Lake/Estuary Profiling and Sample Collection

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Preface

The Watershed Protection Branch (WPB) of the Georgia Environmental Protection Division (GAEPD) has created a series of standard Operating Procedures (SOP) establishing uniform methods for the field collection of data, document control, quality assurance, laboratory safety, as well as other activities. These guidance documents were developed to document and ensure the validity of measurements, analyses, and the representativeness of samples collected. This is necessary in the event of a dispute with other parties regarding data collection techniques and the resulting quality of field information. Enforcement activities by the Branch require full documentation on particulars of data collection and the equipment used to collect it. Because studies and data derived from non-enforcement type investigations could be used for enforcement purposes at a later time, both investigations follow the procedural guidelines presented in this document. All Branch Associates who collect samples or field data must be familiar with the measures outlined in the appropriate SOPs.

Requirements pertaining to specifics of sample collection for certain parameters are specified in federal regulations under the authority of the Clean Water Act (CWA) and the National Pollutant Discharge Elimination System (NPDES) permitting program. The most widely applicable guidance at this level is *Title 40 of the Code of Federal Regulations (40 CFR)*. The procedures and techniques given in *40 CFR* are updated periodically by the United States Environmental Protection Agency and field workers are advised to consult the latest revision for proper procedures and new developments. In addition, the SOPs utilized by the Branch should be reviewed annually to certify their concurrence with federal statutes. Other references used in developing each SOP are cited at the conclusion of the individual documents.

The collection protocols in *40 CFR* are in many instances based on the concern for quality assurance. As such, each SOP will contain a section devoted to maintaining and improving the quality of data collected. 'Quality Assurance and Quality Control' sections contained within individual SOPs are not meant to replace the overall Quality Assurance Project Plan documents prepared for the Branch, but rather, are provided as supplemental data for each specific, standardized activity.

This document is dynamic and will be continually revised as new developments warrant. As the Branch assumes more responsibilities for studying and sampling in new investigational areas, it is anticipated that additional SOPs will be required.

A. Introduction

The Watershed Protection Branch (WPB) of the Georgia Environmental Protection Division (GAEPD) is responsible for managing the surface waters of the State of Georgia. The WPB works to ensure that Georgia's surface waters are of a quality and quantity sufficient for fulfilling multiple uses within the State by controlling nonpoint sources of pollution, managing storm water discharges, and regulating the amount of point source discharges to, and withdrawals from, surface waters. These tasks are accomplished through the issuance of National Pollutant Discharge Elimination System (NPDES) permits to local governments and industry for the discharge of treated wastewater and to local governments, industry, farmers and subdivisions for surface water withdrawals. However, none of these tasks would be possible without the vital data collected through water quality monitoring.

Water quality monitoring is integral to the WPB's successful management of the waters of the State. Monitoring and studies conducted by the WPB can be broadly categorized as either enforcement or non-enforcement related activities. The enforcement related monitoring includes water enforcement case investigations, NPDES compliance sampling inspections (CSIs), some diagnostic evaluations of municipal and industrial wastewater treatment plant discharges, and monitoring of sewage spills into surface waters. Monitoring conducted that does not have a specific enforcement objective includes trend monitoring, surveys to verify issued permit limits, waste load allocation and model calibration studies, and other intensive surveys for documenting water quality Used to develop the 305(b)/303(d) list.

Monitoring is accomplished through surface water sampling events planned in accordance with the type, amount, and time frame of data required. Surface water sampling techniques and equipment have been designed not only to minimize possible contamination of the chemical and physical integrity of the sample, but also to provide a sample that is representative of the waterbody under investigation. If the guidance provided in this SOP is followed, an unbiased, representative sample of the surface water should be obtained.

B. Purpose and Applicability

The purpose of this SOP is to establish uniform procedures for collecting composite water samples and establishing profiles from lakes and reservoirs in the State of Georgia. This protocol is applicable to all Branch Associates who sample or assist in the sampling of lakes and reservoirs for water quality and compliance monitoring.

C. Summary of Method

Lake sampling is performed in accordance with the guidelines outlined in this SOP at intervals previously established in the Work Plan (GAEPD SOP EPD-WPMP-1: *Planning*

and Documentary Protocols for Water Quality Assessments.). Composite water samples are collected either on a monthly basis. Lakes that have established standards are sampled once per month during the growing season (April-October) each year when primary productivity is highest. Water samples are collected at a depth of approximately 0.1 meter and at one (1) meter intervals within the photic zone and homogenized so as to generate a single photic zone composite sample for analysis. From that composite sample, one (1) nutrient bottle, one (1) chlorophyll *a* bottle, one (1) hardness bottle, and one (1) half-gallon bottle are filled. A separate bacteria grab sample is taken from just below the water surface. Sample identification labels, detailing the site location name, MonLoc ID, collection date, collection time, and responsible Associate(s) are adhered to the sample bottles. Chain of Custody (Orange Sheets) are completed, the samples are packed in ice, and then delivered or shipped to an appropriate, State certified laboratory.

In-situ water quality parameters are measured and lake profiles are established by using a Sonde and data logger. The Sonde should be capable of measuring depth, dissolved oxygen, temperature, pH, salinity, and conductivity. An initial measurement of each parameter is taken at 0.1 m and recorded. Parameters are then measured at discrete depths until reaching the lake bottom.

D. Definitions

1. **Van Dorn sampler** – is a device for obtaining samples of water at a discrete depth. It is a plastic tube with a 10 cm inner diameter, and open to the water at both ends. Each end is equipped with a cap and connected by an elastic rope. The sampler is lowered to a specified depth, and a weighted messenger is used to trip both caps shut and seal the tube.

2. **Clean Water Act (CWA)** – As amended in 1977, the Act established the basic structure for regulating discharges of pollutants into the waters of the United States. It gave the U.S. EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also contains requirements to set water quality standards for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into a Water of the United States, unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants under the construction grants program and recognized the need for planning to address the critical problems posed by nonpoint source pollution.

3. **Compliance Sampling Inspections (CSI)** – Studies that monitor permitted discharges for compliance with NPDES permits.

4. **Composite Sample** – In this case, a sample that is taken over multiple depths. Equal aliquots of water are collected and combined into one homogenous sample.

5. **Discrete Depth Sample** – A discrete depth sample collects water from a specified depth in the water column using a specialized sampling device.

6. **Grab Sample** – A grab sample is an instantaneous sample from one point in the waterbody. This produces a sample that is representative of the surface water quality at the exact moment when the sample was taken.

7. **Intensive Survey** – An intensive survey is a study that incorporates many different fields of research to fully understand the complexity of a water system. In most cases, this includes tributary and lake sampling for water quality characteristics, biotic life, sediment quality, and flow status. These studies tend to be a minimum of a year in duration.

8. **Multiparameter Water Quality Probe (Sonde) –** A water quality meter consisting of multiple probes for analyzing parameters of interest. For the purposes of GAEPD's monitoring, these probes will generally consist of pH, dissolved oxygen (DO), conductivity, salinity, and temperature.

9. **National Pollutant Discharge Elimination System (NPDES)** – As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources include, but are not limited to, discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal and other facilities must obtain permits if their discharges go directly to surface waters.

10. **Photic Zone** - the upper layer of a body of water delineated by the depth to which enough sunlight can penetrate to permit photosynthesis. For the purposes of lake sampling summarized in this SOP, the photic zone is considered to be the depth to which $1/100^{th}$ of the sunlight penetrates the water column relative to the light received at the water surface.

11. **Photometer -** An instrument used to measure the amount of light penetrating the water column. A photometer is used to measure the depth of the photic zone

12. **Secchi Disk** - an opaque disk, typically white and black, used to gauge the transparency of water by measuring the depth (*Secchi depth*) at which the disk ceases to be visible from the surface.

13. **Special Response Investigation** – A special response investigation is a study conducted in response to a complaint or request submitted by a member of the general public, a water treatment facility operator, a member of a municipal government, a citizen's action group….etc.

14. **Surface water(s) of the State or surface water(s)** – Any and all rivers, streams, creeks, branches, lakes, reservoirs, ponds, drainage systems, springs producing in excess of 100,000 gallons per day, and all other bodies of surface water, natural or artificial, lying within or forming a part of the boundaries of the State that are not

entirely confined and retained completely upon the property of a single individual, partnership, or corporation.

E. Health and Safety Warnings

Collection and analysis of surface water samples can involve significant risks to personal health and safety. Sampling personnel should treat all water samples as if they contain a chemical contaminant or biological agent that could cause illness and minimize exposure to both the sample and sampling medium. The samplers should wear appropriate personal protective equipment and appropriate clothing when conducting sampling events. Planning for any type of field sampling should include extensive health and safety considerations including required training (CPR, First Aid, Boating Safety), personal protective equipment, and degree of personal, physical condition in accordance with Federal, State, or organizational requirements. Boat safety equipment should readily available on all boats including: extra keys, flares, throw cushion, horn/whistle, life jackets of appropriate sizes, paddles, flashlight, toolbox, and boat notebook with service/fuel record.

F. Cautions

All sampling personnel should wear personal flotation devices while the boat is in motion.

During extremely hot weather, be sure to pack plenty of fluids and drink often to ward off the risk of heat exhaustion and heat stroke.

Sampling personnel should also wear clothing and protective head cover suitable to the expected weather conditions and apply sunscreen, especially on sunny days.

Concentrated acids (nitric, sulfuric) are used to preserve nutrients and bacteria samples. Both preservatives are corrosive and toxic and care must be taken when handling them.

*Field sampling should **NEVER** be conducted alone. Sampling teams should always consist of a minimum of two Associates.

G. Interferences

The purpose of representative sampling is to characterize the true picture of the surface water at the time of sampling. Contaminants introduced into the sample containers through improper sampling techniques, careless handling, or by using “dirty” preservatives can bias the true picture. Common contaminants include, but are not limited to:

- Careless handling of sample container lids
- Stirring of bottom sediments in sampling area and subsequent introduction into sample

- Use of sample containers that have been lying unprotected in work vehicle for extended periods of time
- Use of previously used sample containers without proper cleaning and rinsing
- Careless transfer of sample from one container to another
- Failure to pre-rinse Van Dorn samplers and/or sample compositor with de-ionized water and on-site water between sites
- Low batteries or loose connections between Sonde and data logger

H. Personnel Qualifications

All Branch Associates who collect surface water samples or field data must be familiar with the procedures outlined in this document. In all aspects of water quality planning and field assessment activities, safety is to be addressed and treated as a critical element. The Georgia DNR *Safety Manual* (https://dnrintranet.org/hr/DNR-Safety-Manual) is to be consulted and its policies, protocols, and procedures are to be incorporated and implemented in WPB field activities.

I. Procedural Steps

Sampling station characteristics often dictate the equipment and method of sampling to be used. The field team on site will be responsible for determining the most appropriate sampling methodology to employ. The following is a list of sampling techniques employed by the GAEPD in water quality monitoring. Each listed technique is followed by a brief overview of possible situations that could be encountered in the field in which the technique should be employed; a list of required equipment; and procedural steps for completing the sampling activity. This list of sampling techniques, and subsequent procedures, are intended to be dynamic and will be amended as needed when new sampling conditions are encountered.

Equipment and Supplies

- Vehicle capable of carrying or towing boat
- Boat that meets the size requirements of the lake, equipment, and/or staff
- Anchor and rope of appropriate size and length to hold the boat in place while sampling
- Lake map/GPS/Sonar for navigation and determining correct sampling locations
- Boat safety equipment including extra keys, flares, throw cushion, horn/whistle, lifejackets, paddles, properly operating fire extinguisher, flashlight, toolbox, and boat notebook with service/fuel record.
- Field book/Field sheets, writing instruments
- Carboy for mixing composite sample
- Meter stick
- Thermometer
- Calibrated multiparameter water quality probe (Sonde) with cable and data logger

- Underwater photometer to establish the photic zone
- Secchi Disk
- Nitrile gloves
- Water collection device for collecting discrete samples (e.g.Van Dorn sampler)
- Rope for Van Dorn marked off in one meter (m) increments
- Cooler(s) with wet ice
- Cooler(s) with dry ice (for shipping chorophyll *a* samples, if needed)
- Chain of custody form (orange sheet) to be filled out for each sample**.**
- ½-Gallon sample containers
- Nutrient bottles
- Hardness bottles
- Bacteria bottles
- Chlorophyll-a sample bottles
- Container of de-ionized water for rinsing between sites
- Winkler kit
- pH strips

Before leaving the office, ensure that you have all containers necessary for the day's sampling events. Always bring 1-2 more containers than necessary. If the samples must be shipped, ensure the coolers are properly prepared and you have all materials necessary for shipping:

1. Preparations for Field Sampling

Prior to driving to the lake, check the following on boat and trailer to confirm that all are satisfactory: tire pressure and tread, bearings properly greased, trailer lights working, GPS/Sonar working, install drain plug, gasoline and oil levels adequate, boat batteries fully charged. Also check the weather forecast to ensure that expected conditions will be safe for boating.

Load all above-listed items into the boat or vehicle and drive to lake

- Prior to departing in a boat, all staff should be wearing high-visibility U.S. Coast Guard approved personal flotation devices of the proper size

- Once the boat is launched, proceed to the sampling location, and anchor at the sample site. The sampling sites should be located in the deepest part of the lake channel at each location.

2. Field Measurements and Field Observations

- At the site, take an ambient air temperature reading and record on the field data sheet

- Take a photometer reading to measure the depth of the photic zone

    - Remove the photometer (e.g. Li-Cor) from the storage case. There are two sensors, a surface sensor and an underwater sensor, which is attached to a metal weight.

    - The surface sensor should be plugged into I1 and the underwater sensor into I2 on the data logger. If the unit is working properly, the I2 reading should be slightly higher than the I1 reading.

    - Turn the data logger on and set it to I2. Record I1 and I2 readings on field data sheet

    - Set the data logger to M1 and lower the underwater sensor into the water until the M1 reading is 100. This is the depth where where 1/100 of the amount of surface light can penetrate, which represents the bottom of the photic zone.

    - Measure and record this depth on field data sheet

    - **NOTE:** The Li-Cor meter is not waterproof and should not be used in the rain. If it is raining, the depth of the photic zone should be determined using the Secchi disk as described below.

- Take a Secchi disk reading. The Secchi disk depth is a measure of water clarity and a basic water quality diagnostic tool.

    - The Secchi disk is lowered slowly on the shaded side of the boat until the disk is not visible.

    - Raise the disk slowly until it is barely visible.

    - Lower and raise the disk again.

    - Lower the disk a third time until it is just beyond visibility. This is the Secchi disk depth, and is measured from the water surface to the disk.

    - Measure and record this depth on field data sheet.

    - ****Estimating photic zone using Secchi disk** If a photometer is not available, a Secchi disk reading can be used to estimate the photic zone. The estimated photic zone is three (3) times the depth of the Secchi disk reading.

It should be noted that using a Secchi disk is very subjective, and different staff may get very different results. For this reason, it is not recommended that a Secchi disk be used for determination of photic zone on a regular basis.

3. Collecting the composite sample

A discrete sampler (Van Dorn) attached to a rope marked in 1 m increments should be used to collect the composite sample.

- Determine the number of discrete samples (grabs) needed for the composite sample by rounding the measured depth to the nearest whole number. For example, a depth of 6.23 m equates to 7 grabs (1 subsurface + 6 grabs at 1 m intervals). A depth of 6.63 would necessitate 8 grabs (1 subsurface + 7 grabs at 1 m intervals). If the photic zone is greater than 7 m, adjust water volume from each grab accordingly as it is deposited into carboy to guarantee that total volume for sample does not exceed the volume of the carboy (Currently 20L). Alternatively, one must collect a minimum of four grabs, so if the photic zone is less than 1.5 m deep, collect 2 subsurface samples and 2 grabs at 1m depth of the photic zone .

- Before heading to the water collection location, the stainless-steel bucket and CSS should be first be rinsed with DI water.

- The first 3 grabs will be used to rinse the Van Dorn sampler and carboy. This is a very important step in lessening the chance of cross contamination between sample sites. Open the Van Dorn caps and lower the sampler just below the water surface. Gently move the Van Dorn back and forth to allow lake water to fill and rinse the interior of the sampler. Then close the caps and pour the contents into the carboy. Replace lid on the carboy and shake upside down several times to rinse the interior of the carboy. Be sure to open the drain valve as well to rinse the interior of the valve. Once rinsing is complete, empty the rinse water on the opposite side of the boat from where the composite sample will be collected. Repeat this step 2 more times prior to sample collection.

    - After the Van Dorn and carboy have been rinsed, lower the Van Dorn to just below the surface of the water, or approximately 0.1 m deep, and collect a sample. Pour into composite carboy.

    - Lower the Van Dorn to the 1.0 m depth and release the weighted messenger to close the caps on the sampler.

    - Repeat this process and continue collecting samples at one m intervals down to the bottom of the photic zone.

- Once the composite sample has been completed, shake the carboy gently for several moments to homogenize the composite sample.

- Once the sample is completely mixed, fill one (1) nutrient bottle, one (1) ½-gallon bottle, one (1) chlorophyll *a* bottle, and one (1) hardness bottle. If ortho phosphorus, anions and/or volatile organic compound (VOC) samples are required at the site, they are also collected from the composite.

- Collect a bacteria grab sample from approximately 0.1 m depth. Take care not to touch the inside of the bottle.

- Place the appropriate sample label on each bottle and store all samples on ice immediately.

- Repeat this process at each site.

4. **Measure Lake Profile Data –** Dissolved oxygen, temperature, pH, conductivity, and salinity data are measured at discrete depths to establish a lake profile.

Equipment and Supplies

- Properly calibrated Multiparameter Water Quality Probe (Sonde) with data logger (surveyor) and cable

*NOTE: Calibration procedures are outlined in *GAEPD SOP EPD-WPMP-7: Sonde Calibration*. Refer to the manufacture's manual for specific calibration instructions if the model is different from those listed in the above referenced SOP.

Procedures

- Remove Sonde from storage container, place protective guard over sensors, and attach to data logger with cable.

- An initial reading should be made at 0.1 m. Calibrate the depth on the Sonde at this depth as well.

- Measurements are then taken every meter from 1.0 to 20.0 m.

- Below 20.0 m depth, measurements are taken every two meters to 30.0 m

- Below 30.0 m depth, measurements are taken every 5 m until the lake bottom is reached. Avoid contact with the lake bottom to prevent stirring of sediment.

- Once a measurement is made at the lake bottom, raise the Sonde and place it in a container with water or replace the protective cup over the probes until reaching the next site.

- Complete the field data sheet for the site by recording the data for the 0.1 and 1.0 depths and all other field observations.

- After all sites have been visited, return the Sonde back in the storage container.

5. QC Sampling

In accordance to the Georgia Quality Assurance Project Plan (QAPP) section B5.2 *https://epd.georgia.gov/watershed-protection-branch/monitoring#toc-sops-and-qapp-* Georgia EPD associates will collect replicate samples at 10% of all sample events (this is subject to change based on the project plan and/or lab constraints).

- For each day of sampling that requires a replicate QC sample, the site to receive the replicate QC sample should be determined prior to going out in the field.

- Replicates must be obtained by repeating the entire sampling procedure after the initial sample event is processed; that is, the Van Dorn sampler and carboy must be rinsed, and the samples are collected in the same manner and location as the initial sample.

After measuring the lake profile, retrieve the Sonde up to one-half the distance to the bottom (rounded to the nearest meter). Allow the Sonde an adequate amount of time to stabilize and then record a QC reading from this depth. Repeat this process at the 1.0 and 0.1 meter depths as well.

6. Post-Sampling Activities

Once all samples for the day have been collected, and upon returning from the lake, three primary tasks must be finished before the end of the field day: the cooler must be prepared for shipping or overnight storage; the Sonde must be post-calibrated; and the equipment must be cleaned.

Sample Handling

- After collection, all sample handling should be minimized.

- Investigators should use extreme care to ensure that samples are not contaminated.

- If samples are placed in an ice chest, investigators should ensure that melted ice cannot cause the sample containers to become submerged, as this may result in sample cross-contamination.

- Resealable plastic bags should be used when small sample containers (e.g., VOC vials) are placed in ice chests to prevent cross-contamination.

Complete the Chain of Custody form for each sample

Shipping/Storage Preparations

- If the samples are to be hand delivered, but will have to be stored overnight before delivery, observe the following steps:

- Bring the cooler(s) into a climate-controlled facility for storage. Do not leave them in a vehicle overnight.

- Drain excess water from the cooler

- Add more ice until the cooler is full and all samples are completely covered.

- If the samples are to be shipped, place a plastic liner into a dry cooler

    - Transfer the sample bottles into the new cooler and add ice until the samples are completely covered. This is especially important during warm weather months

    - Twist the bag opening several times and wrap tape around the twisted portion.

    - Place the completed chain of custody (COC) forms in a resealable plastic bag and seal. Fold the seal and tape the bag to the inside lid of the cooler.

    - Use clear tape to seal the cooler. Vertically wrap the cooler in at least two locations.

    - Place the overnight shipping label on top of the cooler.

Sonde Post-Calibration

- The Sonde used for in-situ measurements must be post-calibrated at the end of each field day.
- If the Sonde is to be used the following day, then it may be calibrated the

next morning, which would serve as both a post-check for the current day's sampling and pre-calibration for the next day.

- If the Sonde will not be used the next day, then it must be post-checked that evening.

- Information regarding Sonde calibration and care is located in *GAEPD SOP EPD-WPMP-7: Sonde Calibration*.

Equipment Cleaning

Upon returning from the field, Van Dorns and mixing carboys must be cleaned.

- Using a soft brush and phosphate-free detergent (i.e. Liquinox or Citrinox), scrub both the inside and outside of each sampler and carboy, and thoroughly rinse with DI water. If ortho-phosphorus samples were collected, the syringes will need to be sterilized using the following method:

    - Make sure the plungers are separated from the syringes and fully immerse both in a water bath containing 5% HCl.

    - Allow the syringes to soak for at least two hours.

    - While wearing gloves, remove and rinse the syringes and plungers using two stations of DI water (this is to ensure that all of acid has been rinsed off of the syringes. Check with pH strips).

    - Allow to air dry before placing in a resealable plastic bag for storage.

J. Data and Records Management

Data and records will be managed according to the policies outlined in the *GAEPD SOP# EPD-WPMP-1*. Any deviation from the policies outlined in the SOP should obtain prior permission from first the Unit manager, and then the Program manager, and be documented accordingly.

The data collected in the field should be entered into a database as soon as possible after each sampling day, so as to minimize the loss of information in the event that the field sheets/log book is lost or destroyed. The data logger files should also be saved in at least two locations as a backup in order to avoid losing the lake profile data. The lake profile data should also be uploaded to the GOMAS database along with the in situ data.

K. Troubleshooting and Error Management

1. Field Sheets/Log Cook and COC data recording

- If an error is made while recording information within either the log book or COC form, draw a single line through the erroneous entry, write the correct information next to it, and initial the correction.

- Do not attempt to erase or "scratch out" the erroneous information.

2. Potentially erroneous Sonde values

- If, during a site visit, the Sonde is reporting water quality values that deviate substantially from typical values given at a particular site, relocate the Sonde to a different section of the sample site and check to see if the values at the new position agree with the original readings.

- If both readings agree with one another, use the field verification kit to confirm or refute the Sonde's reported values, and note the results in the log book or on the field sheets.

- If the Dissolved Oxygen (DO) measurement is below water quality criteria of 4.0 mg/L, verify the reading using a Winkler Kit

- If the pH measurement is below or above water quality criteria of 5.0 SU or 8.5 SU
    - Use pH strips to check Sonde reading; If possible dip the pH strip directly into the waterbody being sampled
    - Collect a fresh water sample in a bucket that is located where the Sonde was collecting in-situ readings. Place the Sonde directly into the bucket and allow it 5-10 minutes for the pH to stabilize.

3. Damage to the Sonde

- If any damage occurs to the Sonde that impairs its ability to function (i.e., the case or one of the sensors is physically cracked, the membrane on the clark cell is removed or destroyed, the pH bulb is broken), do not continue to use it in the field.

4. Loss of equipment

- In the event that a piece of equipment falls into the water from the boat or a dock, only retrieve it if you can locate it and it is easily retrievable via wading.

- DO NOT attempt to swim or dive after lost equipment.

- Report any instance of lost or broken equipment to your supervisor immediately upon returning from the field so that replacements may be obtained as quickly as possible.

L. References

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