC CHECK:** The final part of the titration is best conducted against a white background (such as a white sheet of paper) so that you can clearly see when all the blue color has disappeared.

**Step 10:**

Continue the titration process (described in Step 8) with the remaining sodium thiosulfate until the test solution turns from blue to clear. Be careful not to add any more sodium thiosulfate than is necessary to turn the sample completely clear. Be sure to swirl the vial very thoroughly after each drop. A half drop can be added by tapping the vial.

**QC CHECK:** If you use 9 mL of sodium thiosulfate and the color is still blue STOP and completely refill your titrator with additional sodium thiosulfate. Remember to add the 9 mL to the additional amount of sodium thiosulfate used to complete the DO test.

**Step 11:**

Using the scale on the side of the titrator, count the total number of units to the nearest 0.1 of sodium thiosulfate used in the titration. Each line on the titrator represents 0.2 mg/L (ppm) of oxygen. That number equals the number of ppm or mg/L of oxygen dissolved in the water. Record this value in the blank on your Monitoring Form for the 1st titration.

**QC CHECK:** Any remaining sodium thiosulfate in your titrator after each titration should be disposed of by injecting it into the titration vial or your waste container. Do not put excess back into the sodium thiosulfate bottle. Store titrator with plunger pulled away from the tip, or it will stick eventually.

Repeat Steps 6-11 on the fixed sample contained in the second sample bottle. Record this value in the blank on your monitoring form for the 2nd titration.
Calculating Dissolved Oxygen Value

Calculate the average of the two tests, and record the average (rounded off to the nearest 0.1 mg/L) in the Dissolved Oxygen blank on the Monitoring Form. If the values for your titrations differ by more than 0.5 mg/L oxygen, repeat the titration on one of the sample bottles. If the range between the two sample bottles is still more than 0.5 mg/L oxygen, repeat the titration on the remaining sample bottle. The average of all titrations within .5 mg/L of each other should then be recorded.

QC CHECK: If the values are still more than 0.5 mg/L oxygen apart, Texas Stream Team suggests you perform the entire DO test a second time and record only the second test result on your Monitoring Form. If this is not possible, please indicate all four initial DO values on your Monitoring Form, but do not average the results.

SAFETY CHECK: A sealable waste container should be used for collection of all sample waste. Safely dispose of all out of date or waste chemicals by flushing them down a sanitary sewage system drain with plenty of water. Do not dispose of chemicals in a septic waste system, water body, or onto the ground.

pH is a measure of how acidic or basic (alkaline) a solution is. In any given solution, some molecules of water break apart to form H+, hydrogen ions, and OH-, hydroxyl ions. The pH scale shows which ion has the greater concentration. At a pH 7.0, the concentration of both ions is equal and the water is said to be neutral, neither acidic nor alkaline. Pure water has a pH of 7.0. When the pH is less than 7.0, there are more hydrogen ions than hydroxyl ions and the water is said to be acidic. When the pH is greater than 7.0, there are more hydroxyl ions than hydrogen ions and the water is said to be basic or alkaline. For the majority of streams, ponds, lakes and bays in Texas, the pH is usually slightly alkaline ranging from 7.0 to 9.0. Many streams and ponds in East Texas are acidic with pH values as low as 5.5.

pH is defined as the negative logarithm of the hydrogen ion concentration. This means that on the pH scale (0 - 14), the concentration of hydrogen ions does not increase or decrease in a linear fashion. Because the pH scale is logarithmic, increases are in powers of 10, and a change in pH value of 1 unit is equivalent to a 10 times increase or decrease in the acidity or alkalinity of the water. This means pH of 3 is not twice as acidic as a pH of 6; it is 1000 times as acidic.

Water’s ability to resist changes in pH is its buffering capacity or alkalinity. Buffering materials are added to the water from the soils, minerals and rocks in the watershed. If a body of water has an abundance of buffering materials, it is more stable and resistant to changes in pH. The buffering capacity of a water body is critical to aquatic life. Generally, an aquatic organism’s ability to complete a life cycle greatly diminishes as pH becomes greater than 9.0 or less than 5.0.

Photosynthesis by aquatic plants also influences pH. It removes carbon dioxide from the water, which increases the alkalinity. In
especially low-velocity or still waters with lots of plant life (including planktonic algae), an increase in pH can be expected during the growing season or even during warm, sunny afternoons.

The carbon dioxide content of water in rivers and streams is less likely to change pH, but be aware of other events in the watershed that may affect pH. Human activities such as accidental spills, agricultural runoff (pesticides, fertilizers, animal wastes), and sewer overflows may also change pH.

**Measuring pH**

There are two procedures for determining the value of pH. One is by the use of a liquid Wide Range indicator and Octo-Slide Viewer. The other is a pH meter.

**QC CHECK:** Remember that the pH scale is logarithmic and a change in pH value of 1 unit is equivalent to a 10 times increase or decrease in the acidity or alkalinity of the water.

The following table shows some pH values of common substances:

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery acid</td>
<td>0.3</td>
</tr>
<tr>
<td>Lemon juice</td>
<td>2.1</td>
</tr>
<tr>
<td>Vinegar</td>
<td>3.0</td>
</tr>
<tr>
<td>Orange juice</td>
<td>4.3</td>
</tr>
<tr>
<td>Pure rainwater</td>
<td>5.8</td>
</tr>
<tr>
<td>Milk</td>
<td>6.9</td>
</tr>
<tr>
<td>Blood</td>
<td>7.5</td>
</tr>
<tr>
<td>Seawater</td>
<td>8.0</td>
</tr>
<tr>
<td>Baking soda</td>
<td>8.3</td>
</tr>
<tr>
<td>Ammonia</td>
<td>11.4</td>
</tr>
<tr>
<td>Bleach</td>
<td>12.7</td>
</tr>
<tr>
<td>Lye</td>
<td>13.8</td>
</tr>
</tbody>
</table>

**Wide Range Indicator and Color Comparator Viewer**

Wide Range pH indicator is a dye that changes color according to the pH of the solution. The color is then matched to color stan-
standards representing known pH values using a Color Comparator viewer system. Liquid Wide Range indicator allows measurement of pH in a range of 3.0 pH to 10.5 pH.

QC CHECK: If the water is strongly colored or extremely turbid, do not perform this test.

Wide Range pH Indicator Test Procedures

Step 1:

Rinse the sample test tube supplied with the pH kit twice with water from the sample bucket or water body.

Step 2:

Fill test tube to the 5 mL line with sample water, ensuring meniscus rests on top of indicator line.

SAFETY CHECK: Use your safety goggles and gloves during the remainder of this test, but remove goggles for color comparison (Step 5).

Step 3:

Add 10 drops of the pH wide range indicator. Cap and gently invert 10 times (do not shake).

Step 4:

Insert the tube in the top of the Color Comparator Viewer. Remove the blue cap prior to reading the test result.

Step 5:

Hold the Color Comparator Viewer up to a light white background to read. Make sure you are not looking through tinted glasses or safety goggles. The pH value is determined by matching the color in the comparator to the sample tube color. Read the results in pH standard units. Estimate the pH value to the nearest 0.1 pH unit. Record your results on your Monitoring Form in the pH box.
**QC CHECK:** The key to this test is the color of the sample, not how dark or light the sample is. The colors which influence the calibrated ampules in the color comparator graduate from red (acidic) to yellow to blue (basic) with green (a more common color to observe due to its indication of midrange pH) being a combination of yellow and blue. If the sample looks green, compare the amount of yellow in the sample vial with the amount of yellow in the calibrated ampules. The more yellow sample will have the lower pH. The sample with a darker green color will actually have more blue added to it. This color represents a higher pH value.

**SAFETY CHECK:** A sealable waste container should be used for collection of all test samples. Safely dispose of all out of date or waste chemicals by flushing them down a sanitary sewage system drain with plenty of water. Do not dispose of chemicals into a septic waste system, water body, or onto the ground.

**Using a pH Meter**

In using a pH meter the following steps are recommended to get the best results.

**Calibrating the pH Meter**

These steps should be performed before pH testing is performed. Calibrate the meter using the pH calibration Standard Solution.

**Step 1:**

Under the pH “Standard Value” box on the data sheet, record the value of the pH calibration standard (usually 7.0 su).

**Step 2:**

Remove the protective cap from the pH meter. Rinse the beaker and meter twice with a small volume of 7.0 pH calibration standard.

**Step 3:**

Pour about 50 mL of pH calibration standard into the beaker. Submerge and hold the meter in the pH calibration standard solution.

**Step 4:**

Turn the meter on by pressing the ON/OFF button. Hold the meter one-half inch off the bottom of the beaker and swirl gently. Wait one minute for the display to stabilize and then check the meter reading. Record this value under the pH “Initial Meter Reading” box in the calibration log. If the reading is not 7.0, proceed to step 5.

**Step 5:**

While the meter is still submerged in the pH standard solution, begin calibration by pressing the CAL button. The number displayed should begin flashing and will approach 7.0. It will rest on a number and stop changing. The number will continue flashing.

**Step 6:**

Calibrate the meter by pressing the HOLD button. The reading should immediately change to 7.0.

**Step 7:**

Turn the meter off. Rinse the beaker and meter twice with distilled water.
Step 8:

Keep the calibration standard for use during a post-test pH reading after sampling, but make sure the standard does not become contaminated during the time between the readings.

pH Meter Test Procedures

Step 1:

Remove the meter’s protective cap.

Step 2:

Rinse the beaker and meter twice with a small volume of sample water.

Step 3:

Fill the beaker halfway and then submerge and hold the meter in the sample water.

Step 4:

Turn the meter on by pressing the ON/OFF button. Hold the meter one-half inch off the bottom of the beaker and swirl gently, dislodging any air bubbles that might have formed. Wait one minute for the display to stabilize, and then check the reading. Record this number as your pH value under the “Core Tests and Measurements” section on your monitoring form. Turn the meter OFF, and replace cap.

Step 5:

Post-calibration check should be completed after you have sampled your designated monitoring location. Complete a post-calibration check by first rinsing the probe in distilled or deionized water and then placing it in a beaker with the same standard used for pH calibration. Allow the reading to stabilize and then record it in the Post Calibration blank in the calibration log on your data sheet. DO NOT CALIBRATE THE METER AT THIS TIME. If the value is not within 0.2 su of the standard value, the pH reading may not be accurate and representative. Please note this on the data sheet and be sure to change the batteries before your next sampling.

Note: After post-test, dispose of standard solution by rinsing it down the drain with plenty of water.

Maintenance of the pH Meter

After each use, rinse your pH meter with deionized water, distilled water, or tap water if the others are not available. When storing the pH meter, it is recommended that you wet the cotton in the base of the cap with tap or distilled water, and then replace the cap firmly. This retards leakage from the reference electrode and prolongs the useful life of the pH meter.

NOTE: Large differences in readings of pH (0.5 su) could be due to dry electrode or rundown batteries. To improve performance, leave pH meter up to 2 inches deep in tap water for a few minutes at least once a week.

To change batteries, open the cover at the top of the meter and replace batteries.
2.15 Conductivity

There are several terms used for describing inorganic materials in water: conductivity, dissolved solids, total dissolved solids, salinity, salt concentration, specific conductance, and resistivity. Although they are read in different measurements, their values can be converted and related to each other. The term salinity is typically used as an indication of how salty the water is in bays and estuaries. Strictly speaking, salinity describes the relative amounts of certain salts, especially chloride, that is in the same ratio to each other as they occur in seawater.

There are a wide variety of inorganic substances or dissolved solids like sodium, chloride, sulfate, calcium, bicarbonate, nitrates, phosphates, iron, magnesium, etc. in water solutions. All of these materials at certain concentrations are essential for life and all have the ability to carry an electrical current. These substances affect the flow of materials in and out of the cells of organisms living in the water and they may also be used as energy sources for certain organisms. They also serve as the parts of molecules necessary for building new cells.

In very general terms, water with high concentrations of dissolved solids (such as seawater) is considered salty and has a high level of conductivity. Water with low concentrations of dissolved solids is considered fresh. Most fish, plants and other organisms are adapted to living in waters with a particular salt concentration range. For this reason we would never expect to catch a largemouth bass in the Gulf of Mexico, and, on the other hand, we would not expect to see a red snapper in the Brazos River. Inorganic
materials in water are generally determined by the geology of the watershed. For example, if the soil and rock formations are composed of limestone, water draining this watershed will probably be high in calcium, magnesium and carbonate, the common constituents of limestone.

Fluctuating levels of dissolved solids and conductivity can be indicators of pollution from a number of activities. Examples of these activities include: wastewater discharges that may be high in salts; brine waters from oil production activities; irrigation; removal of vegetation shading a stream and causing increased evaporation; overuse of fertilizers; or the spreading of road salt during icy conditions.

Salt pollution is a problem because it can cause the salt levels of drinking water supplies to rise above recommended levels for human consumption. In some areas, it can cause rivers or streams to become unsuitable for agricultural irrigation or industrial use. Increasing levels might also impair aquatic life in ways that are difficult to determine.

**Measuring Conductivity**

Conductivity is a measure of the ability of water to pass an electrical current and is affected by the presence of dissolved solids. Dissolved substances in water dissociate into ions with the ability to conduct electrical current. As the level of total dissolved solids (TDS) rises, the conductivity will also increase.

Conductivity is measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µS/cm). Micromhos (µmhos) and microsiemens (µS) are equivalent units of measure, and can be used interchangeably. Distilled water has a conductivity in the range of 0.5 to 3 µS/cm.

Conductivity (or total dissolved solids) can be recorded using the EC Testr Low or High. (Older meters may be labeled as TDS Testr 3 or 4, respectively.) Which meter you use depends on the type of water you are sampling. As a rule of thumb, most freshwater measurements are best made with a EC Testr Low (or equivalent) low conductivity range meter that measures from 0 to 1990 µS/cm. For measuring in bays, estuaries, and certain areas where ground water is particularly high in dissolved solids (far north and west Texas) an EC Testr High with a range of 0 to 19.90 S/cm will be necessary.

**Conductivity Meter Calibration**

Monitors may use one of two methods for calibrating the conductivity meter. In the first method, the monitor records the temperature of the conductivity standard during calibration to ensure that the standard has not been exposed to temperature extremes. In the second method, the monitor performs a post-calibration of the meter without recording the temperature of the conductivity standard. Both methods adequately ensure the validity of the measurement, and this topic is covered in every training. Contact your program partner or Texas Stream Team if you are unsure of which method to perform.

Calibration is performed using a standard solution consisting of potassium chloride or sodium chloride mixed with deionized water. It is not toxic or hazardous. The meter should be calibrated to the nearest 0.10. For both calibration methods mentioned above, the temperature of the conductivity standard solution should be stable. For this reason, it is recommended that the calibration and post-calibration be performed in your house or lab at room temperature. Storing the standard in the trunk of a car or in a garage can interfere with proper pre- and post-calibrations, thus resulting in unreliable measurements.

**QC CHECK:** Conductivity calibration can be performed up to 24 hours in advance of the sampling event, but it is recommended that this procedure be performed immediately before going into the field.
Step 1:

Under the conductivity “Standard Value” box on the data sheet, record the value of the conductivity calibration standard.

Step 2:

Remove the protective cap from your conductivity meter. Rinse the beaker (and thermometer if performing the calibration method involving temperature) and meter’s probe twice with a small (approximately 1.5 oz or 50 mL) volume of conductivity standard.

Step 3:

Pour about 50 mL of conductivity calibration standard into the beaker. Submerge and hold the meter in the calibration standard.

Step 4:

Stir gently and check to make sure there are no small air bubbles trapped on the bottom of the probe. If there are air bubbles, they can be removed by tapping the bottom of the probe against the side of the beaker while the bottom of the probe is under water.

Step 5:

Turn the meter on.

Step 6:

The readings might initially increase or decrease as the meter reacts to the temperature difference between the meter and the calibration solution. Wait two minutes to allow the temperature sensor to fully compensate for this difference.
QC CHECK: Your meter reading will not be accurate if your meter is resting on the bottom or the sides of the beaker. Whenever calibrating or reading the meter, make sure that it is always at least one centimeter (½ inch) above the bottom of the beaker.

Step 7:

If applicable, record the thermometer’s temperature after 1.5 minutes in the calibration box on the data sheet and remove it from the beaker.

Step 8:

After two minutes, once the display has stabilized, read and record the meter reading in the calibration box under the column entitled “Initial Meter Reading.”

Step 9:

If the conductivity meter is not reading the same value as the standard solution (rounded to the nearest 10), remove the battery compartment lid. Next to the batteries are two white buttons. One button increases the value in the meter display, and the other decreases it. When adjusting, make sure that the meter is not resting on the bottom of the beaker and that there are no bubbles on the bottom of the meter probe. Press one or the other button to make the meter reading match the value of the conductivity standard solution (rounded to the nearest 10). The display will flash again and ENT will appear in the meter display. This means that the meter accepts the calibration and returns to measurement mode. Replace the battery compartment lid. The final meter reading should be recorded in the calibration box under the column entitled “Meter Adjusted To.”

Step 10:

Turn the meter off and remove from the solution. Shake the excess standard solution from the meter, rinse with distilled or deionized water, and replace the cap. Periodically soak or swab probes with alcohol.

Step 11:

If using the post-calibration method, keep the calibration standard for use during a post-test conductivity reading after sampling. Ensure that the standard does not become contaminated between the readings.
Conductivity Test Procedures

**Step 1:**

Remove the cap from the meter and rinse the sample beaker and the meter twice with the water from the same location and depth as the water to be sampled. Throw the rinse water downstream or up on the shore to avoid affecting your sample.

**Step 2:**

Collect the sample and place the meter in the beaker. Check the probe of the meter to make sure that there is not an air bubble trapped on the bottom.

**Step 3:**

Turn the meter on and wait 2 minutes and read the meter display. Make sure that the beaker with sample and meter are out of direct sunlight and protected from rapid temperature changes. Remember that the meter must be at least one centimeter above the bottom and not touching the sides of the beaker when you make your reading.

**Step 4:**

Record the meter reading in the “Conductivity” box on the monitoring form. Be sure to check off whether you are using the EC Tester Low or High. Rinse the meter with deionized water, wipe dry, and return to kit.

**Step 5:**

Post-calibration check should be completed after you have sampled your designated monitoring location as soon as possible and within 24 hours of your original calibration. Complete a post-calibration check by first rinsing the probe in deionized water and then placing it in a beaker with the same standard used for conductivity calibration. Allow the reading to stabilize and then record it in the Post-Calibration box in the calibration log on your data sheet. **DO NOT CALIBRATE THE METER AT THIS TIME.** If the reading is greater than 30 μmohs/cm from the conductivity standard value, the conductivity sample value is not considered accurate and representative.

**NOTE:** After post-calibration, dispose of standard solution by rinsing down the drain with plenty of water.
Data Management

Participation in either of Texas Stream Team quality assured programs requires use of a standardized form to record data (see form below). If the participant does not use the Texas Stream Team Project Specific QAPP form, the Texas Stream Team QA Officer must approve the form prior to submittal. Test results are always recorded as the tests are completed. All applicable sections of the data sheet should be completed. For example, if information is not collected for a certain variable, such as salinity, the space on the form is left blank.

Recording Data

To ensure proper recording of information on data sheets, monitors should observe the following rules:

1. Write legibly in ink or pencil.
2. Correct errors with a single line followed by an initial and date.

Data will only be accepted and entered into the Texas Stream Team Volunteer Database when it meets the following conditions:

1. It is collected by monitors with appropriate level of training.
2. It is collected by monitors who have successfully completed all required training and QC reviews.
3. It is collected with equipment which has been checked and approved by a Certified Trainer or QA Officer.
4. Data entries are legible.
5. Monitoring Forms are signed by monitors and include date, time, station number, and station description.
6. All required equipment calibrations have been completed and recorded.

The original (top) copy of the Monitoring Form is sent to Texas Stream Team and the yellow copy is sent to your Texas Stream Team Partner following each sample event so water quality problems can be identified immediately. Your Data Manager will review the form and make sure it is accurate and complete before entering it into an electronic format. See the Data Manager’s Checklist at the end of this section for a comprehensive list of verification requirements. Both you and your Data Manager should retain and file a copy of each Monitoring Form.

Any questions that arise later about reported data are much easier to address if you keep a copy of the reported data.
3.1 Data Manager's Checklist:

Before entering data, the following checklist is used to verify data meet Texas Watch quality control standards. Questions must be answered yes for the variable to be considered quality-assured.

Site and General Information
- Is the “Site Description” correct?
- Is the “Group ID” filled in?
- Is the “Monitor’s Name” filled in and legible?
- Has the Monitoring Form been signed by the monitor?
- Has the “Sample Date” been filled in? (mm/dd/yy)
- Has the “Sample Time (military)” been filled in using the 24 hour military time format? (hh:mm)
- Has the “Sample Depth (meters)” been recorded in meters?
- Are any reagents expired?
- Has the monitor completed his/her quality control sessions within the time limits defined by the QAPP?

Calibration Information
- Has the “Meter Calibration” been performed within 24 hours of the sample time?
- Is the “Meter Adjusted to” +/- 10 µmhos/cm of the “Standard Value”?
- Are the “Date, Time, Standard Value, Standard Temp (°C when applicable), Initial Meter Reading and Meter Adjusted To” filled in?
- If pH is done with a meter, are “Date, Time, Standard Temp (°C) (when applicable), and Initial Meter Reading” filled in?
- If pH is done with a meter is the pH “Standard Value” at 7.0 and “Meter Adjusted To” at 7.0?

Core Tests and Measurements
- Is “Conductivity” recorded in correct measurement according to tester used?
  - TDS Tester 3 0-1990 µmhos/cm
  - TDS Tester 4 0-19.90 µmS/cm
- Are “Air Temperature” and “Water Temperature” recorded in degrees Centigrade?
- Does “Dissolved Oxygen” have two titrations, then the “Average” entered?
- Are the two titrations within 0.5 mg/L or less of each other?
- Are “Secchi Disk Transparency” and “Total Depth” recorded in meters?

Note: The following parameters do not affect the validity of the field sample data but are extremely important for data integrity.

Field Observations
- If a parameter has more than one value listed, enter the first value only. The second value should be entered in the comments section.
- All values should be one of the standard values listed on the form.
- Is “Rainfall Accumulation” recorded in inches?
- Is “Days Since Last Significant Precipitation” recorded?

Additional tests
- Is the “TYPE” of test filled in correctly?
- Is the correct unit of measurement included for the test conducted?

Salinity
- Has the gray “Coastal Area Salinity Tests” correction box been filled in?

Comments
- Are comments legible?
- Are “Total Time Spent Sampling and Traveling” and “Total Roundtrip Distance Traveled” recorded?

QC CHECK: Documenting time spent and distance traveled provides vital information for state and funding agencies.
3.2 Clean-up and Storage of Equipment

QC CHECK: Do not use soap when cleaning your equipment. This can leave a residue, which can alter your results.

Thermometer
Rinse the thermometer in tap water. Place back in protective sheath. Store in kit.

Secchi Disk
Rinse the Secchi disk in tap water. Allow the disk and rope to air dry. Wind rope around disk and return to kit. Check line measurements annually for inaccuracy due to stretching.

Dissolved Oxygen
Safely dispose of all out-of-date or waste chemicals by flushing them down a sanitary sewage system drain with plenty of water. Do not dispose of chemicals into a septic waste system, water body, or onto the ground. Thoroughly rinse sampling containers and vials after each test preferably with deionized or distilled water (tap water is acceptable if the other two are unavailable). Do not rinse out the titrator used to add sodium thiosulfate. Dry the outside of the containers. Put all chemicals away in a cool, dark place away from children and pets until next sampling time.

pH Colorimetric Comparison Viewer
Rinse all tubes and tops with distilled water. Dry. Place back in protective kit.

Conductivity Meter
To store and care for your conductivity meter:
• Check to make sure the meter is turned off at all times except when it is in water
• The meter probes should be dried off before replacing the protective cap
• The probes can be regularly rubbed dry and cleaned with a paper or cloth towel

CAUTION: Many of the conductivity meters are not waterproof or even water resistant. Be very careful to protect against moisture, especially during damp conditions. Meters will not work properly if moisture gets inside.

• Do not immerse in water above the indicator level line
• On meters that are not water resistant, cover the calibration hole in the back of the meter with a small piece of tape after calibration to protect the electronics from moisture

Helpful Hints For Improving Performance Of A Conductivity Meter:
• Clean the stainless steel electrodes periodically, rinsing them in alcohol for a few minutes.
• Replace all 4 batteries if the display becomes faint or disappears or if the readings are unstable or the meter cannot be adjusted to the standard value.
• To change batteries, pull out the battery case (carefully lift the black top that has the on-off switch) and replace batteries.

Care and Storage of Chemicals
• pH wide range indicator can crystalize at the bottle mouth. Gently inverting the bottle several times will dissolve the crystals.
• Caps and bottles can be numbered with permanent black marker to prevent mixing, as well as, sequencing use (example: 1 = manganese sulfate, 2 = alkaline potassium iodide, 3 = sulfuric acid).
4.0 *E. coli* Monitoring and Analysis Procedures

**Training Requirements**

Texas Stream Team supports certification programs in both the “core” field parameters covered in the first part of the Texas Stream Team Water Quality Monitoring Manual and bacteriological monitoring protocols for *Escherichia coli* (*E. coli*) bacteria. In addition to the “core” volunteer monitoring certification training, volunteer certification in bacteriological monitoring includes:

- bacteriological information background and sample collection procedures
- media storage and preparation
- proper dilution, plating, and incubation procedures
- colony enumeration
- proper documentation and safety procedures

In order to ensure the highest confidence levels among data users, Texas Stream Team recommends that bacteriological monitors attend an annual bacteriological QC session during which they are updated and evaluated on monitoring techniques and enumeration of bacterial colonies.

**Scope and Application**

Texas Stream Team monitors will perform bacteria tests on streams, lakes, swimming beaches, and springs. The primary reasons for bacteria testing are determination of ambient conditions. Tests results may also be used to identify potential contamination from broken or leaking septic tanks and sewer lines, wastewater treatment plants, animal-holding operations and other point and nonpoint sources. Bacteriological monitors will develop sampling strategies to suit their objectives and budget, and sampling frequency will vary accordingly.

Results of the tests are evaluated against State of Texas contact recreation standards. If test results indicate contamination, Texas Stream Team advises the monitor to repeat and verify the initial results. If repeated high counts are found at a site over an extended period of time, the information will also be communicated to the appropriate local and state authorities.

**Summary of Method**

Coliscan Easygel is a method used to test for *E. coli* and general coliform bacteria. Dr. Jonathan Roth developed the technology for Micrology Laboratories, LLC. Easygel is not an agar, but is a pectin-gel. Easygel comes in a sterilized, two-piece unit, including a bottle of liquid medium and a petri dish treated with a special formulation.

With this method, a .5 to 5 mL of sample of water is collected using a sterile pipette and introduced into a 10 mL bottle of sterile liquid medium. The prepared medium is then plated on a treated petri dish, and incubated at a temperature of 33°C for 28 hours. Commercially available incubators, such as the Hovabator, are recommended. Incubator temperature is maintained and verified with the thermometer included with the incubator. Monitors will conduct field blank quality control analysis for ten percent of sampling events or once a month if less than 10 samplings are done in a month.

Upon incubation, the general coliforms and *E. coli* produce enzymes that react with color reagents in the media to produce pink to red colonies (general coliforms) or dark blue colonies (*E. coli*). Two samples from each monitoring site are analyzed, and a mean value is reported.

**Range and Accuracy**

The Coliscan Easygel test can detect as little as one bacterial colony per sample, and can be used to identify up to 200 colonies per sample. Concentrations exceeding 200 colonies per
sample are recorded as too numerous to count (TNTC). A black and a white grid, which is the same size as the petri dishes, is provided to assist monitors in counting *E. coli* colonies.

Accuracy of Coliscan Easygel is based on the reasonable performance of properly stored, pre-treated sterile plates, media, and pipettes. Extensive evaluation of the Coliscan Easygel method was conducted by Alabama Water Watch, Alabama Department of Fisheries, and Auburn University from February to September 1998 to confirm the accuracy of the Coliscan Easygel method. The results indicated that this method is a reliable and valid tool for the detection of fecal contamination through a variety of concentrations.

In December 1999, Coliscan Easygel was approved by the U.S. Environmental Protection Agency (EPA) Region 4 for use in the bacteriological monitoring of surface waters as part of the program developed by the Alabama Water Watch under the direction of Dr. William G. Deutsch of the Department of Fisheries of Auburn University. As a result of this program and other studies, Coliscan Easygel has become the preferred method for bacteriological monitoring in volunteer water quality monitoring programs throughout the United States.

### Supplies and Equipment

#### Necessary Items

The items needed to conduct bacteriological monitoring using the Coliscan Easygel method include:

- sterile bacteriological bottles
- Whirl-Pak™ or Whirl-Pak Thio-Bags™
- sterile Easygel medium
- pre-treated petri dishes
- sterile pipettes
- sterile diluent
- an incubator
- gloves
- bleach or isopropyl alcohol
- sealable plastic bags
Easygel proprietary items like media and pre-treated petri dishes can be ordered directly from Micrology Laboratories at (888) EASY-GEL or micrologylabs.com. Other equipment and supplies, including sterile diluent, can be purchased from a variety of sources like grocery and laboratory supplies stores. See the monitoring supplies section of the Texas Stream Team website for additional information.

**Sample Media Storage and Disposal**

When Coliscan Easygel reagents are received, the production date (if known) or arrival date, and the expiration date should be written on the box of media and petri dishes. Media bottles should be kept frozen until ready for use, allowing for a shelf life of up to one year. Thawed media is usable for up to two weeks when stored at room temperature. Medium can be refrozen but repeated freezing and thawing should be avoided. Pre-treated petri dishes should be stored at room temperature which also allows for a shelf life of one year. To dispose of expired media, pour a teaspoon of bleach into the bottle, cap the bottle, shake well, place the bottle in a sealable plastic bag, and dispose of it in household trash.

**Quality Control**

Analyzing samples for *E. coli* can introduce challenges in ensuring that contamination does not occur during sample collection and processing. It is important that all Texas Stream Team monitors use the same methods and procedures so that samples within and between streams can be compared to each other, and understanding the importance of quality assurance and quality control practices is crucial to generating credible environmental information. Quality assurance is the system used to make sure that all data collection activities are managed in a way that collected information meets the intended use of the project. Some examples of quality assurance measures include: the consistent Texas Stream Team training program, the use of consistent methods, written procedures, establishing data quality objectives, maintenance of records, and specifying the chain of custody procedures. Quality control procedures reassure that samples are being collected and documented in a consistent and accurate manner at all sites by all monitors. Examples of quality control include: double rinsing of nonsterile equipment prior to use, checking reagents for expiration dates, using data quality objectives to assess data validity, calibrating meters within 24 hours of use, and collecting field blanks on a routine basis. Together, quality assurance and quality control serve volunteer water quality monitors by bringing enhanced data credibility and use.

**Cross Contamination**

Efforts should be made to avoid contaminating sample containers, hands, tabletops, or any other surface or object. Do not touch bacterial
colonies. The dishes should be taped shut and kept out of reach of children, pets, and curious wildlife. A disinfectant should be used to clean tabletops or other areas that colonized plates have touched. Monitors should wash hands before and after handling the plates.

Field Blank

Field blanks are used to assess potential contamination from sample handling, airborne materials, equipment, media, and other sources. A field blank usually consists of a sterile diluent sample of 1 mL that is taken to the site and poured into a properly labeled sample container during the first bacteria sampling event of that day. The blank sample is collected in the same type of container, labeled as a field blank, and handled and analyzed along with all the bacteria samples collected on that day. It is used to identify errors or contamination in sample collection and analysis. The frequency of a bacteria field blank is one with every 10 samples. If less than 10 samples are collected in a month, include at least one field blank for any month bacteria samples are collected. Report the results of the field blank on your data form. There should be no *E. coli* colony growth on the field blank samples. If *E. coli* growth occurs on the blank, discard all data collected on that day. Document the results on the data sheet and consult with your trainer.

4.1 Sample Collection Procedures

1.0 Sample Site Location

Establishing sampling site locations should follow procedures outlined in Section 2.00 Choosing a Monitoring Location. In streams, rivers, and lakes, care should be taken to collect the bacteriological sample at an undisturbed location.

1.1 Sample Containers

Collect bacteriological samples in sterile bacteriological bottles or Whirlpak bags.

*Never pre-rinse the sample container.* For Whirl-Pak bags, squeeze out the top one inch of water from the bag and whirl the bag to seal. The sealed bag must retain at least 50 mL of sample but leave a small pocket of air. This airspace will help mix the sample when it is shaken just before making dilutions and membrane filtration. During every tenth sampling event (or a minimum of once per month), prepare one additional sample container and petri dish for a quality control field blank. If your sample site is downstream of a wastewater treatment plant outfall, the effluent might contain chlorine disinfectant that could debilitate bacteria. At these sites, Texas Stream Team recommends that monitors use the Whirl-Pak Thio-Bag™. These bags contain 10 mg tablets of sodium thiosulphate to neutralize free chlorine in the sample.

1.2 Sample Labeling

Label each sample container with the station number, site name, date, and time collected.

If it is appropriate to process a field blank sample, this container will have the previously mentioned information plus a “field blank” label.
1.3 Collecting Samples

When submerging the sample container, take care to avoid contamination by surface scums. The surface film is enriched with particles and bacteria not representative of the water mass. Also be careful not to collect sediment from the bottom of stream or lake. The correct procedure for collecting samples is demonstrated during trainings. When it is appropriate, remember to collect the field blank using the sterile diluent prior to conducting routine sampling at your site. This involves transferring the sterile diluent from its original container to the routine sampling container while at your monitoring location.

In flowing streams, dip the open sample container to a depth of 0.3 m (1 ft), or roughly half the depth, in very shallow streams. Avoid contact with the sediment. With the open end facing upstream, push the mouth of the bag upstream at this depth until full. Always hold the mouth of the sample container upstream of the sampler, sampling apparatus, and any disturbed sediments.

In reservoirs and coastal waters, dip the sample container to a depth of 0.3 m (1 ft). At this depth, push the mouth of the sample container away from the boat, dock, shore, sampler, and any disturbed sediment.

When collecting samples from a bucket of water, collect the bacteria sample before other monitoring activities occur. Pour water into the bacteriological sample container. Never immerse water sample containers in the bucket. This could introduce contamination.

1.4 Sample Preservation and Hold Times

Place sample(s) on ice immediately after collection. Bacteriological samples must transported, processed (diluted and plated), and placed in incubator within 6 hours of sample collection. Do not report samples that are not processed within the time limit. Record the hold time on the Texas Stream Team E. coli data sheet.

4.2 Analyzing E. coli Using Coliscan Easygel Pour Plate Method

2.0 Preparation

Prepare media for a minimum of two samples for each site. Bottles of media should be removed from the freezer in time to ensure that they have reached room temperature (typically 2-3 hours) before use.

Prepare two petri dishes per sample. During every tenth sampling event (or once per month minimally), prepare one additional petri dish for a quality control field blank. Label the top of each petri dish with:

- site name
- date
- volume of sample
- time the sample is poured into the petri dish

The field blank consists of a sterile diluent sample, and the sample container and petri dish will be labeled like the other samples and will also include “field blank” next to the site name.

2.1 Drawing Proper Sample Size

Shake the sample container vigorously, and then carefully open it without touching the lip of the bag. Leave the pipette in the sterile wrapper until ready to draw the sample. Unwrap the pipette from the bulb end and avoid contacting the tip with anything except the sample water. Submerge the bottom half of the pipette into the sample container and squeeze the bulb to expel the air. Draw the appropriate sample size (1 mL, 3 mL, or 5 mL) into the pipette by releasing the bulb slowly. Squeeze out any sample water in excess of the desired volume. Deposit the sample into the Easygel media bottle, cap, and swirl gently. Record the sample size in the E. coli section of the Texas Stream Team data sheet. Draw a 1 mL aliquot for field blanks.
• **Figure A** portrays a monitor labeling a petri dish with the appropriate monitoring information.
• **Figure B** depicts a monitor holding a Whirlpak bag.
• **Figure C** shows a monitor using a 5 mL pipette to remove a sample from the Whirlpak bag.
• **Figure D** shows the monitor placing the stream sample into the Coliscan Easygel bottle media.
• **Figure E** shows a monitor pouring the media, which includes the stream sample, onto the petri dish.
NOTE: Once mixed with Easygel media, the prepared samples should be either be plated within 10 minutes, or kept on ice or in a refrigerator until plated.

2.2 Determining Sample Size

The ideal number of colonies resulting from a single prepared plate is 20 to 60, and not over 200. Since the number of resulting colonies is dependent on the sample size, it may be necessary to experiment with several sample volumes to determine the best probable sample size to achieve 20-60 colonies. Draw a 1 mL aliquot for field blanks.

To establish a baseline for typical conditions, collect a 1 mL and a 5 mL sample volume during the first sampling event. If the 1 mL *E. coli* colony reading results in zero or only a few colonies, the sample volume should be increased to 3 mL or 5 mL. Conversely, if the 5 mL sample results in more than 60 colonies, the sample size should be reduced to 1 mL or 3 mL during the next sampling event.

Environmental and precipitation variables will influence levels of bacteria. Urban creeks with low discharge often have abundant *E. coli* and other coliform growth, and the volunteer should begin sampling with 1 mL and 3 mL volumes. Pristine waters may require a 5 mL sample to achieve the preferred range of colonies.

2.3 Plating the Sample

Pour the prepared sample (the Easygel media mixed with the water sample) slowly into the petri dish. Gently swirl until there is a smooth coating of prepared sample across the bottom of the petri dish (but be careful not to splash over the side or on the lid). Set on a level surface and allow five to forty-five minutes for the media to gel. This will help ensure that the sample will be spread uniformly across the petri dish and help prevent shifting or pooling of the media after being placed in the incubator.

2.4 Incubation

Turn on the incubator far enough in advance to ensure the appropriate temperature is reached before loading petri dishes. Place petri dishes right-side up in the incubator and maintain a steady incubation temperature of 33°C. At this temperature, colonies should not be counted for a minimum of 28 hours. For optimum results, count and record colonies at 28 hours of incubation. No counts should be made after 31 hours. Record the incubation time and temperature on the *E. coli* section of the Texas Stream Team data sheet.

2.5 Counting *E. coli* Colonies

Count the number of individual and distinct dark purple and dark blue colonies.

Colonies which have the blue-green color with a well established dark center are also considered to be *E. coli* and should be counted as well. Colonies which are white or pink should be ignored.

Record the number of *E. coli* colonies on the Texas Stream Team data sheet.

Field Blanks:

The frequency of a bacteria field blank is one with every 10 samples. If less than 10 samples are collected in a month, include at least one field blank for any month bacteria samples are collected. Follow routine handling, plating, and analysis procedures, and report the results on your data form. There should be no *E. coli* colony growth on the field blank samples. If *E. coli* growth occurs on the blank, discard all data collected on that day. Document the results on the data sheet and consult with your trainer. Trainers will work closely with monitors who have issues concerning field blank contamination to resolve the problem.
2.6 Data Reporting

Final results of the analysis for the two samples per site plus the field blank are reported on the Texas Stream Team data sheet as “colonies per 100 mL” of sample water. To arrive at that number you must first determine the dilution factor.

Dilution factor = 100 / sample size

For example, if you collected a sample size of 1 mL in the pipette and added this to the Easygel solution, your dilution factor is 100 / 1 or 100. Common dilution factors are:

.5 mL sample = dilution factor of 200
3 mL sample = dilution factor of 33.3
5 mL sample = dilution factor of 20

To determine the number of colonies per 100 mL, multiply the number of colonies counted times the dilution factor.

For example, if you counted 8 colonies and had a dilution factor of 33.3 (3 mL sample size), your final result is 8 times 33.3 or 266 E. coli colonies/100mL. For a count of 11 colonies times a dilution factor of 20 (5 mL sample size) your result is 220 E. coli colonies/100mL.

This information should be entered on the E. coli section of the Texas Stream Team data sheet to document the final results of each set of samples analyzed. Verify that the dilution factor calculation is correct and marked accordingly on the Data Quality Review Checklist.

2.8 Waste Disposal

To dispose of the used petri dishes, lift the lid and pour 5 ml (about 1 teaspoon) of straight bleach or isopropyl alcohol into each dish. Re-tape the lid, make sure the bleach has covered the entire dish, and allow to stand for a minimum of fifteen minutes. Place the dishes in a sealed plastic bag and place in normal household trash.

Periodically clean the inside of incubator with dilute bleach solution and allow it to air dry before the next use.

2.9 Data Review

The following Data Quality Review Checklist is used by the monitor, Texas Stream Team staff, and data user to verify that data are valid.
5.0 Appendix

5.0 Material Safety Data Sheets

New requirements mandate an arrangement of LaMotte’s MSDS information into 16 standard headings, making the form several pages long. As such, we are providing the first two pages of a four to five page data sheet for each reagent we use. These pages have the first aid and fire safety information. If you would like the full MSDS for any reagent, you can download the information on LaMotte’s website at http://www.lamotte.com/support/instructions_msdscertificates_of_analysis.html. Select the MSDS tab and type in the reagent code listed below to get a PDF of the data sheet.

<table>
<thead>
<tr>
<th>LaMotte Reagent</th>
<th>Code</th>
<th>Pg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline Potassium Iodide</td>
<td>7166</td>
<td>60</td>
</tr>
<tr>
<td>Manganous Sulfate Solution</td>
<td>4167</td>
<td>61</td>
</tr>
<tr>
<td>Sodium Thiosulfate, .025 N</td>
<td>4169</td>
<td>62</td>
</tr>
<tr>
<td>Starch Indicator Solution</td>
<td>4170</td>
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</tr>
<tr>
<td>Sulfuric Acid, 1:1</td>
<td>6141</td>
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</tr>
<tr>
<td>Wide Range Indicator</td>
<td>2218</td>
<td>65</td>
</tr>
</tbody>
</table>

5.1 Glossary

5.2 Notes & Observations Pages
Material Safety Data Sheet

Alkaline Potassium Iodide Azide - 7166

1. Product Identification
   - Manufactured By: LaMotte Company
   - Product Code: 7166
   - Product Description: Alkaline Potassium Iodide Azide

2. Composition/Information on Ingredients
   - Hazardous Name
   - CAS # % OSHA PEL ACGIH TLV
   - Acute Toxicity

3. Hazards Overview
   - Primary Route of Entry: Skin
     - Poison! Danger! Corrosive. Causes severe burns to eyes and skin. Harmful if inhaled. May be fatal if swallowed. Sodium Azide component is highly toxic.
   - HMIS Hazard: (Scale: 4 = Extreme, 3 = High, 2 = Moderate, 1 = Slight, 0 = Least)
     - Health: 3
     - Flammability: 0
     - Reactivity: 2
   - Carcinogenicity: None
   - Other Health Related Comments: See Section 11, Toxicity

4. First Aid Measures
   - Eye Contact: Immediately flush with water for 15 minutes. Get medical attention immediately.
   - Skin Contact: Immediately flush with water while removing affected clothing and rinse skin thoroughly for 15 minutes. Consult physician.
   - Ingestion: Do not induce vomiting. Rinse out mouth, drink plenty of water and call a doctor immediately.
   - Inhalation: Remove to fresh air.

5. Fire Fighting Measures
   - Flash Point: N/A
   - LEL: N/A
   - UEL: N/A
   - Extinguishing Media: Not a fire hazard
   - Special Fire Fighting Procedures: Wear self contained breathing apparatus and protective clothing to prevent inhalation and contact with eyes.
   - Hazardous Combustion and/or Decomposition Products: Hydrogen gas
   - Unusual Fire & Explosion Hazard: Violent exothermic reaction occurs with water. May produce enough heat to ignite combustibles. Can react with metals to produce hydrogen, forming explosive mixture with air.

6. Accidental Release Measures
   - Wear gloves and eye protection. Neutralize by carefully and slowly adding dilute hydrochloric acid (conc. 6M or less) to pH 7 or 8. Collect waste liquid. Dispoese of collected liquid as hazardous waste as described in Section 13.

7. Handling & Storage
   - Store in cool, well ventilated area away from strong acids and other incompatible materials.

8. Exposure Controls/Personal Protection
   - Ventilation: Use with adequate ventilation.
   - Protection When Handling: Gloves, Eye Protection, Lab Coat
   - Work/Hygienic Practices: Avoid contact with skin and clothing. Use Neoprene gloves, goggles, face shield, protective clothing. Neutralization of waste quantities of #7166 should be done in a fume hood or with good ventilation. Addition of strong acid may generate a small amount of hydrazoic acid from the sodium azide. (Hydrazoic acid is harmful to breathe).

9. Physical & Chemical Properties
   - Appearance: Colorless Clear Liquid
   - Boiling Point: Unknown
   - Melting Point: N/A
   - pH: 14
   - Odor: None
   - Vapor Density: Unknown
   - Solubility in Water: Soluble
   - Vapor Pressure: Unknown
1. Product Identification

Product Code: 4167
Product Description: Manganous Sulfate Solution

Manufactured By: LaMotte Company
802 Washington Avenue
Chestertown, MD 21620

2. Composition/Information On Ingredients

<table>
<thead>
<tr>
<th>Hazard</th>
<th>CAS#/Name</th>
<th>%</th>
<th>PEL</th>
<th>TLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Manganese Sulfate monohydrate</td>
<td>36</td>
<td>0.5 mg/cubic m (comp. as Mn)</td>
<td>0.2 mg/cubic m (comp. as Mn)</td>
</tr>
<tr>
<td>No</td>
<td>Water</td>
<td>to 100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Hazards Overview

Primary Route Of Entry: Ingestion, Skin
May irritate eyes and skin. Harmful if swallowed.

HMS Hazard
Scale: 4 = Extreme, 3 = High, 2 = Moderate, 1 = Slight, 0 = Least
Health: 1 Flammability: 0 Reactivity: 0

Carcinogenicity: None

Other Health Related Comments:
Manganese investigated as a tumorigen, mutagen, reproductive effector.

4. First Aid Measures

Eye Contact: Immediately flush with water for 15 minutes. Consult a physician.

Skin Contact: Wash thoroughly with water. Remove contaminated clothing and wash skin with soap and water. Consult physician.

Ingestion: Induce vomiting immediately. Consult a physician.

5. Fire Fighting Measures

Flash Point (Method Used): N/A
Extinguishing Media: Not a fire hazard
Special Fire Fighting Procedures: N/A
Unusual Fire & Explosion Hazard: N/A

6. Accidental Release Measures

Mop up carefully and hold for disposal.

7. Handling & Storage

Store in cool, dry, storage area away from incompatible materials.
# Material Safety Data Sheet

## 1. Product Identification

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4169</td>
<td>Sodium Thiosulfate, .025 N</td>
</tr>
</tbody>
</table>

**Manufactured By:** LaMotte Company  
802 Washington Avenue  
Chestertown, MD 21620

## 2. Composition/Information On Ingredients

<table>
<thead>
<tr>
<th>CAS/Name</th>
<th>%</th>
<th>PEL</th>
<th>TLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1310-73-2</td>
<td>&lt;0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium Hydroxide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10102-17-7</td>
<td>&lt;1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium Thiosulfate, 5-hydrate</td>
<td>to 100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7732-18-5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## 3. Hazards Overview

**Primary Route Of Entry:** Ingestion, Skin  
Large doses by mouth can cause GI irritation. May cause skin irritation.

**Hazard:**  
**Health:** 1  
**Flammability:** 0  
**Reactivity:** 0

**Hazard:** None

**Carcinogenicity:** None

**Other Health Related Comments:**

## 4. First Aid Measures

**Eye Contact:**  
Flush with water for 15 minutes.

**Skin Contact:**  
Flush with water. Wash with soap and water.

**Inhalation:**  
Drink plenty of water. Consult a physician if symptoms appear.

## 5. Fire Fighting Measures

**Flash Point (Method Used):** N/A  
**Extinguishing Media:** N/A  
**Special Fire Fighting Procedures:** N/A  
**Unusual Fire & Explosion Hazard:** N/A

## 6. Accidental Release Measures

Neutralize with vinegar or other dilute acid and mop up.

## 7. Handling & Storage

Store in cool, dry, storage area away from heat and light.
1. Product Identification

Product Code: 4170
Product Description: Starch Indicator Solution

Manufactured By: LaMotte Company
802 Washington Avenue
Chestertown, MD 21620

2. Composition/Information On Ingredients

<table>
<thead>
<tr>
<th>CAS#</th>
<th>Name</th>
<th>%</th>
<th>PEL</th>
<th>TLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>60-73-5</td>
<td>0.13</td>
<td>15 mg/cu m total dust</td>
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<tr>
<td>Yes</td>
<td>Salicylic Acid</td>
<td>0.5</td>
<td>5 mg/cu m (total dust)</td>
<td>10 mg/cu m (total dust)</td>
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<tr>
<td>No</td>
<td>Soluble Starch</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Water</td>
<td></td>
<td>to 100%</td>
<td></td>
</tr>
</tbody>
</table>

3. Hazards Overview

Primary Route Of Entry: Ingestion
May be harmful if swallowed.

Hazard:

<table>
<thead>
<tr>
<th>Health</th>
<th>Flammability</th>
<th>Reactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Carcinogenicity: None.

Other Health Related Comments:
See Section 11.

4. First Aid Measures

Eye Contact: Flush with water.
Skin Contact: Flush with water.
Ingestion: Solution is acidic (pH 3) and may irritate stomach if large amount is swallowed. Drink water or milk. Consult physician.
Inhalation: N/A

5. Fire Fighting Measures

Extinguishing Media: Not a fire hazard
Special Fire Fighting Procedures: N/A
Unusual Fire & Explosion Hazard: N/A

6. Accidental Release Measures

Mop up. Flush down drain.

7. Handling & Storage

Store at room temperature, out of direct sunlight.
5.0 Material Safety Data Sheet

Sulfuric Acid, 1:1 - 6141

<table>
<thead>
<tr>
<th>Product Code:</th>
<th>6141</th>
<th>Product Description: Sulfuric Acid, 1:1</th>
</tr>
</thead>
</table>

6. Accidental Release Measures

Wear gloves, eye and skin protection. Cover spill with sodium bicarbonate or soda ash/calcium hydroxide mixture. Mix and carefully add water to form slurry, avoiding heat, spattering, and flames. Scoop up neutralized slurry and flush to drain with excess water.

7. Handling & Storage

Store in cool, dry, ventilated storage with acid resistant floors and good drainage. Keep out of direct sunlight and away from heat, water, and such incompatible materials as combustibles, strong bases, metals, cyanides, and sulfides.

8. Exposure Controls/Personal Protection

Ventilation
A system of local or general exhaust is recommended.

Protection When Handling
Gloves, Eye Protection, Lab Coat, Other: vinyl apron, face shield to avoid body splashes.

Work/Hygienic Practices:
Avoid contact with skin and clothing and inhalation of vapor.

9. Physical & Chemical Properties

Appearance:
Colorless Liquid

Boiling Point:
>100 deg C

Melting Point:
N/A

pH:
<1

Odor:
None

Vapor Density:
>1 (Air=1)

Vapor Pressure:
<1 mm Hg at 20 deg C

10. Stability & Reactivity

Stable: Yes

Condition to Avoid:
Moisture

Materials to Avoid:
Organics, combustibles (may cause fire), strong bases, metals (yields hydrogen gas), cyanides (yields poisonous HCN gas), sulfides (yields poisonous H2S gas), strong oxidizers and many other reactive substances

Hazardous Decomposition Products:
SOx; reacts with water to produce toxic and corrosive fumes; reacts with metals to produce flammable hydrogen gas.

11. Toxicological Information

Oral rat LD50: 2140 mg/kg for sulfuric acid
Sulfuric acid mists investigated as a tumorogenic, mutagen, reproductive effector. IARC has classified “strong inorganic acid mists containing sulfuric acid” as a known human carcinogen (IARC category 1). This applies to mists—not to liquid sulfuric acid or its solutions.

Target Organs:
Skin; Corrosive to all body parts.

12. Ecological Information

When released into the soil, sulfuric acid may leach into groundwater. When released into the air, it may be removed from the atmosphere to fall as acid rain or as dry deposition. This material may be toxic to aquatic life.
1. Product Identification

Product Code: 2218

Product Description: Wide Range Indicator

Manufactured By: LaMotte Company
802 Washington Avenue
Chester, MD 21620

2. Composition/Information On Ingredients

<table>
<thead>
<tr>
<th>Hazard</th>
<th>CAS#/Name</th>
<th>%</th>
<th>PEL (mg/cubic m)</th>
<th>TLV (mg/cubic m)</th>
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<td>1000 ppm</td>
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<tr>
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<td>200 ppm</td>
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<tr>
<td>Yes</td>
<td>51-28-4</td>
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<tr>
<td>Yes</td>
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<td>C 2 mg/cubic m</td>
<td>C 2 mg/cubic m</td>
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<tr>
<td>No</td>
<td>7732-18-5</td>
<td>to 100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Hazards Overview

Poison! Danger! Flammable liquid & vapor! Harmful if swallowed, inhaled, or absorbed through skin. Ingestion may be fatal or cause blindness. Inhalation can cause headache, nausea. Affects central nervous system. May cause irritation to eyes and skin.

Primary Route Of Entry:

- Skin
- Ingestion
- Inhalation

Carcinogenicity: Yes: NTP

Warning! This product contains phenolphthalein, a chemical known to the state of California to cause cancer. Phenolphthalein listed in NTP 9th Report on Carcinogens (2000) as "reasonably anticipated to be a human carcinogen".

4. First Aid Measures

Eye Contact: Flush thoroughly with water. Consult a physician.

Skin Contact: Wash with soap and water.

Ingestion: Give plenty of water. Call a physician immediately.

Inhalation: Remove to fresh air. Consult physician.

5. Fire Fighting Measures

Extinguishing Media: Dry chemical, CO2, or water spray

Special Fire Fighting Procedures: N/A

Unusual Fire & Explosion Hazard: Vapors may travel distance to ignition source and flash back.

6. Accidental Release Measures

Ventilate area. Eliminate all sources of ignition. Absorb on paper or spill pads. Allow to evaporate on iron pan (or other non-combustible container) in fume hood.
5.1 Glossary of Terms

**Acute Toxicity** - The ability of a substance to cause poisonous effects resulting in severe biological harm or death soon after a single exposure or dose. Also, any severe poisonous effect resulting from a single short-term exposure to a toxic substance.

**Algae** - Plants that lack true roots, stems, and leaves. For the physical assessment described herein, algae consist of nonvascular plants that attach to rocks and debris or are free floating in the water. Such plants may be green, blue-green, or olive in color, slimy to the touch, and usually have a coarse filamentous structure.

**Alkalinity** - A measure of the acid-neutralizing capacity of water. Bicarbonate, carbonate and hydroxide are the primary cause of alkalinity in natural waters. Concentrations are expressed as mg/L of CaCO₃.

**Ammonia-Nitrogen (NH₃-N)** - Ammonia, naturally occurring in surface and wastewaters, is produced by the breakdown of compounds containing organic nitrogen.

**Aquatic Macrophyte** - Vascular plants that usually are arranged in zones corresponding closely to successively greater depths in shallow water. The characteristic plant forms that dominate these gradients (in order of decreasing depth) are: (1) submersed rooted aquatics, (2) floating-leaved rooted aquatics, (3) emergent rooted aquatics, and (4) marginal mats. Some vascular plants (like duckweed) may live unattached in the water and may occur anywhere on the water surface.

**Bank** - The portion of the channel that tends to restrict lateral movement of water. It often has a slope less than 90° and exhibits a distinct break in slope from the stream bottom. Also, a distinct change in the substrate materials or vegetation may delineate the bank.

**Benthic Region** - The bottom of all waters that supports the benthos.

**Benthos** - Aquatic bottom dwelling organisms that include: worms, leeches, snails, flatworms, burrowing mayflies, clams.

**Bioaccumulation** - The process in which a chemical is moved through the biological food chain by being passed from one organism to another as the contaminated organism is preyed upon by another organism.

**Bioassay** - The use of living organisms to measure the effect of a substance, factor or condition by comparing before and after data.

**Biochemical Oxygen Demand (BOD)** - A measure of the amount of oxygen consumed in the biological demand processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

**Biological Magnification** - The process by which certain pollutants (for example; pesticides or heavy metals) become very concentrated, above their normal concentrations in water or mud. The concentration of pollutants occurs as organisms, which take the pollutants from the water or mud, are consumed by other organisms higher in the food chain. The substances become concentrated in tissues or internal organs as they move up the chain.

**Bloom** - The accelerated growth of algae and/or higher aquatic plants in a body of water. This is often related to pollutants that increase the rate of growth.

**BOD₅** - The amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter.

**Channel** - That portion of the landscape which contains the bank and the stream bottom. It is distinct from the surrounding area due to breaks in the general slope of the land, lack of terrestrial vegetation, and changes in the composition of substrate materials.

**Channelization** - Straightening and deepening streams so water will move faster, a method of flood control that disturbs fish and wildlife habitats and can interfere with a water body’s ability to assimilate waste.

**Chemical Oxygen Demand (COD)** - A measure of the oxygen required to oxidize all compounds in the demand water, both organic (living) and inorganic (non-living).

**Chloride (Cl⁻)** - One of the major inorganic ions in water and wastewater. Concentrations can be increased by industrial processes. High chloride concentrations can affect metallic objects and growing plants.

**Chlorophyll a** - Photosynthetic pigment which is found in all green plants. The concentration of chlorophyll a is used to estimate phytoplankton biomass (all of the phytoplankton in a given area) in surface water.

**Chronic Toxicity** - The capacity of a substance to cause long-term poisonous human health effects (See acute toxicity).
Conductivity - A measure of the electrical current carrying capacity, in µmhos/cm, of 1 cm of water at 25°C. Dissolved substances in water dissociate into ions with the ability to conduct electrical current. Conductivity is a measure of how salty the water is; salty water has high conductivity.

Contact Recreation - Recreational activities involving a significant risk of ingestion of contaminant water, including wading by children, swimming, water skiing, diving and surfing.

Criteria - Water quality conditions which are to be met in order to support and protect designated use.

Cubic Foot Per Second (ft³/s)(cfs) - A commonly used measure of the rate of flow where a 1 cubic foot volume of water travels one foot in 1 second.

Cut Bank - The outside (concave) bank of a stream channel bend characterized by high erosion. Stream flow usually increases along the cut bank side of the channel.

Detritus - Decaying organic material.

Ecological Impact - The effect that a man-made or natural activity has on living organisms and their abiotic (non-living) environment.

Eddy Current - A circular water movement formed on the side of a main current. Eddies may be formed where the main stream passes obstructions (logs, rocks).

Effluent - Wastewater (treated or untreated) that flows out of a treatment plant or industrial outfall (point source), prior to entering a water body.

Emergent Vegetation - Aquatic macrophytes (plants) that are rooted in the sediment, near shore or in marshes, with nearly all of the leaves above the water surface (cattails).

Epilimnion - The warmer oxygen-rich region of a lake or reservoir that extends from the surface to the thermocline.

Escherichia coli – E. coli, more commonly associated with human waste only, has replaced fecal coliform as the indicator bacteria for freshwater bodies in Texas. The presence of fecal coliform, or E. coli indicates the presence of inadequately treated sewage, improperly managed animal waste from livestock, pets, wildlife (birds and mammals; either aquatic or living near water, for example, birds nesting under a bridge), or failing septic system.

Estuary - Regions of interaction between rivers and near shore ocean waters, where tidal action and river flow create a mixing of fresh and salt water.

Euphotic Zone - The zone of water from the surface to depth of light penetration. Photosynthesis respiration occurs in this zone.

Eutrophic - Refers to shallow, murky bodies of water that have excessive concentrations of plant nutrients resulting in increased algal production.

Eutrophication - The slow, aging process during which a lake, estuary or bay evolves into a bog or marsh and eventually disappears.

Family - A group of related plants or animals forming a category ranking above a genus and below an order and usually comprising several to many genera.

Fecal Coliform Bacteria - Bacteria found in the intestinal tracts of warm-blooded animals. Organisms used as an indicator of pollution and possible presence of waterborne pathogens.

Floating Vegetation - Rooted plants (some free floating) with leaves floating on the surface (ex: water lily, water shield, duck weed and water hyacinths).

Flood Plain - The area adjacent to the channel which is occasionally submerged under water. Usually the flood plain is a low gradient area well covered by various types of riparian vegetation.

Food Chain - The dependence of organisms upon others in a series for food. The chain begins with producers (plants) and ends with the largest of the consumers (carnivores).

Food Web - An interlocking pattern of several to many food chains.

Fry - The stage in the life of a fish between the hatching of the egg and the absorption of the yolk sac.

Genus - A category of biological classification ranking between the family and the species, comprising structurally or phylogenetically (evolutionary relationship) related species and being designated by a Latin or latinized capitalized singular noun.
**Glide** - Portion of the water column in which the flow is characterized by slow-moving laminar flow, similar to that which would be found in a shallow canal. Water surface gradient over a glide is nearly zero, so velocity is slow, but flow is shore to shore without eddy development. A glide is too shallow to be a pool, but the water velocity is too slow to be a run.

**Habitat** - The area in which an organism lives.

**Hypolimnion** - The cold, oxygen-poor region of a lake or reservoir that extends from the thermocline to the bottom and is not influenced by surface conditions.

**Impoundment** - A body of water confined by a dam, dike, floodgate or other barrier.

**Indicator Organisms** - An organism, species, or community that indicates the presence of a certain environmental condition or conditions.

**Inorganic** - Any compound lacking carbon.

**Intolerant Organism** - Organisms that are sensitive to degradation in water quality and habitat. Sensitive organisms are usually driven from an area or killed as the result of some contaminant, especially organic pollution (e.g., sewage, feedlot runoff, food waste).

**Invertebrate** - Animal lacking a backbone.

**Lentic** - Standing water systems; lakes, ponds or bogs.

**Limnetic Zone** - The open-water portion of a pond, lake or bog which is too deep for rooted plants, but with enough light penetration for photosynthetic activity.

**Littoral Zone** - Area of shallow water where light penetrates to the bottom allowing for rooted plant growth (lake or pond).

**Lotic** - Running or flowing water systems; rivers and streams.

**Macrophyte** - Any large vascular plant that can be seen without the aid of a microscope or magnifying device (cattails, rushes, arrowhead, water lily, etc.).

**Mesotrophic** - A term used to classify bodies of water that fall midway between oligotrophic and eutrophic; characterized by moderate amounts of nutrients entering the water body and moderate shoreline aquatic vegetation and occasional plankton blooms.

**Natural Vegetative Buffer** - The natural vegetative buffer refers to an area of either natural or native vegetation which buffers the water body from terrestrial runoff and the activities of man. In natural areas, it may be much greater than the riparian zone width. In man-altered settings, the natural vegetative buffer limit would be at the point of man’s influence in the riparian zone such as a road, parking lot, pasture or crop field. It is the width of this buffer that we are most interested in measuring for purposes of quantifying potential stream impairments.

**Nekton** - Free-swimming organisms (e.g., fish, insects).

**Nitrate-Nitrogen (NO₃-N)** - A compound containing nitrogen which can exist as a dissolved solid in water. Excessive amounts can have harmful effects on humans and animals (>10 mg/L).

**Nitrification** - The process where ammonia in water and wastewater is oxidized to nitrite and then to nitrate by bacterial and chemical reactions.

**Nitrite-Nitrogen (NO₂-N)** - An intermediate oxidation state in the nitrification process (ammonia, nitrite, nitrate).

**Non-Point Source** - Pollution sources which are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outfall. The pollutants are generally carried off the land by stormwater runoff. The commonly used categories for non-point sources are: agriculture, forestry, urban, mining, construction, dams and channels, land disposal and saltwater intrusion.

**Nutrient** - Any substance used by living things to promote growth. The term is generally applied to nitrogen and phosphorus in water and wastewater, but is also applied to other essential and trace elements.

**Oligotrophic** - A water body characterized by few nutrients entering the water body, few to no shoreline aquatic plants and rare plankton blooms.

**Organophosphate Pesticides** - Pesticides that contain phosphorus; short-lived, but some can be toxic when first applied.

**Orthophosphate (O-P)** - Nearly all phosphorus exists in water in the phosphate form. The most important form of inorganic phosphorus is orthophosphate, making up 90% of the total. Orthophosphate, the only form of soluble inorganic phosphorus that can be directly utilized, is the least abundant of any nutrient and is commonly the limiting factor.
**Outfall** - A designated point of effluent discharge.

**Overhanging Vegetation** - Vegetation that overhangs the water column and provides food and cover for fish and benthic macroinvertebrates and shades the water from solar radiation.

**Periphyton** - Organisms that cling to rock, plants, logs, tires, etc.

**pH** - The hydrogen-ion activity of water caused by the breakdown of water molecules and presence of dissolved acids and bases.

**Pheophytin a** - An important degradation product of chlorophyll a, interferes with the measurement of chlorophyll a. Pheophytin a can cause an over or under estimation of chlorophyll a. Pheophytin a is used to determine a more accurate measure of chlorophyll a.

**Phosphorus** - Essential nutrient to the growth of organisms and can be the nutrient that limits the primary productivity of water. In excessive amounts, from waste-water, agricultural drainage and certain industrial wastes, it also contributes to the eutrophication of lakes and other water bodies.

**Photosynthesis** - The manufacture by plants of carbohydrates and oxygen from carbon dioxide and water in the presence of chlorophyll using sunlight as an energy source.

**Plankton** - Organisms (plants and animals) which live in open water, either suspended or floating. Phytoplankton (plant): (1) Microscopic (2) movement dependent on currents (3) primary producers (solar radiation and nutrients used for growth) (4) have effect on water quality. Zooplankton (animal): (1) microscopic, but some can be seen by the naked eye (2) capable of movement (3) secondary producers (feed on phytoplankton, bacteria and detritus (dead organic matter).

**Point Bar** - The inside (convex) bank of a stream channel bend characterized by high deposition of sand, gravel, or cobble. The top of the point bar defines the floodplain. Point bars are built up during periods of flooding and are usually devoid of woody vegetation.

**Point Source** - A specific location from which pollutants are discharged. It can also be defined as a single identifiable source of pollution (e.g., pipe or ship).

**Pollution** - the man-made or man-induced alteration of the chemical, physical, biological and radiological integrity of water (EPA CWA definition).

**Pool** - A portion of a stream where water velocity is slow and the depth is greater than the riffle, run or glide. Pools often contain large eddies with widely varying directions of flow compared to riffles and runs where flow is nearly exclusively downstream. The water surface gradient of pools is very close to zero and their channel profile is usually concave.

**Profundal Zone** - Area of a pond or lake lacking light penetration and photosynthesis.

**Receiving Water** - A river, stream, lake or other body of surface water into which wastewater or treated effluent is discharged.

**Reservoir** - Any natural or artificial holding area used to store, regulate or control water.

**Riffle** - A shallow portion of the stream extending across a stream bed characterized by relatively fast-moving turbulent water. The water column in a riffle is usually constricted and water velocity is fast due to a change in surface gradient. The channel profile in a riffle is usually straight to convex.

**Riparian Zone** - Generally includes the area of the stream bank and out onto the flood plain which is periodically inundated by the flood waters from the stream. The limit of the zone depends on many factors including native plant community make up, soil moisture levels, and distance from the stream (or the limit of interaction between land and stream processes). It is periodically inundated by the flood waters from the stream. Interaction between this terrestrial zone and the stream is vital for the health of the stream.

**River Basin** - The land area drained by a river and its tributaries.

**Rough Fish** - Those species of fish considered to be of poor fighting quality and/or poor food quality. Most rough fish are tolerant of pollution. Examples: common carp and gar.

**Run** - A relatively shallow portion of a stream characterized by relatively fast moving non-turbulent flow. A run is usually too deep to be considered a riffle and too shallow to be considered a pool. The channel profile under a run is usually a uniform flat plane.

**Run-Off** - The part of precipitation or irrigation water that runs-off land into streams and other surface water.

**Salinity** - The amount of dissolved salts in water, generally expressed in parts per thousand (ppt).
**Sediment** - Particles and/or clumps of particle of sand, clay, silt, and plant or animal matter carried in water and are deposited in reservoirs and slow moving areas of streams and rivers.

**Segment** - Waters designated by the Texas Natural Resource Conservation Commission in the Texas Surface Water Quality Standards, which include most rivers and their major tributaries, major reservoirs and lakes and marine waters. Segmented waters have designated physical boundaries, specific uses and numerical physicochemical criteria (Ex: DO, temperature, fecal coliform, chloride, sulfate) in the state’s water quality standards.

**7 Q2** - Seven-day, two year low flow.

**Species** - A category of biological classification ranking immediately below the genus, comprising related organisms potentially capable of interbreeding. A species is identified by a two part name; the name of the genus followed by a Latin or latinized uncapitalized noun agreeing grammatically with the genus name.

**Stream Bend** - Curved part of a stream. A well-defined bend has a deep outside area (cut bank) and shallow inside area accentuated by point bar development. Due to sharp bending, stream flow is forced to the cut bank side and eddies develop on the inside of the bend. A moderately developed bend forces some flow to the outside and has only a slight change in depth across the channel. A poorly defined bend has no noticeable change in water depth across the channel, and stream flow is generally not forced to one side.

**Submerged Vegetation** - Rooted plants with almost all leaves below the water surface (e.g. alligator weed, hydrilla or elodea).

**Sulfate** (SO4-2) - Sulfate is derived from rocks and soils containing gypsum, iron sulfides and other sulfur compounds. Sulfates are widely distributed in nature.

**Surface Water Quality Standards** - The designation of water bodies for desirable uses and the narrative and numerical criteria deemed necessary to protect those uses.

**Tailwater** - Excess surface water drainage, normally from irrigation. Also water released from dams.

**Terrace** - The area of a stream bank where the vertical slope of a bank sloping away from the water column changes to a horizontal slope. It is usually identified by an abrupt change in slope and usually marks the beginning of the floodplain.

**Tolerant Organism** - Organisms that have the capacity to grow and thrive when subjected to unfavorable environmental factors.

**Total Dissolved Solids (TDS)** - The amount of material (inorganic salts and small amounts of organic material) dissolved in water.

**Total Hardness** - The sum of the calcium and magnesium concentrations, expressed as calcium carbonate in mg/L.

**Total Suspended Solids (TSS)** - A measure of the total suspended solids in water, both organic and inorganic.

**Transect Line** - A straight line, perpendicular to stream flow, between two points on opposite stream banks.

**Tree Canopy** - The uppermost spreading branching layer of streamside trees that shades the water surface. Tree canopy is reported as percent cover and is measured with a canopy densiometer. Possible measurement range is from 0% (totally open) to 100% (totally closed canopy cover).

**Tributary** - A stream or river that flows into a larger stream or river.

**Volatile Organic Compounds (VOC)** - Substances containing carbon, hydrogen, and oxygen that easily become vapors or gases.

**Volatile Suspended Solids (VSS)** - The portion of the TSS that is lost after ignition. This represents the organic part of the TSS.

**Water Quality Limited** - Designated water body segments are classified as water quality limited (1) if surface water quality monitoring data has shown significant violations of water quality standards established by the Texas Surface Water Quality Standards; (2) if advanced waste treatment for point source wastewater discharges is required to meet water quality standards;(3) to protect existing conditions of exceptional water quality; or (4) if the segment is a domestic water supply reservoir.

**Water Quality Standards** - Established limits of certain chemical, physical, and biological parameters in a water body; water quality standards are established for the different designated uses of a water body (e.g., aquatic life use, contact recreation, public water supply).

**Watershed** -The area of land from which precipitation drains to a single point. Watersheds are sometimes referred to as drainage basins or drainage areas.
5.2 Notes and Observation
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