Water Transparency Protocol

Purpose

To determine the transparency of water using a Secchi disk (still, deep water) or transparency tube (flowing or shallow waters)

Overview

In still, deep water, students will lower a Secchi disk until it cannot be seen and then pull up the disk until it just reappears. In flowing or shallow waters, students will collect a sample of water in a bucket and then pour water into a transparency tube just until the bottom of the tube cannot be seen. Students will record the depth of water in the tube. The depth of water for both the Secchi disk and transparency tube depends on the amount of suspended and colored material in the water.

Student Outcomes

Students will learn to,

- use the Secchi disk or transparency tube;
- examine reasons for changes in the transparency of a water body;
- communicate project results with other GLOBE schools;
- collaborate with other GLOBE schools (within your country or other countries);
- share observations by submitting data to the GLOBE archive.

Science Concepts

Earth and Space Sciences

Water is a solvent.

Earth materials are solid rocks, soils, water and the atmosphere.

Physical Sciences

Objects have observable properties.

Life Science

Organisms change the environment in which they live.

Humans can change natural environments.

All organisms must be able to obtain and use resources while living in a constantly changing environment.

Scientific Inquiry Abilities

Use a transparency tube or Secchi disk to measure water transparency.

Identify answerable questions.

Design and conduct scientific investigations.

Use appropriate mathematics to analyze data.

Develop descriptions and explanations using evidence.

Recognize and analyze alternative explanations.

Communicate procedures and explanations.

Time

10 minutes

Level

All

Frequency

Weekly

Materials and Tools

Hydrology Investigation Data Sheet

Cloud Cover Protocol Field Guide

Latex gloves

Secchi Disk Measurement

- *Secchi Disk Transparency Protocol Field Guide*
- Secchi disk (with rope)
- Meter stick
- Clothespins (optional)

Transparency Tube Measurement

- *Transparency Tube Transparency Protocol Field Guide*
- *Collecting a Water Sample in a Bucket Field Guide*
- Transparency tube
- Cup for pouring water into the tube

Preparation

If a Secchi disk or transparency tube is not purchased, one must be made.

Prerequisites

A brief discussion of how the Secchi disk or transparency tube is used to measure water transparency is necessary before students make their first measurement.

Practice protocol before taking measurements.

Water Transparency Protocol – Introduction

How clear is the water? This is an important question for those of us who drink water. It is an even more important question for the plants and animals that live in the water. Suspended particles in our water behave similarly to dust in the atmosphere. They reduce the depth to which light can penetrate. Sunlight provides the energy for photosynthesis (the process by which plants grow by taking up carbon, nitrogen, phosphorus and other nutrients, and releasing oxygen). How deeply light penetrates into a water body determines the depth to which aquatic plants can grow.

Transparency decreases with the presence of molecules and particles that can absorb or scatter light. Dark or black material absorb most wavelengths of light, whereas white or light materials reflect most wavelengths of light. The size of a particle is important as well. Small particles (diameters less than 1 μm) can scatter light.

The fate of light entering a water body depends on the amount, composition and size of the dissolved and suspended material. "Hard" water lakes with lots of suspended $CaCO_3$ particles preferentially scatter blue-green light, whereas lakes with organic materials appear more green or yellow. Rivers with high loads of sediments are often the color of the sediments (e.g. brown).

Sediments can come from natural and human sources. Land with little vegetative cover (such as agricultural land and deforested land) can be major sources of sediments. Colored organic material can come from *in situ* productions such as detritus and biota or from inputs into the water body.

GLOBE offers two techniques to measure transparency. If your hydrology site is at a water body that is deep and still (not flowing as a stream), use the Secchi disk. If your site is at a water body that is shallow or flowing, then you need to use the transparency tube. These two measurements are related but slightly different. Both measure transparency; however, you cannot directly compare Secchi disk and transparency tube measurements between sites.

Figure HY-TR-1: Measuring Transparency in Shallow or Running Water

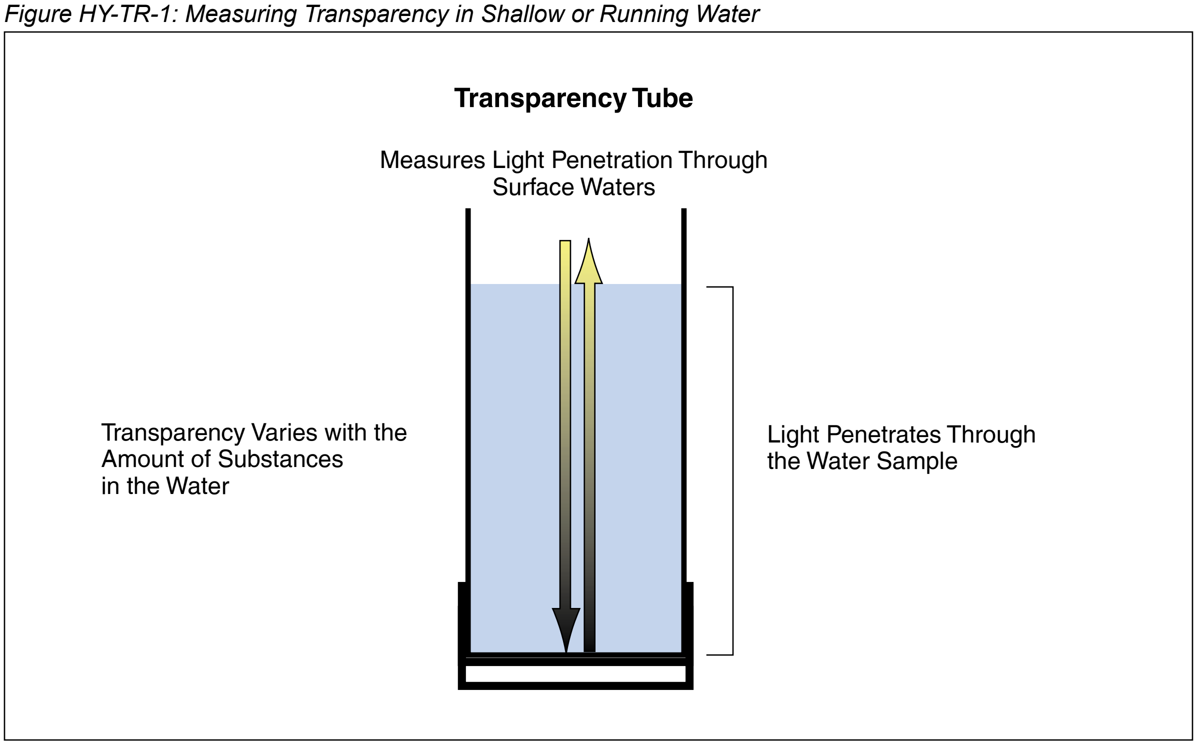
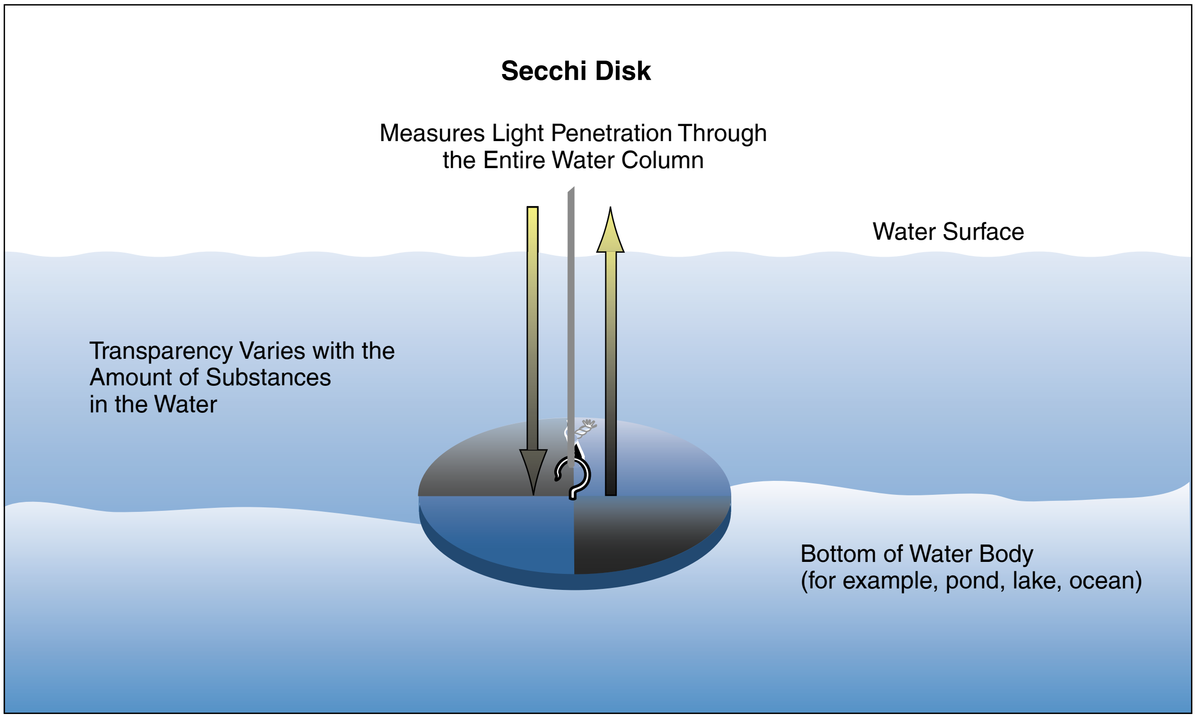


Figure HY-TR-2: Measuring Transparency in Deep and Still Water



The Secchi disk measures a column of water. Light penetration may vary with depth in that column of water. All light being reflected from the Secchi disk is passing through the water from the surface. The transparency tube, on the other hand, measures the transparency of a sample of water taken from just below the surface. Light may enter the transparency tube from the sides as well as the top. Because the water sampling is different (a column vs. a surface sample) and the instrument used does not allow equivalent penetration of light, the two measurements are not directly comparable. Figures HY-TR-1 and HY-TR-2 illustrate these differences.

Teacher Support

Supporting Protocols

Atmosphere: Atmospheric data, such as precipitation and temperature, can be important to the interpretation of transparency data. Transparency may change rapidly in response to inputs of water, such as precipitation or runoff from snowmelt. Snowmelt will occur when the air temperature warms enough to melt the snow.

Land Cover: Seasonal changes in land cover may affect transparency. For instance, runoff from agricultural fields during plowing may cause transparency changes. Land cover changes may increase erosion rate by exposing the soil. It is helpful to know the land cover upstream of your Hydrology study site in order to interpret your transparency data.

Supporting Activities

The *Transparency Protocol* may be used to illustrate how different variables may affect a measurement (*Practicing Your Protocols: Transparency*). Students can graph variations in their data resulting from taking the measurement in the sun, shade, wearing sunglasses, waiting different amounts of time before taking the reading, etc. These experiments help students to understand the importance of following the protocols, as well as help them identify the variables that affect transparency.

Measurement Procedures

The *Transparency Protocol* asks for cloud cover measurements. See the *Cloud Protocol* in the *Atmosphere Investigation*.

Transparency measurements are made in the shade. Glare on the water from sunlight or differences in visibility between measurements on cloudy days or sunny days may affect the measurements. To standardize the data, all measurements are made in the shade.

Secchi Disk Protocol

The *Secchi Disk Transparency Protocol* asks for three measurements: 1) the distance between the water surface and where the disk disappears, 2) the distance between the water surface and where the disk reappears, and 3) the distance between the observer and the water surface. If you are taking measurements at the water surface, then record "0" for the last measurement. Knowing the distance between the observer and the water surface helps scientists better interpret and compare data among sites.

If the Secchi disk reaches the bottom of your water body before it disappears, record the depth of the water with a greater sign (e.g., >30 m).

Do not mark the rope for the Secchi disk with distance measurements so that you can read the depths directly on the rope. Often ropes stretch when they are wet. It is better to use the meter stick than to mark the rope.

Safety Precautions

Students should wear gloves when handling water that may contain potentially harmful substances such as bacteria or industrial waste.

Instrument Maintenance

1. Rinse the transparency tube or Secchi disk with clean water after use, then let it drain and dry completely.
2. Store the tube with an extra PVC cap over the open end to protect it from damage.
3. Do not store meter sticks inside the tube –dampness may warp the stick or cause the varnish to peel off.

Questions for Further Investigation

Does the transparency of the water change with other parameters, such as precipitation, water temperature, wind speed and direction, seasons, and land cover?

Secchi Disk Transparency Protocol (for deep, still waters)
Field Guide

Task

Measure the transparency of your water sample.

What You Need

- ❑ *Hydrology Investigation Data Sheet*
- ❑ *Cloud Cover Protocol Field Guide*
- ❑ Secchi disk with rope attached
- ❑ Meter stick
- ❑ Pen or pencil
- ❑ Clothespins (optional)
- ❑ Latex gloves

In the Field

1. Fill in the top portion of the *Hydrology Investigation Data Sheet*.
2. Record the cloud cover (see *Cloud Cover Protocol Field Guide* in the *Atmosphere Investigation*).
3. Stand so that the Secchi disk will be shaded or use an umbrella or piece of cardboard to shade the area where the measurement will be made.
4. If you cannot reach the water surface, establish a reference height. This can be a railing, a person's hip, or the edge of a dock. All measurements should be taken from this point. Wear latex gloves, as you will probably touch the rope wet with sample water.
5. Lower the disk slowly into the water until it just disappears.
6. Mark the rope with a clothespin at the water surface or, if you cannot easily reach the water surface (for example, if you are standing on a dock or bridge), mark the rope at your reference height.
7. Lower the disk another 10 cm into the water, then raise the disk until it reappears.
8. Mark the rope with a clothespin at the water surface or at your reference height.
9. There should now be two points marked on the rope. Record the length of the rope between each mark and the Secchi disk on your *Hydrology Investigation Data Sheet* to the nearest cm. If the depths differ by more than 10 cm, repeat the measurement and record the new measurements on your *Data Sheet*
10. If you marked the rope at the water surface, record "0" as the distance between the observer and the water surface.
11. If you marked the rope at a reference point, lower the disk until it reaches the surface of the water and mark the rope at the reference point. Record the length of the rope between the mark and the Secchi disk as the distance between the observer and the water surface.
12. Repeat steps 5-11 two more times with different students observing.

Frequently Asked Questions

1. When comparing data between sites, do you need to make an adjustment for data taken at the water surface compared to data taken from a bridge or dock?

This distance is not used to adjust the Secchi disk data. However, reporting the distance between the observer and the water helps in data interpretation.

2. My students are using a pond for our hydrology measurements. They go out in a boat and use a Secchi disk for the transparency. We are not sure of the two measurements we are asked to give. They measure the line at the surface of the water to the top of the disk when it disappears and reappears. What is the other measurement?

For the other measurement, distance from where you read the line to the water surface, you should enter zero. Some schools will make Secchi disk readings from a bridge or pier, and report the depth measured using a reference level that is not the water surface, but some distance above the water surface. So they need to also enter the distance from the pier to the water. That way we have all of the raw data in the database.

Transparency Tube Transparency Protocol (for shallow or flowing waters)
Field Guide

Task

Measure the transparency of your water sample.

What You Need

- ❑ *Hydrology Investigation Data Sheet*
- ❑ *Collecting Your Water Sample in a Bucket Field Guide*
- ❑ *Cloud Cover Protocol Field Guide*
- ❑ Transparency tube
- ❑ Cup for pouring water into the tube
- ❑ Latex gloves
- ❑ Pen or pencil

In the Field

1. Fill in the top portion of the *Hydrology Investigation Data Sheet*.
2. Record the cloud cover. See *Cloud Cover Protocol Field Guide* from *Atmosphere Investigation*.
3. Put on gloves.
4. Collect a surface water sample. See *Collecting Your Water Sample in a Bucket Field Guide*.
5. Stand with your back to the sun so that the transparency tube is shaded.
6. Pour sample water slowly into the tube using the cup. Look straight down into the tube with your eye close to the tube opening. Stop adding water when you cannot see the pattern at the bottom of the tube.
7. Rotate the tube slowly as you look to make sure you cannot see any of the pattern.
8. Record the depth of water in the tube on your *Hydrology Investigation Data Sheet* to the nearest cm. **Note:** If you can still see the disk on the bottom of the tube after the tube is filled, record the depth as >120 cm.
9. Pour the water from the tube back into the sample bucket or mix up the remaining sample.
10. Repeat the measurement two more times with different observers using the same sample

Frequently Asked Questions

1. Is it all right to make a small hole in the transparency tube near the bottom, fill the tube with water, then slowly release water until the pattern at the bottom appears?

This method is acceptable as long as the measurement is made very quickly. Particles settle quickly, especially if they are being pulled down by water being released at the bottom. The reading must be made before particles settle and obscure the pattern.

Water Transparency Protocol – Looking at the Data

Are the data reasonable?

As always the first thing a researcher should ask when looking at data is: Does the data seem reasonable and make sense? However, when dealing with transparency data, this might not be an easy question to answer. As some general guidelines, most natural waters have transparency values ranging from 1 meter to a few meters. A low value, less than 1 meter, would be expected in a highly productive (i.e., lots of microscopic algae) body of water. A low value can be due also to a high concentration of suspended solids. Extremely clear lakes, coastal waters and areas around coral reefs can have transparency values of up to 30-40 m.

Transparency values, however, can be highly variable, even within a single body of water. Suspended particulates of varying nature effect how transparent a water body is. Some of these substances include soil, algae and other planktonic organisms, decaying leaves, and various pollutants. Transparency can also change with respect to time. For example, a large rainstorm could drastically reduce the transparency in a stream, river or pond over the course of minutes by the introduction of turbid runoff. A sudden warming during spring can produce a large influx of snowmelt that could increase the transparency. Since transparency is very site specific, the best way to see if the data are reasonable is to keep collecting samples over several years or longer. The data in Figure HY-TR-3 seem reasonable because the points in this data show a temporal trend. The large number of consistent data points makes this trend apparent. When looking at Figure HY-TR-4 the erratic nature of these data points makes it unclear if these data are reasonable. A more consistent data record could show that a trend is indeed present. However, these data could be perfectly reasonable without the presence of a trend because its erratic nature could be caused by any combination of the above-mentioned factors.

What do scientists look for in these data?

Transparency data can give a good indication of the biological productivity of a water body. Typically a productive lake will have low transparency due to an abundance of biota (particularly algae). If the Secchi depth is less than 1 m, small changes in nutrient inputs can cause major changes in productivity and therefore in transparency. During warm weather in highly productive lakes, oxygen depletion can occur, causing massive fish kills. The depth to which light penetrates determines the depth at which rooted plants can grow.

Yearly trends in transparency data can be used to investigate annual cycles within a water body. A good example of this is the data in Figure HY-TR-3 that was taken from the inlet of a reservoir in Czech Republic. There is an apparent increase in transparency during winter months and a decrease in transparency for the summer months. One possible explanation is that algae are a major factor affecting the transparency of this water body. In the summer months, the algae are in greater abundance causing the transparency to decrease. Winter months, decreased sunlight, and cold temperatures are usually associated with low algal production leading to an increase in transparency. Seasonal trends in precipitation might be seen in the transparency data as well.

Transparency is not a good indicator of water quality. It provides information on how many particulates are in a water sample, but does not reveal the nature of these particulates. Therefore, a clear water sample with a high transparency could contain harmful substances while a more turbid sample with lower transparency could be harmless.

Example of a Student Research Investigation.

Forming a Hypothesis

A student decides to look for seasonal variations in GLOBE transparency measurements. He first looks for GLOBE schools that have taken transparency data. In order to have enough data points to draw some conclusions, he looks only at schools that have taken 30 or more transparency measurements.

He finds an interesting trend in the data from Crescent Elk School, California. The measurement site, Elk Creek, shows higher transparency values in the summer months and lower values in the winter months. This student realizes that this trend is the opposite of what one would expect if algal growth was the primary factor controlling transparency. The student remembers learning somewhere that the winter months are the rainy season for the West Coast of the United States.

Since quite often increased rainfall is associated with increased runoff, he hypothesizes that in Elk Creek transparency levels will be lower during the raining season and higher during the dry season.

Collecting and Analyzing Data

Using the GLOBE Web site, the student plots both the transparency tube measurements and the precipitation data for Elk Creek from July 1998 to July 2001. From this graph there appears to be a correlation between the two data sets. See Figure HY-TR-5.

He then downloads the monthly averages for precipitation and transparency tube measurements for this site (Table HY-TR-1). He then plots the data on two different axes in a plotting program. It is now apparent from this plot that there is indeed a correlation between precipitation and transparency in the Crescent Elk data (Figure HY-TR-6). The correlation is best seen in the data from the summer months of 1998 to the winter months of 1999. The transparency plot is inversely proportional to the precipitation for this time. In other words, the transparency decreases as the amount of precipitation increases. There are some extraneous peaks in the transparency data, but this can be expected. Transparency is influenced by many additional factors other than precipitation.

The precipitation for 2000 was more sporadic for this site. It does not show as strong a seasonal trend as the other years examined. This is also reflected in the transparency data for this time period.

Based on these results he concludes that the initial hypothesis was partially supported by the data. It appears that the transparency for the Elk Creek site is influenced by precipitation events, however there are other factors also affecting transparency.

Future Work

He now wants to contact the Elk Creek School and discuss his hypothesis with them. The school might be able to provide clues as to what other factors may be influencing the transparency in

Table HY-TR-1

Month	Ave. Rain (mm)	Ave. Turb. Tube (cm)
71/998	0	125
8/1998	0	125
9/1998	0	125
10/1998	88.3	101
11/1998	431.4	
12/1998	265.0	101
1/1999	188.4	96
2/1999	390.1	102
3/1999	103.6	90
4/1999	62.3	119
5/1999	72.5	104
6/1999	4.5	113
7/1999	1.0	110
8/1999	11.5	115
9/1999	4.0	77
10/1999	43.0	115
11/1999	137.0	99
12/1999	143.4	86
1/2000	470.5	92
2/2000	316.7	83
3/2000	306.3	94
4/2000	452.0	105
5/2000	451.2	85
6/2001		125

Figure HY-TR-3

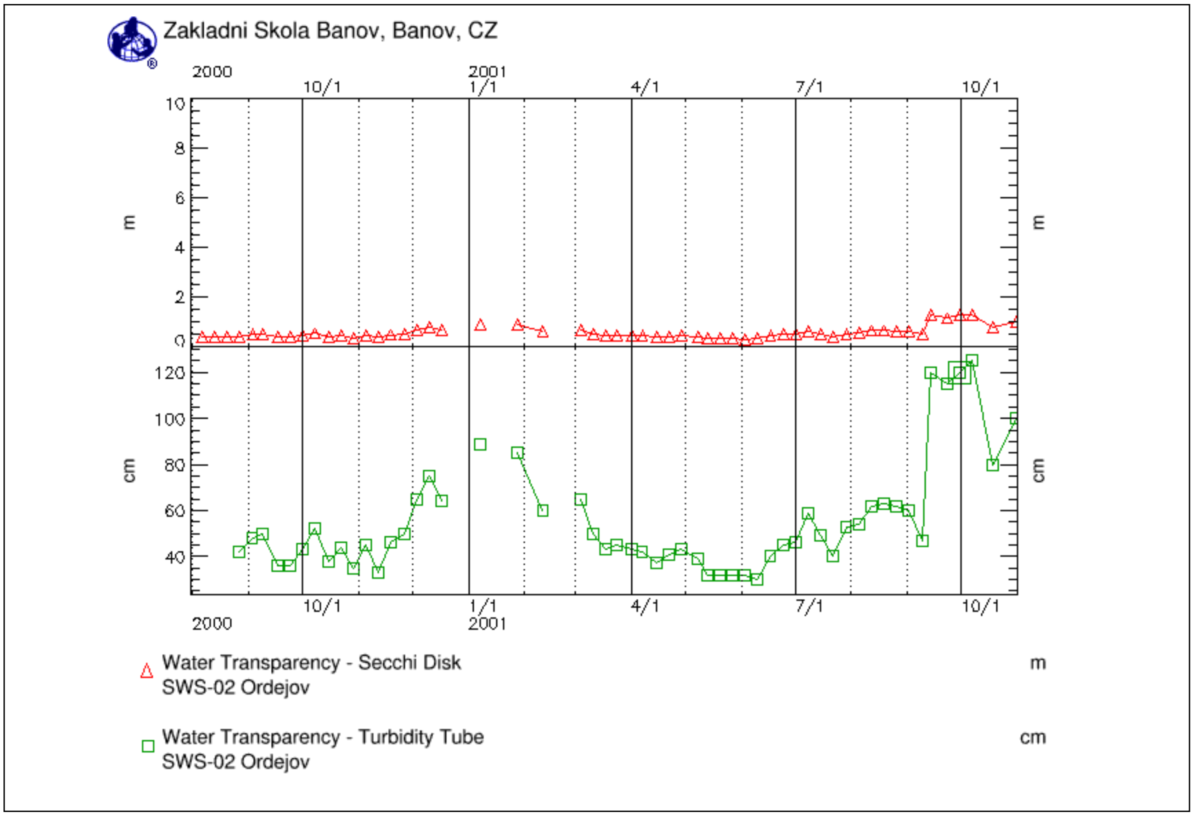


Figure HY-TR-4

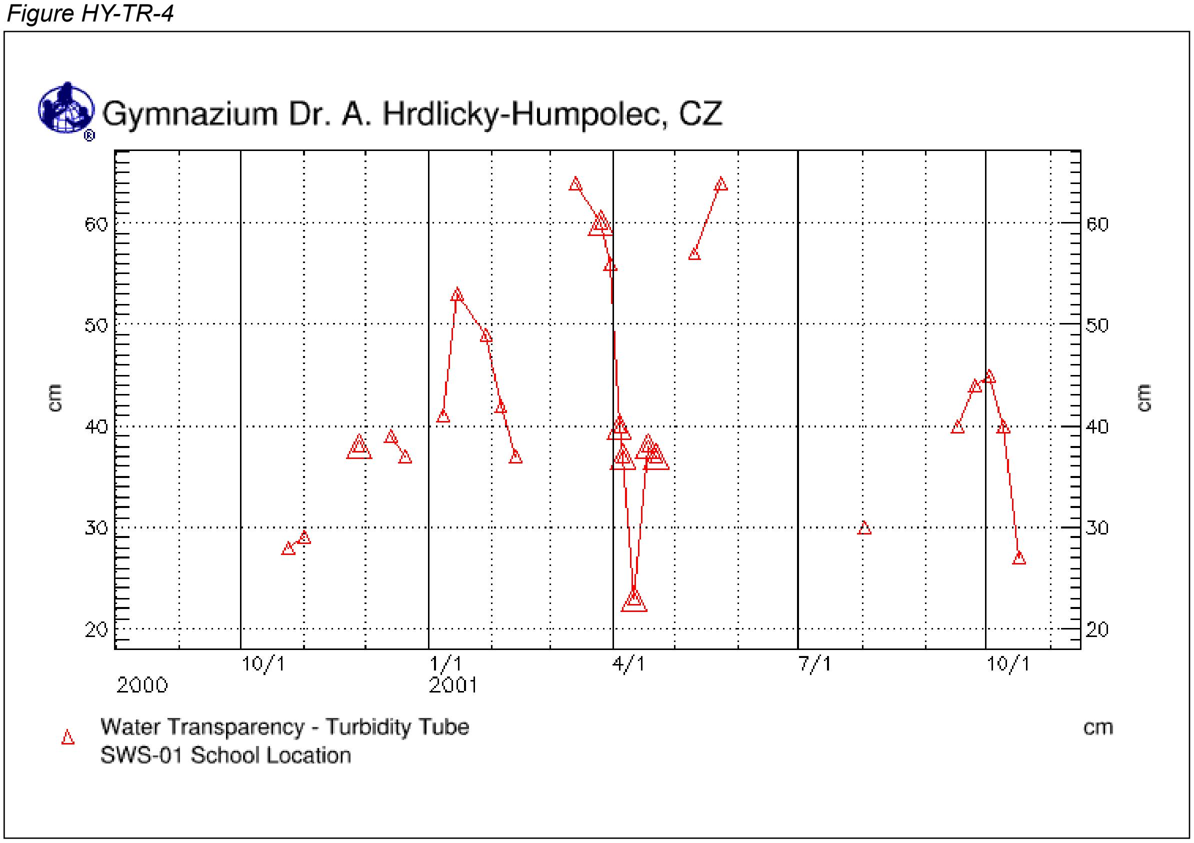


Figure HY-TR-5

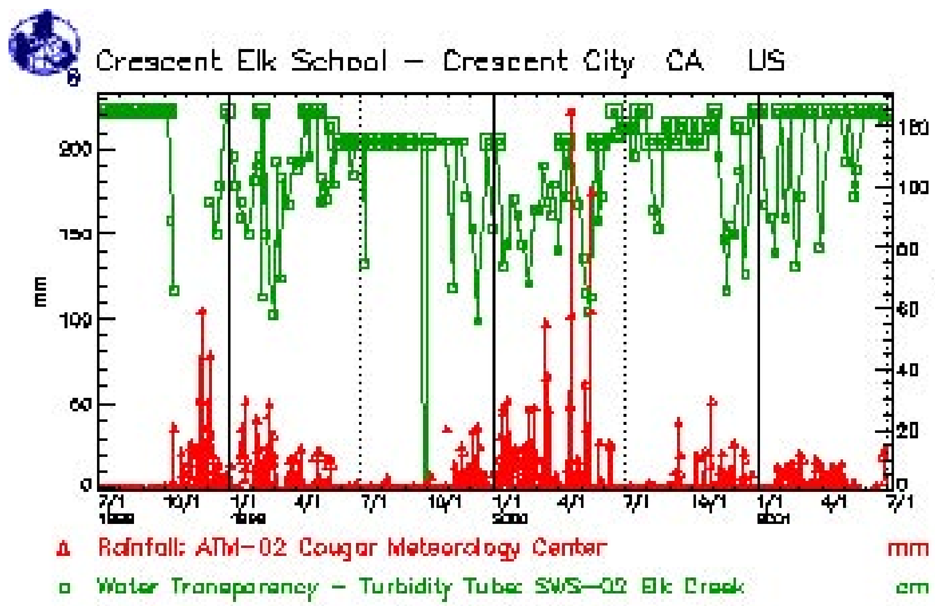


Figure HY-TR-6