Streamflow Measurements

January 2008

Prepared by: Alan Fizer **Date: 2/28/08**

Title: Environmental Engineer

Reviewed by: Jeremy Smith **Date: 2/29/08**

Title: Environmental Program Manager I

Approved by: Dr. Elizabeth Booth **Date: 2/29/08**

Title: Environmental Program Manager II

Annual Reviewer				
Date				

Table of Contents

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. All Branch associates who collect samples or field data must be familiar with the measures outlined in the appropriate SOP's.

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 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.

Streamflow measurements are vital to developing calibrated stream models to determine the assimilative capacity of Georgia's surface waters to enable GAEPD to issue NPDES permits for the discharge of treated wastewater. Streamflow measurements are also vital to quantifying the loading of point sources and non-point sources of pollution in Georgia's streams and lakes. Streamflow measurements are generally conducted during trend monitoring studies, model calibration studies, and other intensive surveys for documenting water quality

B. Purpose and Applicability

The purpose of this SOP is to establish uniform procedures for measuring streamflow and discharge in rives and streams in the State of Georgia. This protocol is applicable to all Branch associates who measure, or assist in the measuring of streamflow for water quality and compliance monitoring.

C. Definitions

1. **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 continued 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 navigable waters, 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.

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

3. **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.

4. **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 are 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.

5. **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.

6. **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 which are not entirely confined and retained completely upon the property of a single individual, partnership, or corporation.

7. **AA Current Meter** – A vertical axis current meter that has a rotor 5 inches in diameter and 2 inches in height with 6 cone shaped cups mounted on a stainless steel shaft. A pivot bearing supports the rotor shaft. The meter has a magnetic contact and makes one contact for each revolution of the rotor. The AA meter has a tailpiece that keeps the meter pointing into the current.

8. **Pygmy Current Meter** –A vertical axis current meter that is scaled two-fifths as large as the AA meter. This meter also has a magnetic head and makes one contact for each revolution of the rotor. The pygmy meter does not have a tailpiece.

9. **0.6 Depth** – A depth 60% of the vertical distance from the stream surface to the streambed.

10. **0.2 Depth** – A depth 20% of the vertical distance from the stream surface to the streambed.

11. **0.8 Depth** – A depth 80% of the vertical distance from the stream surface to the streambed.

D. Health and Safety Warnings

The Associate 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.

E. Cautions

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. Associates should also wear sunscreen, especially on sunny days.

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

F. Personnel Qualifications

All Branch associates who collect streamflow 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* is to be consulted and its policies, protocols, and procedures are to be incorporated and implemented in WPB field activities.

G. Site Selection

The site where the flow measurement will be made is selected using the following criteria:

1. A straight section where the threads of velocity are parallel to each other.
2. Stable streambed free of large rocks, aquatic plants, and woody debri which would create turbulence.
3. A flat streambed profile to eliminate vertical components of velocity.

It is usually not possible to satisfy all of these conditions. The best possible site is selected based on these criteria. A general reconnaissance of the stream is first made in order that the most suitable site for the flow measurement may be selected. This may require walking upstream and downstream a few hundred yards.

When natural conditions for measuring flow are in the range that is considered undependable, the streambed can be altered to provide acceptable conditions. Often it is possible to build small dikes to cut off dead water and shallow flows at a site. The site can be improved by removing large rocks and woody debri. After modifying a site, allow the flow to stabilize before starting the flow measurement.

H. Stage and Tapedown Measurements

General

It is important that a stage or tapedown measurement be done prior to and after doing a streamflow measurement. This documents the stability of the flow during the flow measurement. A relation between stage and flow can also be defined after several measurements at a site. A rating curve and rating table can be developed from this relationship.

Stage

The stage of a stream is the height of the water surface above an established datum plane. The datum may be a recognized datum, such as mean sea level, or an arbitrary datum plane chosen for convenience. The datum selected for operating purposes must be below the elevation of zero flow on the control for all conditions. For staff gages the arbitrary datum is generally set at the zero mark on the staff.

Staff gages

Staff gages can be installed in the stream using several techniques. A common technique is to install the staff gage on a post of some type and place the post in the stream. Be sure it is positioned to prevent large objects from washing downstream and damaging it during rain events. Installing staffs on bridge supports and concrete culvert wingwalls are two other common techniques.

Reference Points

Reference points need to be placed on stable structures which are positioned above the surface of the stream at all flow conditions. For bridge rails or concrete culverts chisel a square on the top edge of the rail or culvert. For metal culverts chisel 2 parallel chisel marks on the top edge of the culvert. For overhanging trees drive a nail into the tree to within one-quarter inch of the nail head.

Tapedowns

A tapedown measurement is the distance from the reference point to the surface of the stream. A 100 feet nylon coated steel measuring tape, calibrated in tenth of feet, with a brass weight attached is the standard equipment used to measure tapedown distance. The total tapedown distance is the distance indicated on the tape at the reference point plus the distance from the zero mark on the tape to the bottom of the brass weight (TD = Tape + WT). The following is a list of common reference points and the correct method used to measure the tapedown distance from the reference point:

1. Chiseled square on beveled surface – Read from the top edge of the bevel.
2. Chiseled square on flat surface – Read from the top edge of the surface.
3. Two parallel chisel marks on top edge of metal culvert – Read from top edge of culvert between parallel marks.
4. Nail in overhanging tree – Read from bottom of nail head.

I. Streamflow Measurement Procedure

General

Streamflow is expressed as the volume of water passing a given point within a unit time period. Usually expressed in cubic feet per second (ft^3/sec). In the making of a streamflow measurement the cross-section is divided into 20-30 partial sections with width (ft), depth (ft), and velocity (ft^2/sec) of each partial section measured separately.

Midsection Method

A streamflow measurement is the summation of the products of the partial areas of the stream cross-section and their respective average velocities. The formula

$$Q = \Sigma(a*v)$$

represents the computation where Q is total flow, *a* is an individual partial cross-section area, and *v* is the corresponding mean velocity of the flow normal to the partial area.

In the midsection method of making a streamflow measurement it is assumed that the velocity at each location represents the mean velocity in a partial rectangular area. The area extends laterally from half the distance from the preceding location to half the distance to the next and vertically, from the water surface to the streambed (see Figure 1).

Partial Section Spacing

After the cross-section has been selected, determine the width of the stream. String a tag line or measuring tape across the stream. String the tape at right angles to the direction of flow to avoid horizontal angles in the cross-section.

Determine the spacing of the verticals (velocity observation points), generally using about 25-30 partial sections. With a smooth cross-section and good velocity distribution, fewer sections may be used. Space the partial sections so that no partial section has more than 10 percent of the total flow in it and preferably no more than 5 percent of the total flow in it. Equal widths of partial sections across the entire cross-section are not recommended unless the flow is well distributed. Make the width of the partial sections less as depth and velocities become greater.

Current Meter Selection

Current meter selection depends on the average depth of the stream. If the depth is less than or equal to 1.5 feet then use the pygmy current meter. If the average depth is greater than 1.5 feet then use the AA current meter. Continue with the same current meter for the entire cross-section. Magnetic head current meters work the best with streamflow computers.

Velocity is measured with the pygmy current meter by the 1-point (.6) method. With the 1-point method the meter is positioned at the 0.6 depth from the surface. The velocity measured with the 1-point method is the mean velocity of the section. Velocity is normally measured with the AA current meter by either the 1-point method or the 2-point (0.2/0.8) method. If the depth at a vertical is less than or equal to 2.5 feet then the 1-point method is used. If the depth at a vertical is greater than 2.5 feet then the 2-point method is used. If the 2-point method is used then the velocity is measured at the 0.2 depth and at the 0.8 depth then the two velocities are averaged together to obtain the mean velocity for the section.

Wading Rod

The wading rods used by the Division are top-setting wading rods. The top-setting wading rod has a one-half inch hexagonal main rod for measuring depth and a three eights inch diameter round rod for setting the position of the current meter. The rod is designed to easily set the position of the current meter at either the 0.6,0.2,or 0.8 depths. If the actual depth is entered with the round rod then the meter is placed at the 0.6 depth. If the actual depth is doubled and then entered with the round rod then the meter is placed at the 0.2 depth. If the actual depth is halved and then entered with the round rod then the meter is placed at the 0.8 depth.

Streamflow Computer Set-up

1. Set up transect information
   -Enter user ID as last 4 digits of social security number
   -Enter site ID number
   -Enter stage
   -Enter meter ID number
   -Enter current meter type used
   -Enter measurement time of 40 seconds

2. Set up system information
   -Check date and time setting
   -Enter flow computer ID number
   -Indicate 1-point (0.6) or 2-point (0.2/0.8) measurement
   -Select English language
   -Select baud rate of 48

Measurements

After the equipment has been readied, begin the flow measurement. Enter in the flow computer the distance on the tape at the edge of the water. Measure and enter the depth at the edge of the water. The depth at the edge of the water will be zero most of the time. Set the rod at the first vertical and enter distance and depth. Position the current meter at the proper location on the top setting rod. Check the method of velocity setting on the flow computer. The velocity method can be toggled between 0.6, 0.2, and 0.8.

Stand in a position that least affects the velocity of the water passing the current meter. This position is usually obtained by facing the bank, with the water flowing against the side of the leg. Holding the wading rod at the tape, stand from 1 to 3 inches downstream from the tape and 18 inches or more from the wading rod. Avoid standing in the water if feet and legs would occupy a considerable percentage of the cross-section of a narrow stream.

After the meter is placed at the proper depth, permit it to become adjusted to the current before starting the velocity measurement. Select measure on the flow computer to begin the measurement.

Keep the wading rod in a vertical position and the meter parallel to the direction of flow while measuring the velocity. If the flow is not at right angles to the tape, measure the angle coefficient carefully and enter into the flow computer. Move to each of the verticals and repeat the procedure. Enter the distance and depth at the final edge of water.

Select calculate discharge button for the flow computer to compute the total flow. The flow measurement can be downloaded onto a computer. The data can be copied into a spreadsheet checksheet to verify the accuracy of the data.

Equipment and Supplies

Streamflow computer
Top setting wading rod
AA current meter- magnetic head
Pygmy meter-magnetic head
100 feet nylon coated steel measuring tape graduated in tenth of feet
300 feet tag line
Measuring tape anchors (2)
Brass tapedown weight
Utility bag
Daypack
Meter oil
Nails, various sizes
Cold chisel
Wood chisel
Hammer
Large flat head screwdriver
Small flat head screwdriver
Jewelers screwdriver
Orange roll flagging
Can orange spray paint
Fieldbook

Chest waders
Hip boots

J. Quality Assurance and Quality Control

Before and after each flow measurement, examine the meter cups, pivot, and shaft for damage, wear, or faulty alignment. Clean and oil meters daily when in use. If measurements are made in water carrying noticeable suspended sediment, clean the meter immediately after each site. Parts to be oiled on the magnetic head meter are the pivot and the rotor bearing.

After oiling, spin the rotor to make certain it operates freely. If the rotor stops abruptly, find the cause and correct the trouble before using the meter. The pygmy meter should spin for a minimum of 30 seconds while the AA meter should spin for a minimum of 90 seconds.

The pivot needs replacement more often than other meter parts. Examine the pivot after each measurement. Replace a fractured, rough, or worn pivot. Keep the pivot and pivot bearing separated when not in use. The AA meter has a raising nut to separate the pivot and bearing. The pygmy meter has a brass plug that replaces the pivot.

K. References

1) Carter, R.W., Jacob Davidian. General Procedures for Gaging Streams , Techniques of Water Resources Investigations of the United States Geological Survey. Washington, D.C. Government Printing Office, Book 3,CH-A6, 1968.

2) Buchanan, Thomas J., William P. Somers. Stage Measurement at Gaging Stations, Techniques of Water Resources Investigations of the United States Geological Survey. Washington D.C. Government Printing Office, Book 3, CH-A7, 1974.

3) Buchanan, Thomas J., William P. Somers. Discharge Measurements at Gaging Stations, Techniques of Water Resources Investigations of the United States Geological Survey. Washington D.C. Government Printing Office, Book 3, CH-A8, 1973.

4) Georgia Department of Natural Resources. Safety Manual. Atlanta, Georgia, May, 1990.

5) JBS Instruments. Aquacalc 5000 Streamflow Computer Operating Instructions. West Sacramento, California, December, 1993.

6) Sontec/YSI, Inc. Flowtracker Handheld ADV Operation Manual. San Diego, California, 2003.