Natural Resources Facts

University of Rhode Island • College of Resource Development
Department of Natural Resources Science • Cooperative Extension

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MEASURING WATER CLARITY

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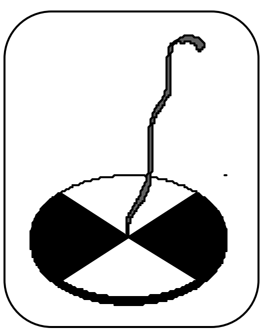
Whether or not we realize it, many of us judge the health of a waterbody by its clarity. Generally speaking, if we can see the bottom of a lake or some distance into its depths- it's clean; if we cannot see the bottom in even shallow water - it's dirty. However, the issue of water clarity is more than an aesthetic issue of "clean" or "dirty." Can water clarity objectively be used to measure water quality?

Although scientists have devised various complicated means to measure water clarity, a simple method was developed by Angelo Secchi, an astrophysicist and scientific advisor to the Pope. On April 20, 1865, Secchi lowered the first Secchi disk from the papal steam yacht and tested its utility in a series of experiments. The Secchi disk has become a universally accepted tool for monitoring water clarity on a long term basis. This fact sheet will describe water clarity, how to measure clarity using the Secchi disk, what these measurements indicate, and how to make a Secchi disk.



Water Clarity and the Secchi Disk

Water clarity is primarily affected by algae and suspended sediments. Algae are naturally occurring microscopic plant life found in most waterbodies. Algae, mostly growing as single cells or in colonies, are part of a healthy lake ecosystem. Their photosynthetic processes are a source of oxygen for the lake and its organisms. Also, many lake organisms depend on algae as a basic food source (Simpson 1991). However, too much algae growth, stimulated by nutrient inputs from watershed activities, can dramatically reduce water clarity and adversely affect a lake's ecological balance.

Sediment carried by streams and storm runoff also decreases water clarity. Additional factors reducing water clarity include "tea" colored staining from naturally occurring tannic acids and resuspension of bottom sediments in shallow waters due to wind, waves, and/or boating activities.

The measurement of water clarity using a Secchi disk is known as Secchi Depth Transparency. This is a direct measure of how deep sunlight penetrates the water column and an indirect measure of the amount of suspended material (algae, microscopic organisms, and sediment) in the water column. The standard Secchi disk consists of a weighted steel or heavy plastic disk, 20 centimeters (8 in.) in diameter either all white or with alternating black and white quadrants, attached to a calibrated line. Although 20 centimeters is the standard size of a Secchi disk for lake monitoring, they can range in size from 2.5 centimeters to 1.2 meters and are used to monitor all sizes of waterbodies from backyard ponds to oceans. The underlying assumption of Secchi disk methodology is that the greater the Secchi depth measurement, the clearer the water. Secchi depth measurements range from several centimeters (a few inches) for very turbid (cloudy) waters to more than 40 meters (130 ft.) for the clearest waterbodies. However, most measurements range from 2-10 meters (about 6-33 ft.).

How to Use a Secchi Disk

The basic procedure for using a Secchi disk is quite simple. The disk is slowly lowered into the water until it disappears from view. Then the calibrated line is marked at the water surface, often with a clothespin. Next, the disk is lowered several more feet and then slowly raised until it is again sighted. A second clothespin is used to mark this point. The Secchi depth measurement is determined by averaging the depths of disk disappearance and reappearance.

Sunlight variability can significantly influence Secchi depth measurements. To compensate for influences of the sun's angle in the sky, measurements should be taken between 10 am and 2 pm. Although usual prescription glasses should be worn, avoid wearing sunglasses.

To compensate for the sun's glare on the water, two variations have been developed for making Secchi depth measurements. The first variation is to take measurements on the shady side of the boat. On the shady side, there is less

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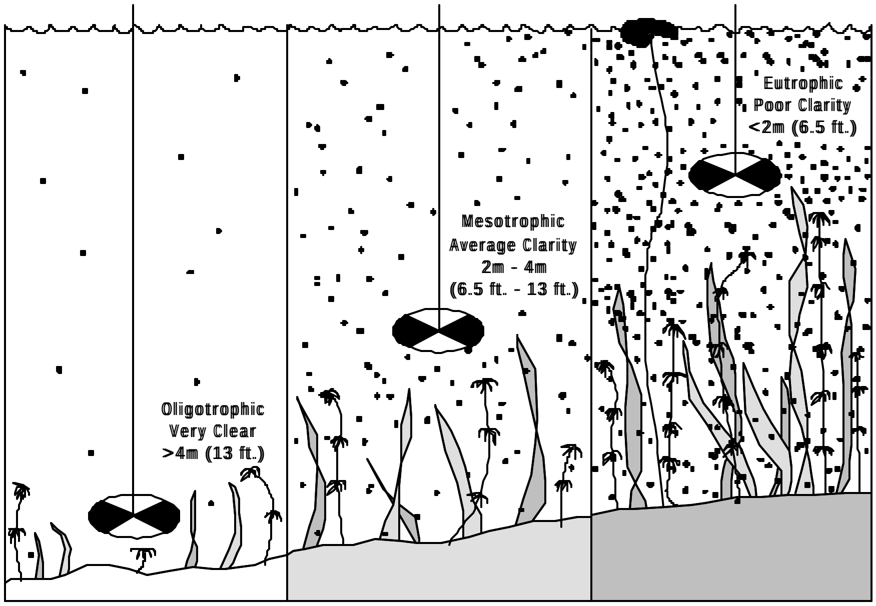


Figure 1:
Water Clarity and Secchi Depth Measurements
This diagram illustrates how Secchi depth measurements are influenced by algae, suspended sediments, and aquatic plants. Ranges of Secchi depth measurements are correlated with the appropriate trophic status.

sunlight variability to affect Secchi depth measurements. The second method, recommended by URI Watershed Watch and thought to be more accurate, is to observe the disk through a view tube on the sunny side of the boat. A view tube is a 2-3 foot long section of PVC pipe, preferably with a black interior and a handle attached near one end. The tube is held vertically, with four inches submerged in water. The view tube reduces interference from surface glare. Some view tubes come with a plexiglass "window" at one end to prevent water from entering the tube, like a scuba mask. Whichever variation you choose or your monitoring program recommends, you must follow it every time you take measurements to ensure consistency and reliability.

As with any water monitoring procedure, opportunities for human error exist when taking Secchi depth measurements. The visual acuity of the monitor can influence the depth to which the disk remains visible from the surface (Pseisendorfer 1986). To reduce chances of human error, some steps can be taken. For example, replicate measurements help to obtain more reliable results. URI Watershed Watch recommends that monitors lower their Secchi disks into the water at least two times, recording all disappearance and reappearance depths. In addition, if two people monitor the lake, the second person should take duplicate measurements at the same location. Under most circumstances, measurements that vary by even as much as 4 to 6 inches are still considered acceptable and useful data. All measurements are averaged for that particular day.

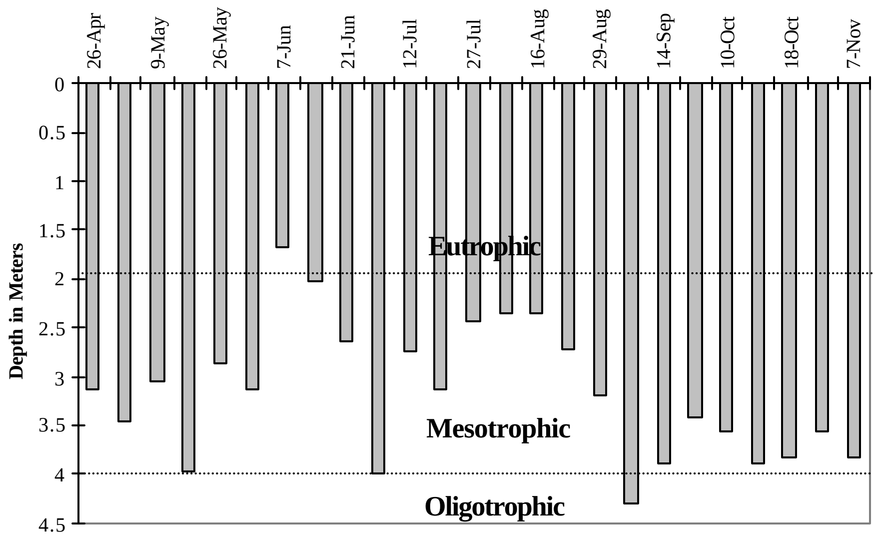
In order to compare water clarity measurements of a lake, it is critical for monitors to take Secchi depth measurements at the same location on the lake every time they monitor. This practice ensures consistency. The usual strategy is to take measurements at the deepest spot on the lake. However, monitors may wish to explore water clarity at other areas of concern. No matter how many locations are monitored, it is critical that replicate measurements be taken at the same location and recorded separately.

To obtain the best Secchi depth results, lakes or ponds ideally should be 50% deeper than the average Secchi depth measurement so that the disk is contrasted against the water and not bottom sediments (Carlson 1995). The biggest problem occurs when the disk is consistently visible at the bottom of the monitoring location. Under such circumstances, Secchi depth measurements are likely to misrepresent actual conditions. However, Secchi depth measurements on such lakes can be useful in identifying general trends in water clarity. For example, if the disk is seen at the bottom less frequently over the years, decreasing water clarity is evident. On the other hand, improving water clarity is indicated by seeing the disk at the bottom when it has not been seen there in the past. Despite these complications, studies have found no significant differences in precision between Secchi depth measurements and more sophisticated techniques (Carlson 1995).

What Do Secchi Depth Measurements Indicate?

Using Secchi depth measurements, lakes and ponds can be grouped into **trophic status** categories, which indicate their general level of clarity, nutrient enrichment, and algae and/or plant abundance (Fig.1). **Oligotrophic** waterbodies are what many people consider most desirable and pristine. Such lakes are clear to great depths and have low nutrient, or productivity levels. At the other end of the spectrum are **eutrophic** lakes, having low water clarity and high productivity levels. **Mesotrophic** lakes occupy the middle range. Lakes naturally progress from oligotrophic to eutrophic status over thousands of years in the process of **eutrophication**. However, human activities have greatly accelerated this process. This is known as **cultural eu-**

Figure 2:
1992 Secchi Depth Measurements
Georgiaville Pond, Smithfield
The top of this graph can be viewed as the surface of the water, and the length of the bars represent how deep the Secchi disk was visible into its depths on that particular day. As can be seen in this graph, Secchi depth measurements can vary from week to week throughout a season. In 1992, Secchi depth measurements on Georgiaville Pond had a range of 2.6 meters.



trophication. (Simpson 1991, Wetzel 1993) For more information on trophic status, refer to Natural Resources Facts, Fact Sheet No. 96-2, "Phosphorus and Lake Aging."

Secchi depth measurements can indicate the amount of algae in a waterbody. The more algae, the less clear the water and consequently, the less visible the Secchi disk. As algal populations fluctuate, individual Secchi depth measurements can also vary throughout a season (Fig. 2). This variation can be up to 2 meters. For example, in the summer, when the sunlight penetrating the lake is more intense, a summer algal bloom may occur if there is an abundance of available phosphorus. If a lake were characterized by only a single Secchi depth measurement during the summer, this could misrepresent the lake's water quality. The frequency and length of algal blooms are highly indicative of water quality problems and can be characterized by weekly Secchi depth measurements. Individual rainfall events may also carry a surge of nutrients to a waterbody. It is useful to examine seasonal variability in Secchi depth measurements on a particular waterbody to detect water clarity trends. Over 200 volunteers in the URI Watershed Watch program monitor more than 70 sites taking over 2000 Secchi depth measurements each year between April and November to detect any such water quality trends.

Secchi depth measurements can also indicate the turbidity (cloudiness) of a waterbody. Turbidity is caused by particulates, such as suspended sediments or algae, scattering the light passing through the water. The more suspended solids in a lake, the lower its clarity. Development greatly increases the amount of suspended sediments entering a waterbody in storm runoff. As vegetation is cleared, soil erosion increases while impervious surfaces increase the rate and volume of polluted runoff entering streams and lakes. Consequently, short term changes in Secchi depth measurements are often observed until the new influx of sediments settles to the lake bottom.

To distinguish between suspended sediment and algal influences on water clarity, chlorophyll *a* and total phosphorus concentrations are frequently measured in conjunction with Secchi depth measurements. Chlorophyll *a* is a green pigment found in algae and all other photosynthyzing plants. Chlorophyll *a* is considered a good indicator of the amount of algae in a waterbody (see Natural Resources Facts, Fact Sheet No. 96-4, "Algae..."). The amount of phosphorus controls the amount of algae and plant growth possible in freshwater lakes and ponds (see Natural Resources Facts, Fact Sheet No. 96-2, "Phosphorus and Lake Aging"). Measuring total phosphorus can also predict the amount of chlorophyll *a*. Using these indicators, along with Secchi depth measurements, can lead to a more accurate portrait of the water quality of a given lake or pond.

Secchi depth measurements can also vary naturally over the long-term, responding to precipitation patterns. Depending on specific lake hydrology, droughts can reduce or improve water clarity. For example, if a lake has a low flushing rate (it takes a long time for water in a lake to be completely replaced by incoming water), drought may cause nutrients to accumulate in a lake resulting in high productivity and low water clarity for that particular year. On the other hand, droughts also suppress the transport of contaminants to a waterbody, which may improve water clarity. The timing of precipitation also influences Secchi depth measurements. For instance, if a heavy storm occurs in the early spring when many land surfaces remain uncovered, more runoff is generated. This additional runoff carries an early load of sediments and nutrients to a pond thereby decreasing water clarity. This illustrates the importance of long-term monitoring of lakes and ponds. If a lake is monitored for only one year, "normal" patterns and potential variation may be overlooked. Long-term monitoring of lakes is frequently supported by volunteer efforts, as with URI Watershed Watch. As of 1995, URI Watershed Watch volunteers have collected up to 8 years of data on some of its Rhode Island monitoring locations.

How to Make a Secchi Disk (Fig. 3)

From a plastics supply house (look under "Plastics" in your local Yellow Pages) order a 20-cm diameter, 1/4" thick, white opaque acrylic disk with a 3/8" hole drilled through the center. (The disk will have paper masking on both sides.) If possible, the plastic surface should have a non-glossy or "flat" finish.

1) On one side of the acrylic disk, divide masking paper into quarters and peel paper from opposing quadrants. A straight edge will be needed for use as a knife guide.

2) Rough up the exposed quadrants with fine sandpaper and warm the disk under bright lights. While the disk is still warm, paint exposed quadrants with flat black enamel paint. After applying a second coat of paint, peel off the remaining masking paper. The paint will take about two weeks to fully harden. If the disk is used during the hardening period, it must be treated gently to prevent chipping.

3) To weight the disk, use 1/4", 5" x 5" steel plate. The steel plate should be painted to avoid rusting. You could also use a series of washers, or even a brick or a sand-filled plastic bottle as a weight.

4) Assemble the disk with a 5/16" diameter stainless steel eyebolt. Use flat washers between the disk and nut, and between the steel plate and locking washer. Use one 5/16" nut at the top of the eyebolt, and another to bolt the steel plate onto the disk.

5) Attach the nylon line to the disk through the eye of the bolt. Measuring from the face of the disk, mark remaining length of line at meter and half meter (or foot and half foot) increments using an indelible pen or wire ties. The line should be calibrated periodically to ensure accurate measurements.

Pre-made Secchi disks and other water quality apparatus can be purchased from a number of commercial sources. Three sources are:

LaMotte Chemical Co. (1-800-344-3100)
Laurence Enterprises (1-207-276-5746)
Hach Chemical Co. (1-800-227-4224)

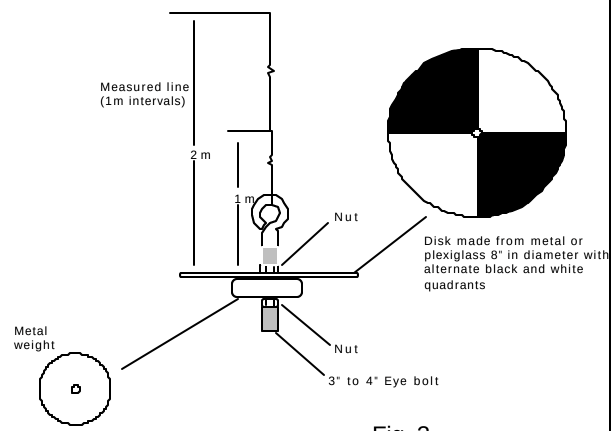


Fig. 3
Making a Secchi Disk

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For more information:

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography. 22:361-369.

Carlson, R.E. 1995. The Secchi Disk and the Volunteer Monitor. *Lakeline*. 15:28-29,35-37.

Diet for a Small Lake: A New Yorker's Guide to Lake Management. 1990. Prepared by the New York State Department of Environmental Conservation and the Federation of Lake Associations, Inc. (315)655-4700.

The Lake and Reservoir Restoration Guidance Manual. Second Edition. 1990. EPA 440/5-88-002. (904)462-2554.

Manson, Bruce A. 1992. *A Primer on Limnology, Second Edition*. Water Resources Research Center, College of Natural Resources, University of Minnesota, Room 302, 1518 Cleveland Avenue, N., St. Paul, MN 55108. (612)624-9282.

Natural Resources Facts, Fact Sheet No. 96-2, "Phosphorus and Lake Aging," 1996. Cooperative Extension, URI.

Natural Resources Facts, Fact Sheet No. 96-4, "Algae in Aquatic Ecosystems," 1996. Cooperative Extension, URI.

Pseisendorfer, R.W. 1986. Secchi disk science: Visual optics of natural waters. *Limnology and Oceanography*. 31(5):909-926.

Simpson. 1991. Volunteer Lake Monitoring: A Methods Manual. EPA 440/4-91-002. (202)260-7018.

Wetzel, R. G. 1983. Limnology. Saunders College Publishing, Philadelphia, PA. pp. 48-68.

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