Standard Operating Procedure #4: Measuring Water Level

Version 1.1

***In* Water Quality Monitoring Protocol for Inland Lakes**

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September 2015

Suggested citation:
Elias, J., R. Wise, and D. VanderMeulen. 2015. Standard operating procedure #4: Measuring water level. *In* J. E. Elias, R. Axler, E. Ruzycki, and D. VanderMeulen. 2015. Water quality monitoring protocol for inland lakes: Great Lakes Inventory and Monitoring Network, version 1.1. Natural Resource Report NPS/GLKN/NRR—2015/1027. National Park Service, Fort Collins, Colorado.

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Revision History Log

The following table lists all edits and amendments to this document since the original publication date. Information entered in the log must be complete and concise. Users of this standard operating procedure will promptly notify the project manager and/or the Great Lakes Network (GLKN) data manager about recommended and required changes. The project manager must review and incorporate all changes, complete the revision history log, and change the date and version number on the title page and in the header of the document file. For complete instructions, please refer to Revising the Protocol, SOP #13.

Revision History Log:

Previous Version #	Revision Date	Author (with title and affiliation)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
1.0	5/01/2015	David VanderMeulen, GLKN	Updated the NPS contact author, deleted a few obsolete references, fixed a handful of grammatical errors throughout	To clarify and update SOP based on changes that have occurred since Version 1.0 was published in 2008	1.1
Add rows as needed for each change or set of changes tied to an updated version number					

Acknowledgements

Many thanks to Pete Penoyer, NPS-WRD, for informational material and feedback on this SOP. We appreciate the brainstorming with Larry Kallemeyn, USGS, and Chris Holbeck, VOYA, which led to the procedures we are now using in remote areas.

4.0 Introduction

An estimate or measurement of flow or water level is highly recommended by the National Park Service (NPS) Water Resources Division (WRD) (National Park Service 2002) for water quality monitoring programs. Water level data are important in understanding overall lake processes. These data help define the spatial extent of littoral zones, which are critical habitat for many aquatic organisms. Accurate volumetric estimates, hydrologic budgets, heat budgets, and mass balance budgets for chemical compounds and oxygen also require lake level data. Changes in bioaccumulation of mercury in aquatic organisms may be explained in part by lake level, as methylation rates are correlated with water level fluctuations (Sorensen et al. 2005). In reservoirs and other systems where lake level is controlled, such as Lake Kabetogema in Voyageurs National Park and Glen Lake adjacent to Sleeping Bear Dunes National Lakeshore, lake levels and discharge from the lake are controversial management issues (Kallemeyn et al. 2003, Vana-Miller 2002). Fluctuations in lake level also have importance in terms of lakeshore development and wetland conservation and function (Mitsch and Gosselink 2000).

In inland lakes, estimates or measurements of water level can be acquired through the use of a staff gage or reference mark and level. A staff gage is a ruler, usually made of enameled steel, placed in a stream or lake, and is used to measure the water level. Staff gages are usually mounted on permanent structures, such as a bridge piling, but may also be sunk into a stable bottom substrate or anchored to bedrock.

A reference mark is a permanent marking (e.g., an ‘X’ etched into concrete or a bolt drilled into a structure), the elevation of which is considered to be gage zero (www.srh.noaa.gov/ohx/dad/hydro/Doingasurvey.html). If the elevation of the reference mark is established it is called a bench mark.

If staff gages or bench marks are not already installed and maintained by another agency, the Great Lakes Network will install reference marks for measuring water level of inland lakes.

4.1 Installing Reference Marks

Prior to installing reference marks, complete and submit a minimum tools analysis, if required by the park, and ensure that the park grants permission.

4.1.1 Site Selection

Choose a site for the reference mark that is not obtrusive from a visitor’s viewpoint, yet is easy to access and relocate. The site should be above current water level by at least 1 m to accommodate a large rise in level, and relatively near the water’s edge to allow viewing a stadia rod from the reference mark. Past reported water level fluctuations should be reviewed to determine an appropriate site and the maximum water level range that may be expected.

4.1.2 Installation Procedures

At lakes where large pieces of bedrock are exposed, such as at Voyageurs National Park, secure an aluminum dome-top concrete reference mark (2" top diameter, 5/8" stem diameter, 2.5" stem length, 3 oz. weight) in the bedrock using the following steps. Drill a hole 2.5" deep into the bedrock using a rock hammer and a 5/8" drill bit. Remove the rock dust from the hole with canned air. Apply the appropriate kind of epoxy to the reference mark. Insert the reference mark into the drilled hole, and ensure proper seating by pounding it briefly with a rock or stepping on it.

Figure 1. *Clockwise from upper left:* drilling a hole into the bedrock, using canned air to blow dust from hole, reference mark in bedrock next to GPS unit, applying epoxy to reference mark.

At lakes where bedrock is not exposed, one of the following alternatives may be used: 1) A nail in a large, long-lived tree, with known height above ground; 2) a long iron rod (approx. 1.5 to 2 m) sunk into the ground until nearly flush with ground level, with a reference marker cemented in the top with concrete; 3) a mark on a nearby structure, such as a building, bridge, or observation deck. Installing a back-up marker will ensure a continuous data record should one marker be dislodged (e.g., frost heave or tampering).

4.1.3 Record Location of Reference Mark

Record the location of the marker with a GPS unit. Use the GPS to also record the distance to and location of a nearby landmark, such as a fire ring at a campsite. Record detailed notes in the field notebook on directions to the reference mark location so that a different field crew will be able to find the marker in the future. Take a compass bearing and photo of the reference mark site from at least one landmark, and a compass bearing and photo of the landmark(s) from the reference mark. Ensure the compass has been set to the proper magnetic declination to get the true compass bearing.

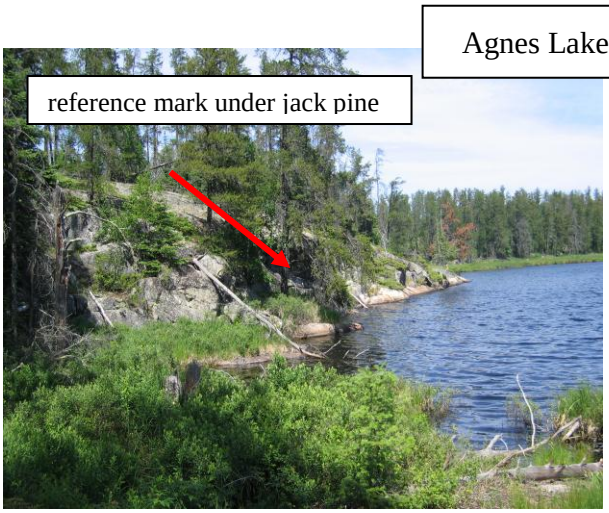
Reference Mark Notes – Agnes Lake

6-10-06 water level = - 1.20m UTM: 5368392N 513742E

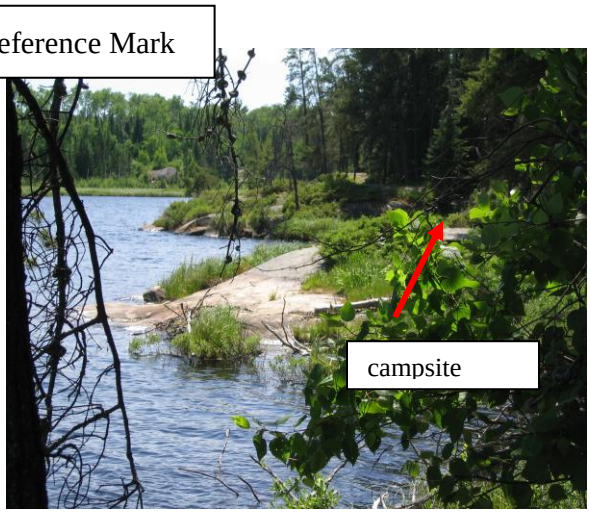
Reference mark is on the northwest side of the lake northeast of the campsite at a straight line distance of 34.5 m. It is below a large rock wall about 1.5 m away from the water's edge beneath a 10" dbh jack pine. Hike along the shoreline to the large jack pine. Reference mark is at a 40º bearing from the fire ring.

Pictures are from the campsite toward marker and marker toward the campsite.

8-2-06 water level = - 1.305 m



Picture of reference mark from campsite



Picture of campsite from reference mark

Figure 2. Example of notes on location and photos of reference marker.

4.2 Measuring Water Level

The Network will always install reference markers well above current water level. The markers may become submerged, however, after extreme flooding events. For example, water levels at some lakes

in Voyageurs National Park have fluctuated by over 1 m from one year to the next due to the transience of beaver impoundments (Kallemeyn, personal communication).

In some cases, the reference marker may have been installed by another agency and may be located below the current water level.

Instructions for measuring water level above and below reference markers are included below. Because many of our lakes are in remote locations, we will use one of the following procedures that require a minimum of equipment. Procedures differ only in the detail; the concept is the same in all.

Water-level measurements at a given lake will always be based on the same reference marker. If a new reference marker has to be used, a new water level data set will be created using this new reference mark as the standard. The use of a new reference mark for measuring water level will be clearly noted in the field notebook and NPSTORET database. Water levels using different reference markers cannot be compared because the markers will likely be located at different elevations above the land-water interface.

4.2.1 Reference Marker Above Water Level

Method 1: One person stands at the water's edge and holds the base of the stadia rod at current water level while a second person at the reference marker uses an eye level to view the rod held vertically (Figure 3). If the reference marker is glued to the bedrock, the second person will need to get his/her eye above the rock in a stable position. A second stadia rod or metric ruler will work for this purpose. The second person looks through the eye level, first focusing the cross-hairs, then focusing on the rod held at water level. When the bubble inside the eye level is centered vertically, the instrument is being held on level (Figure 4). Read the height on the stadia rod. The person holding the rod can assist by sliding a finger or pencil up and down the rod until the person with the eye level sees it in the cross-hair. Record this level to the nearest 0.1 cm, then measure and record the height of the second person's eye level above the reference marker. Subtract this height from the reading of the level on the rod to get water level relative to the reference marker. The resulting number will be negative to indicate water level below reference marker.

Example:

- Eye level reads 174.3 cm on the stadia rod
- Height of eye level above reference marker = 15.4 cm
- Subtract height of eye level from level on stadia rod: 174.3-15.4 = 158.9
- Water level relative to reference marker = -158.9 cm or -1.589 m.

Figure 3. Holding stadia rod at water's edge (*left*), viewing stadia rod through hand-held eye level.

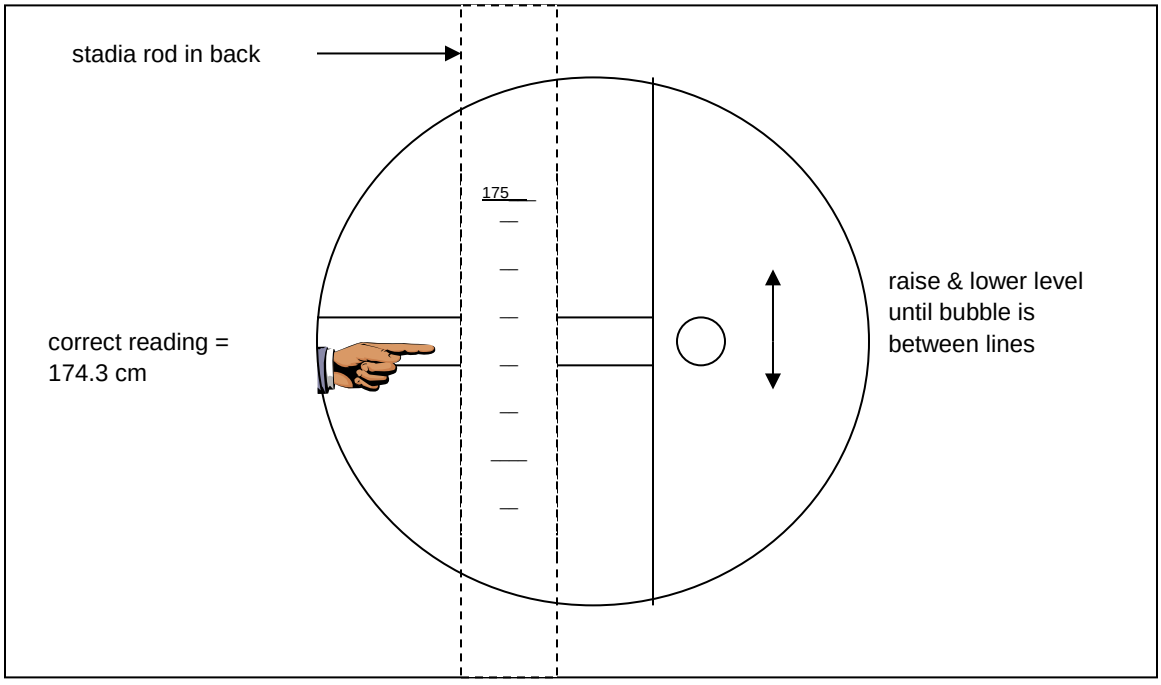


Figure 4. View through hand-held eye level.

Method 2: One person stands at the water's edge and holds the base of the stadia rod vertically at current water level and one end of a line or cord (Figure 5). A second person at the reference marker holds the other end of the line on the marker and stretches it taut. Using a line level, the person holding the stadia rod adjusts the level of the line on the rod until the line is level. The reading to the nearest 0.1 cm is taken directly on the rod when the line is level and will be a negative number to indicate water level below reference marker.

Example:

- Line is level on stadia rod at 158.9 cm
- Water level relative to reference marker = -158.9 cm or -1.589 m

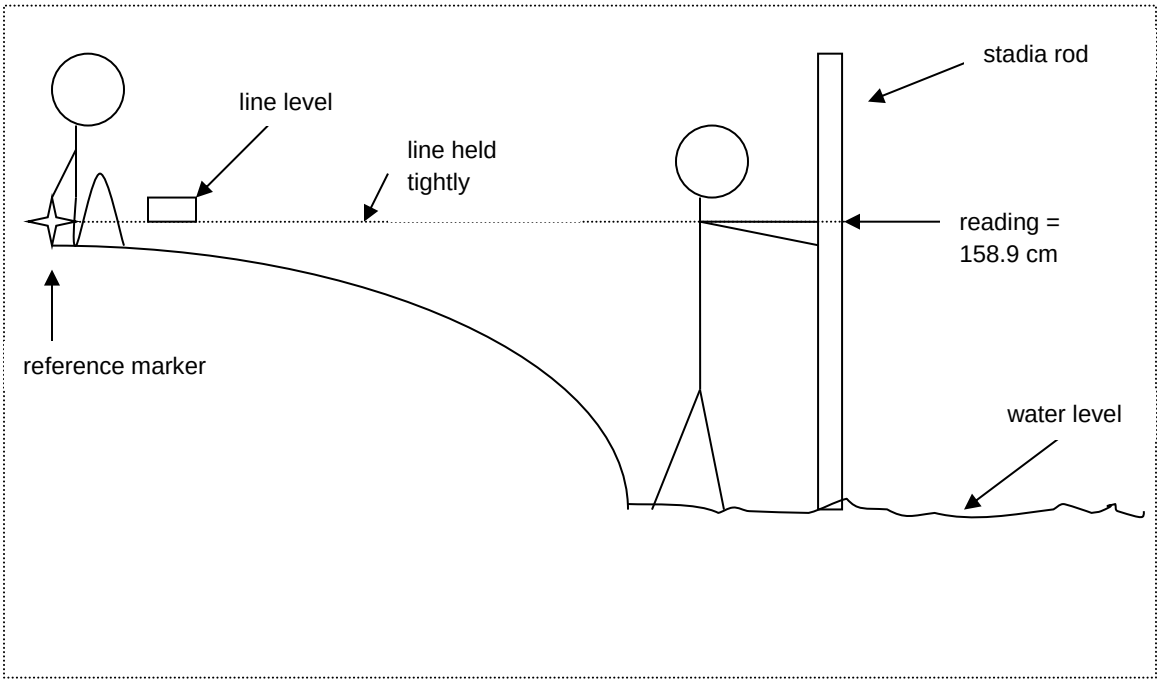


Figure 5. The second method of measuring water level employs the use of a tightly held line stretched from the reference marker to the stadia rod.

4.2.2 Reference Marker Below Water Level

From a boat or while wading, use a stadia rod held on the reference marker to read water level above marker (Figure 6). The reading, to the nearest 0.1 cm, will be a positive number.

Example:

- Water level on stadia rod measures 63.4 cm
- Water level relative to reference mark is 63.4 cm or 0.634 m

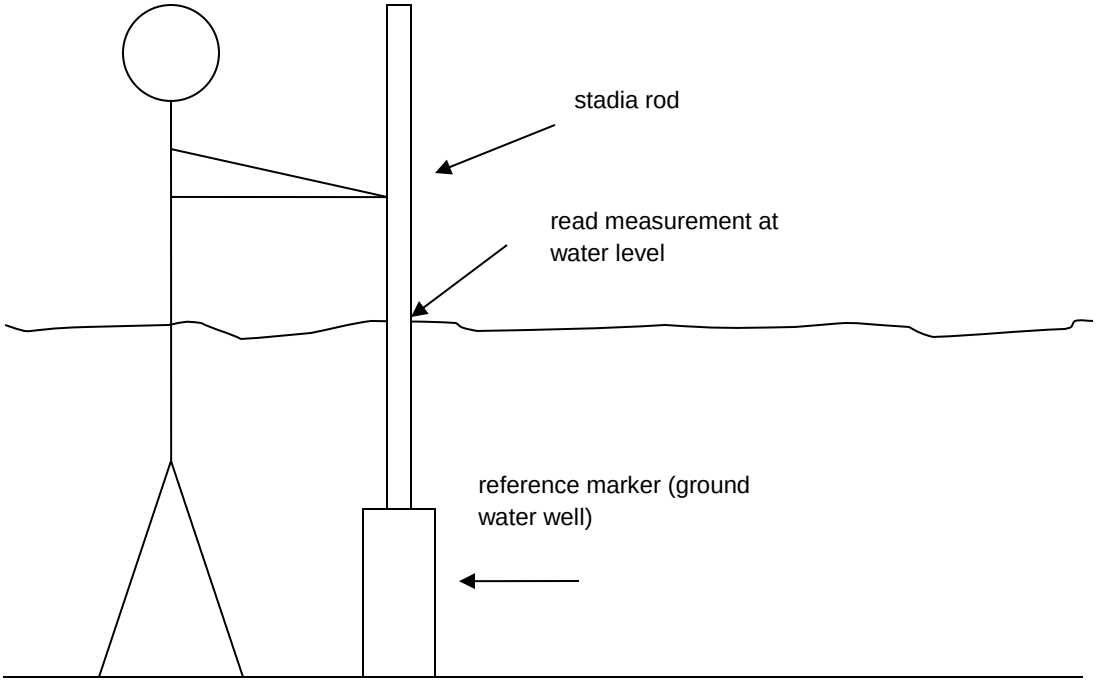


Figure 6. To measure water level from in the water, a stadia rod is held on the reference marker to read water level above marker.

4.2.3 QA/QC

For quality assurance, each measurement should be repeated, with the field personnel switching roles. For example, one person will hold the stadia rod while the other will measure the water level through the eye level, then the people will change roles. Both readings should be recorded on the field data sheet, along with the average. If the repeated measurements differ by 10 cm or more, both readings should be repeated.

To minimize sources of error, use a firm surface on which to set the surveyors rod (e.g., a rock or a Secchi disk) and a firm surface on which to place the eye level (e.g., a piece of 2 × 4 lumber or the clipboard).

4.3 Equipment List

The following equipment and supplies are required for installing reference marks in bedrock and measuring water level.

Installation
aluminum dome cap markers
battery-powered hammer drill and spare battery
drill bit
canned air

epoxy
hard surface for mixing epoxy (e.g., piece of cardboard or rigid plastic)
small plastic bag for garbage
GPS unit and spare batteries
compass
field notebook

Measuring Water Level
stadia rod
eye level or line and line level
GPS unit and spare batteries
compass
field notebook
photos and description of location
data sheets
firm surfaces for placing stadia rod and eye level

If installing a reference mark using a method other than gluing it in bedrock, substitute appropriate installation materials for those listed above. For example, if pounding in an iron rod and cementing a surveyors marker to the top, the following will be needed: sledge hammer, quick-crete, water for mixing, stir-stick, bucket for mixing, iron rod, and aluminum dome cap marker.

4.4 Literature Cited

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