CHAPTER 4: WATERSHED CHEMISTRY

IN THIS CHAPTER:

Field chemistry
- **Temperature**
- **pH**
- **Turbidity**
- **Conductivity**

Water quality standards

Field Chemistry

INTRODUCTION

New Mexico Watershed Watch supports your investigating several measurements about the chemical condition and health of streams for fish and humans. The program provides resources for measuring:

1. pH
2. Temperature
3. Conductivity
4. Turbidity
5. Nitrate Nitrogen
6. Total phosphorus (without heat digestion)
7. Ammonia
8. Copper
9. Zinc
10. Aluminum

Tests 1- 4 are easily done in the field. All you need to bring are functioning and calibrated meters, a beaker for grabing samples (not all tests require a beaker), distilled water to rinse the meters after use, and a field sheet to record the data. The data from these tests should be fairly precise and accurate assuming the meters and thermometer are properly calibrated.

Tests 5-10 can be done in the field if your spectrophotometer has a functioning rechargeable battery and you have the time and resources to do careful supervision of your students. Most schools collect a water sample in a clean bottle (approximately 1000 mL minimum size), refrigerate it overnight and do the analysis the next day. The maximum holding time for these samples are typically less than 48 hours. The possibility of interferences with obtaining precise and accurate analysis with the spectrophotometer include improperly following the instructions, contamination of the sample during transportation, sampling with a dirty sample bottle and analyzing the sample after the 48 hour holding time. However, the entire process of practicing good sampling techniques and carefully analyzing the sample gives students good experience in water quality science.

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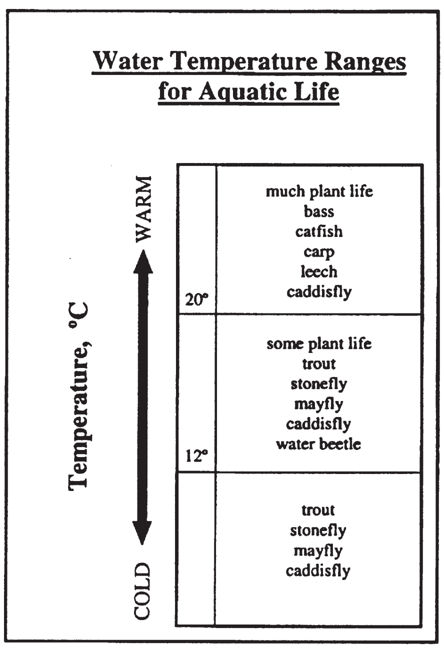
TEMPERATURE – WHAT AND WHY

What is Temperature?

Water temperature is a simple, but important measurement that refers to the coldness or warmness of water. Cool water holds more oxygen than warm water because gases, like oxygen, are more easily dissolved in cool water.

Why is temperature important?

Temperature directly affects many physical, chemical and biological characteristics of a river. The health of all living organisms in a river is dependent on water temperature as each organism is adapted to a particular range of temperatures. Most aquatic organisms have adapted to a specific temperature range that is optimal for its health. Growth and reproduction of the species occur most efficiently at a temperature within this tolerance range.



An increase in water temperature can affect aquatic life in the following ways:

- **Decreased oxygen availability.** Most aquatic organisms depend on the dissolved oxygen in the water. The warmer water is, the less oxygen it can hold, as gases are less soluble in warm water. Higher temperatures decrease the amount of oxygen available for aquatic organisms.

Table 4 - 1: Temperature Ranges for Selected NM Fish

Species	Optimal Growth Range	Maximum Range for Survival	Spawning Range
Rainbow trout- *Oncorhynchus mykiss*	13—21° C	18—25° C	5—15° C
Cutthroat trout- *Oncorhynchus clarki*	N/A	N/A	5.5—9° C
Gila trout *- *Oncorhynchus gilae*	N/A	28.25° and 25.57° C when acclimated at 10° C and 20° C respectively	8° C or greater
Brook trout- *Salvelinus fontinalis*	13.9—15.6° C	20—25° C	N/A
Longfin dace- *Agosia chrysogaster Girard*	24°+ C	50° C	24°+ C
Longnose dace- *Rhinichthys cataractae*	11.1—23.3° C	N/A	15.6° C
Flathead minnow- *Pimephales promelas*	23—30° C	N/A	15.6—18.4° C
Roundtail chub- *Gila robusta*	N/A	30.5—39.5° C dependent on acclimation temperature; fish acclimated at 24° C and 30° C preferred water from 22—24° C	20° C

*Federally listed as endangered (USFWS, 1967); listed in NM as threatened, 1988; listed as threatened by the American Fisheries Society, 1989.

N/A = Lack of information. Often data is only available for sports or endangered fish that are grown in hatcheries.

The greatest human-induced increases in temperature in New Mexico may be caused by devegetation of stream banks and soil erosion.

- **Increased metabolic rate.** The rates of growth, decomposition, and metabolic rates of many aquatic organisms rise with increasing water temperature. More plants grow and die. As they die, bacteria that consume oxygen decompose the dead plant cells. Fish and insects that rely on dissolved oxygen in the water have less available for their consumption when organic matter grows and decomposes faster than typical rates.

- **Spawning success.** Spawning, the act of egg laying and fertilizing by fish, is effected by temperature for many species. Different fish species have a preferred temperature for spawning. For instance, brook trout and rainbow trout find 9^{o} C. An increase in temperature of just a few degrees could prevent spawning.

- **Survival of embryos.** Embryo survival is also temperature dependent; higher than normal temperatures will lead to embryo death and a possible reduction in the population of a species.

Influences on Water Temperature

Natural factors and human influences effect water temperature in streams, rivers and lakes.

Natural factors

The elevation and geographical location of streams affect stream temperatures. Streams in lower elevation areas tend to stay warmer than streams at higher elevations. The time of year also affects water temperature changes as air temperature changes through the seasons. The source of water can cause streams to be cold, particularly those fed by snowmelt which are typically very cold in the spring. Streams fed by cold water springs remain cool all year long while warm water springs keep the water temperature warm. The channel shape impacts stream temperatures by limiting or exposing surface water to the atmosphere. A narrow, deep stream will be cooler than a wide, shallow stream if all other factors are the same. Finally, riparian shading with trees and shrubs makes water cooler by casting shadows over the water to keep temperatures down during hot summer months.

TEMPERATURE – HOW TO MEASURE

Measuring Temperature

1. Check thermometer for liquid-column separation (see if there are bubbles in the colored fluid). If yes, then use a different thermometer that is functioning properly.

2. Take the temperature in the shade. Use your shadow if nothing else.

3. Place the thermometer completely in the water. Hold it underwater for at least one minute (or until the reading stabilizes).

4. Read the temperature while the thermometer is still in the water if possible. If you can't read the thermometer while it is in the water then read it immediately after removing it from the water. This prevents the possibility that the thermometer will adjust to the air temperature before you read it.

5. Take the temperature 2-3 times if time allows and average the results on the Watershed Watch Field Form.

6. Put the thermometer back in its protective case.

Calibrating the Thermometer

1. Create a standard by filling a cup with mostly ice and top the cup off with water. Wait a minute for the water to reach the temperature of the ice (0 degrees C).
2. Put the thermometer in the ice water and wait one minute.
3. Pull the thermometer out of the cup and immediately read the temperature. It should be +/- 1 degree Centigrate from 0 degrees C. If not, the thermometer needs to be replaced.

PH – WHAT AND WHY

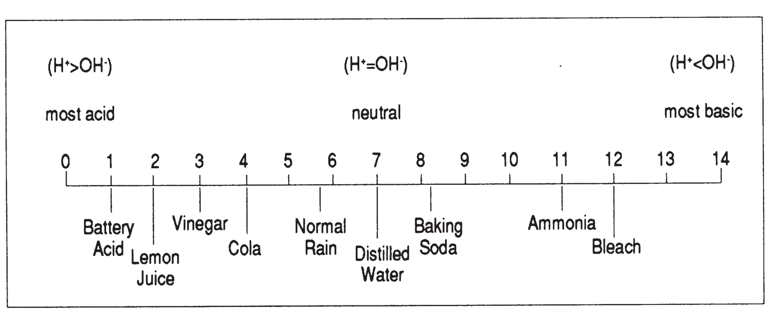
- pH measures how acidic or basic a solution is.
- The pH of rivers is largely due to the composition of the surrounding rock or soil through which they flow.
- Changes in pH can be due to various inputs such as industrial waste, wastewater treatment, and runoff from mining operations, and acid deposition.
- Aquatic organisms are adapted to particular pH levels and are adversely affected by even slight changes in pH.
- Very acidic waters can cause heavy metals to be released from bottom sediments and surrounding soils. These heavy metals can kill or stunt the growth of fish.

What is pH?

pH measures how acidic or basic a solution is. Water (H2O) contains both H+(hydrogen) and OH- (hydroxide) ions. The pH scale is a measure of the relative concentrations of these two ions. Pure water has an equal concentration of H+ ions and OH- ions and is given a pH of 7 on a scale of 0 to 14. An acidic solution has a higher concentration of H+ ions and has a pH of less than 7. A basic solution has a higher concentration of OH- ions and has a pH greater than 7.

The pH scale is a logarithmic scale. For example, a reading of 5 is 10 more times acidic than 6 and a reading of 4 is 100 times more acidic than 6. When compounds enter water and ionize, the water can become more acidic or basic.

The pH value is one of the most important chemical characteristics of a body of water. It impacts the health and diversity of aquatic organisms and also affects the nature of many of the chemical reactions taking place in an aquatic ecosystem.



pH scale showing the values of some common substances. (Source: U.S. Fish and Wildlife Service.)

Why is pH Important?

The pH of water can directly affect the life processes of aquatic plants and animals. Many organisms are adapted to particular pH levels. Slight changes in pH can affect the reproduction rates of some species or even result in death. The largest variety of organisms can survive in neutral to slightly basic water (pH 6.5 – 8.2). At extremely high or low pH values (such as 4.1 or 9.5) the water becomes unsuitable for most organisms.

Very acidic waters can cause heavy metals, such as mercury, copper and aluminum, to be released from bottom sediments and surrounding soils. These heavy metals can kill or stunt the growth of fish. In some parts of the country, the public is advised not to eat fish that may be contaminated with heavy metals.

Table 4 - 2: Effects of various pH levels on aquatic life:

pH	Effect
3.0 – 3.5	Unlikely that fish can survive for more than a few hours in this range, although some plants and invertebrates can be found at pH levels this low.
3.5 – 4.0	Known to be lethal to salmonids.
4.0 – 4.5	All fish, most frogs, insects absent.
4.5 – 5.0	Mayfly and many other insects absent. Most fish eggs will not hatch.
5.0 – 5.5	Bottom dwelling bacteria (decomposers) begin to die. Leaf litter and detritus begin to accumulate, locking up essential nutrients and interrupting chemical cycling. Plankton begin to disappear. Snails and clams absent. Mats of fungi begin to replace bacteria in the substrate. Metals (aluminum, lead) normally trapped in sediments are released into the acidified
6.0 – 6.5	Freshwater shrimp absent. Unlikely to be directly harmful to fish unless free carbon dioxide is high (in excess of 100 mg/L)
6.5 – 8.2	Optimal for most organisms.
8.2 – 9.0	Unlikely to be directly harmful to fish, but indirect effects occur at this level due to chemical changes in the water.
9.0 – 10.5	Likely to be harmful to salmonids and perch if present for long periods.
10.5 – 11.0	Rapidly lethal to salmonids. Prolonged exposure is lethal to carp, perch.
11.0 – 11.5	Rapidly lethal to all species of fish.

Source: Johnson, R., Holman, S. and Holmquist, D. 2000. Water quality with calculators. Vernier Software and Technology. Beaverton, Oregon.

Influences on pH

Natural Factors

The pH of a river or stream is in large part due to the composition of the surrounding rock or sediment through which it flows. In New Mexico, the pH of natural waters ranges between 6.6 and 8.8. However, many of our rivers are more basic (or alkaline) than acidic, probably due to a larger proportion of our soils being formed by alkaline rocks such as limestone.

Related to the measurement of pH is that of alkalinity, the acid-neutralizing, or buffering, ability of some waters. In rivers, this is generally due to the presence of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions dissolved in the water that react with free H^+ ions, thus protecting the water from a drop in pH. Streams that flow through limestone rocks and soils will have higher alkalinity, and better acid-buffering abilities. Streams flowing through granite will have lower alkalinity and less resistance to acidic inputs. Alkalinity can be tested by titrating a water sample with a weak acid.

During photosynthesis plants absorb CO_2, an acid formng anion and release oxygen and HCO_3, a base forming ion. During daylight hours, when algae and other plants are photosynthesizing, pH tends to rise. After sunset when photosynthetic activity stops, pH may drop. These day/night changes are more pronounced in nutrient rich river systems.

Human Influences

The pH of waters can also be affected by various inputs such as industrial waste, wastewater treatment and runoff from mining operations. Acid deposition (acid rain) can also have a serious impact on the pH of river waters. Acid deposition (rain, snow, dry particles) forms from droplets of sulfuric acid or nitric acid created by the burning of fossil fuels

FIELD SHEET 4.2: PH

PH – HOW TO MEASURE

Measuring pH

pH is best monitored in the field with a pH meter. The pH of samples taken and held can change over time or be affected by the container they are held in. A good quality meter that measures to 0.01 pH units is recommended. A pH pen is less expensive but will measure only to 0.1 pH units. pH paper can also be used but will measure only to 1 pH unit.

pH meters work by measuring the electric potential across an electrode (due to hydrogen ion concentration.) pH is then displayed in pH units or millivolts (mV.)

Instructions for measuring pH with the **Oakton pH Testr 2**.

1. On the day of use, you should condition the electrode before you begin.

a) Remove electrode cap.
b) Immerse electrode in electrode storage solution, buffer, or tap water for at least 30 minutes (**do not use deionized water for this brand meter)**

2. At the field site, have a beaker ready to take your water sample.

3. If it is safe, take a small (50 mL) sample in the main current where the water is well mixed. If the current is too strong, take the reading in a flowing part of the stream closer to shore. Try to avoid eddies where the water might not be as well mixed and could be absorbing acidic compounds from organic matter on-shore.

4. Remove cap from electrode and press the ON/OFF button to turn pH tester on.

5. Dip the electrode to a depth of ½ to 1 inches into the water sample, stir the sample lightly, and wait at least 30 seconds to let the probe equalize with the temperature of the water.

6. After the measurement has stabilized, press the HOLD/CON button to freeze the reading.

7. Record the reading on Watershed Watch Field Sheet. After you are finished, press the HOLD/CON button again to release the reading.

8. Rinse the meter in tap water and store instrument in protective case.

Calibrating the pH Meter

Calibration should be done every day the tester is used or as often as possible. You will need buffer solutions of pH 7 and pH 10 (buffer solutions will be supplied by Watershed Watch staff). Make sure that the buffer expiration date hasn't expired before using.

1. Press ON/OFF button to turn the unit on.

2. Dip the ph meter into the pH 10 buffer solution to a depth of ½ to 1 inch.

3. Press the CAL button to enter the calibration mode. "CA" will flash on the display at first, then a value close to the buffer solution pH will flash on the screen.

4. After at least 30 seconds (30 flashes on the screen), press the HOLD/CON button to confirm the calibration. The display will show "CO" and then switch to the buffer value reading.

5. Rinse electrode with tap water before sampling the next buffer solution (pH 7).

6. Dip the pH meter into the pH 7 buffer solution to the same ½ to 1 inch depth.

7. Press the CAL button again to enter the calibration mode. "CA" will flash on the screen, then a value close to pH 7 will appear on the screen.

8. After 30 seconds, press the HOLD/CON button to confirm the calibration. The display will show "CO" and then switch to the buffer value reading.

9. Rinse electrode in clean tap water, and then press the ON/OFF button to turn unit off.

10. YOU ARE CALIBRATED!

TURBIDITY – WHAT AND WHY

Synopsis

- Turbidity is a measure of the relative clarity of water.
- The effects of turbidity include increased water temperature, decreased oxygen levels in water, and impacted health and development of fish and macroinvertebrate insects.
- Turbidity can be caused by silt, clay, plant material, microorganisms, wood ash and chemicals suspended in the water.
- Turbidity is measured with a meter called a turbidimeter, or nephelometer and is reported in nephelometeric turbidity units (NTUs).

What is Turbidity?

Turbidity is a measure of the relative clarity of water, or how murky or cloudy the water appears. It is defined by the American Public Health Association (APHA) as "the optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample." Turbidity measures how particles in the water scatter light as it passes through the water. A turbidity measurement can be used as an indirect way to measure the amount of suspended solids in water. Keep in mind, however, that correlation of turbidity with the weight or particle number concentration can be difficult because of the size, shape and color of the particles.

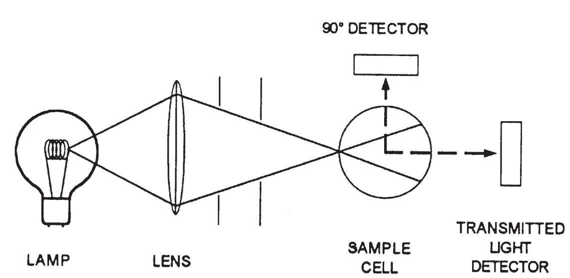


Figure 2 Ratio Optical System

Effects of Turbidity

At high levels of turbidity, water loses its ability to support a diversity of aquatic organisms. High levels of turbidity can raise water temperature by increasing the amount of sunlight that is absorbed by the water. An increase in temperature causes oxygen levels to decrease. Photosynthesis decreases because less light reaches underwater plants causing oxygen levels to drop even more.

Suspended solids can clog gills of fish and prevent the development of eggs and larvae. As particles of silt, clay and organic matter settle from the water to the bottom of rivers, they can cover and suffocate newly–hatched insect larvae. In addition, the settled sediment can take up spaces between the rocks that are important microhabitats for mayfly, caddisfly, stonefly nymphs and other aquatic insects.

Causes of Turbidity

Natural factors

Geologists say, "Silt happens", which describes past and future of turbidity. Natural sources of turbidity include the type of rock or sediment through which a stream flows. Rivers that flow through erodible material such as sandstone are naturally turbid. Turbidity is also caused by algae and plankton growth and by the activity of bottom-feeding organisms.

Human influences

In New Mexico, 95% of water pollution comes from sediment or dirt in the water. Much of this pollution may come from agricultural land uses such as grazing, farming and timbering. High turbidity may also be caused by soil erosion, waste discharge or runoff from urban areas. After the next rainstorm, measure the turbidity of your river or simply observe if it is clear or brown with sediment. See if you can find the source of the sediment and come up with ways to better manage the watershed and keep a good vegetation cover to protect aquatic insects and fish.

How to interpret results

The maximum value for high quality coldwater fisheries is 10 NTU. A maximum of 25 NTU is permitted in certain reaches where natural background prevents lower turbidity measurements.

The standard for most domestic water supply systems is 0.5 NTU.
There are no standards for turbidity for coldwater, marginal coldwater, or warmwater fisheries.

FIELD SHEET 4.3: TURBIDITY

TURBIDITY – HOW TO MEASURE

Turbidity is measured with a Hach 2100P portable turbidimeter provided by the New Mexico Department of Game and Fish. Report your results nephelometer turbidity units (NTUs) on the Watershed Watch Field Sheet.

Measuring Turbidity

1. Check the battery of the turbidimeter by turning on the power button before you go in the field. Replace batteries and recalibrate the machine, if necessary.
2. Collect a representative sample with the sample cells. Take care to handle the sample cell from the top so that finger prints don't dirty the glass.
3. Cap the cell and wipe the cell clean with a soft, lint-free cloth to remove water spots and fingerprints (a clean, recently-washed T-shirt will work fine). Apply a thin film of silicone oil and wipe with a soft cloth to obtain an even film over the entire surface. This should be done very seldom, and then only if the sample cell is scratched.
4. Wipe the cell with a soft lint-free cloth to remove water spots and finger prints.
5. Press the power button. Make sure the lid of the instrument is closed as the machine turns on.
6. Put the sample cell in the cell compartment so the diamond on the cell aligns with the raised orientation mark in the front of the cell compartment.
7. Press **READ.** The display will show "---- NTU" then the turbidity in NTU.
8. Take 2-3 measurements if time allows and record the results on the Watershed Watch Field sheet.

Troubleshooting

1. A flashing numeric display means that the sample is too turbid (or overrange) for the selected range. Press the **RANGE** key until the display reads "AUTO" to put the instrument in the automatic range selection.
2. "E" messages on the display indicates either an instrument failure or an operation cannot be performed for a variety of reasons. You can clear these messages by pressing the **DIAG** key. The meter will continue operating as best it can. Common messages are:
E3 = Low light error. E6 = Open lid during reading or obstructed light path.
E7 = Light leak error. If any of these errors persist, call Richard Schrader, Program Director at 505-992-0726.

Calibrating the Turbidimeter

Watershed Watch staff will calibrate your instrument once a year. However, you may have Gelex Secondary Turbidity Standards with assigned values for checking the calibration of the instrument in the field. Look for your Gelex standards in the instrument's carrying case. The look like vials filled with a firm gelatin (jello).

Insert the Gelex standards in the same way described to measure river samples. Look for a number penciled in the diamond on the vial. If you measured value is greater than +/- 5% of the value written on the vial, your instrument needs to be recalibrated by Watershed Watch staff. Call Rich Schrader to have your instrument calibrated.

CONDUCTIVITY – WHAT AND WHY

Synopsis

- Conductivity is a measurement of the ability of a substance to carry an electric current.
- The more ions present in water, the higher the rate of conductivity.
- Once a normal range of conductivity is established for a stream, large changes can indicate that some source of pollution has entered the water.
- Conductivity is affected by temperature, discharges into a stream, and the geology through which a stream flows.

What is Conductivity?

Conductivity is a measurement of the ability of a substance to carry an electric current. The presence of ions (charged particles) in the water from ionic compounds, such as salts, increases the capacity of the water to carry electricity. For example, sodium chloride will dissociate in water to form positive sodium ions (cations) and negative chloride ions (anions). The presence of free ions in water allows for the conductance of an electric current. The more ions present in water, the higher the rate of conductivity will be. Organic molecular compounds such as oils, phenols and alcohols do not form ions in solution and thus are not good conductors. Conductivity is measured in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C.)

Why is Conductivity Important?

Conductivity measurements provide a general indicator of water quality. Most streams have a relatively constant range of conductivity. Once baseline data is established for a stream, deviations from the normal range can indicate that some source of pollution has entered the water. Runoff from irrigation could increase conductivity because of salts picked up as water flows through the soil. On the other hand, an oil spill from an over-turned tanker truck would lower conductivity since oil is a poor conductor of electricity. Significant changes in conductivity could indicate that a discharge or some other source of pollution has entered the river.

Conductivity does not tell us what substances are present such as a nitrate test. But, a measurement of conductivity can be used to estimate the amount of total dissolved solids (TDS) present in a sample; this is done by multiplying the conductivity by a conversion factor. The factor for converting conductivity to TDS is 0.55 to 0.90, depending on the type of dissolved solids present. A general rule of thumb for New Mexico is to multiply your conductivity measurement by .59 to get TDS in mg/L (USGS, Hemm, Samplng and Analysis of Natural Waters).

The conductivity of rivers in the United States ranges widely from 19 µS/cm on the Rito Gascon to 8,800 µS/cm on the Candadian River just below Ute Dam. Compare this range to distilled water, which ranges between 0.5 to 3 µS/cm.

Influences on Conductivity

Natural factors.

The geology of the area through which a stream flows has the greatest affect on conductivity. Rivers flowing through granite bedrock generally have lower conductivity due to the inert nature of the minerals found in granite. Rivers running through clay soils will have higher conductivity as more inorganic dissolved solids wash into the water. Rivers coming from watersheds that have a limestone geology often have high conductivity since historically limestone is derived from a salty inland sea.

Water temperature also has an affect on conductivity, which increases with temperature. In most solutions an increase of 1oC will increase conductance by approximately 2 percent. Most instruments used in the New Mexico Watershed Watch program have automatic temperature compensation (ATC) with adjusts measured values to 25 oC. It's essential to know if an instrument has ATC or not. If not, report your data with a note after the value that says "no ATC".

Human influences

Land use activities can cause dissolved solids to run into a stream and increase conductivity levels. For example, runoff of fertilizers from lawns or agricultural lands or a sewage spill could raise conductivity because of the increased presence of phosphates, nitrates and salts. Conductivity could be lowered as a result of input from industrial waste such as alcohols and hydrocarbons.

How to interpret results

The acceptable range for high quality coldwater fisheries at 25 degrees Celsius is between 300 – 1,500 µS/cm depending on the natural background at your particular river site. There is no standard for marginal coldwater or warm water fisheries

HOW TO MEASURE CONDUCTIVITY

Conductivity is measured with a conductivity meter. As of the revision date of this instruction form, some meters measure in mg/L and others in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C.) The meters that give values in mg/L TDS convert a conductivity measurement into TDS automatically on the assumption that TDS is ½ of conductivity. Over the next several years these older meters will be replaced with meters that give results in µS/cm rather than mg/L TDS. In addition, some units have automatic temperature compensation and some don't. It is essential that you know what units your meter reads and that you report the units accordingly.

Measuring Conductivity

1. Check battery before going into the field.
2. Check instrument against a known conductivity standard before every field trip (if you didn't calibrate the instrument before the field trip, don't put a check in the "calibrated" box for conductivity field data on the Watershed Watch Field Form).
3. Rinse the probe with sample water from the river.
4. Gather 50 – 100 mL of water in a clean plastic beaker. You can also place the probe directly in the river water.
5. Put the probe in the sample beaker to a depth of about 1.5 inches. Do not immerse the meter above the level of the display.
6. Stir the probe gently and wait a few seconds to allow the display to stabilize. It takes up to about a minute for the metal probe to equilibrate to the temperature of the water.
7. Observe and record the reading on the Watershed Watch Field Form. Make sure to check your units of measure (µS/cm or mg/L TDS) and report them accordingly on the Field Form.
8. Rinse the probe with distilled water. Turn off the meter and store it safely in it's storage box.

Calibrating the conductivity meter:

Each meter has it's own instructions. The following steps are for the Oakton TDS Testr 20.

1. Rinse the probe in tap or deionized water, then in a known calibration solution.
2. Turn the unit on

3. Dip electrode into the calibration standard solution.

4. Press CAL/CON button to enter Calibration mode. “CA” flashes on the display. An uncalibrated value close to the calibration standard will flash.
5. Wait at least 30 seconds (about 30 flashes) for the reading to stabilize. Press the HOLD/INC button repeatedly to adjust the reading to match the value of the known calibration standard.
6. Press CAL/CON button to confirm calibration. The display will show “CO” and then switch to a calibrated conductivity reading.
7. For a second range, repeat steps 1-6.

Water Quality Standards

Water quality standards set goals, limits and rules for each water body and determine which waters must be cleaned up, how much they must be cleaned up.

The New Mexico Environment Department is responsible for enforcing a water quality standards under the federal Clean Water Act. Tribes also set water quality standards that are enforceable in New Mexico. The general purpose of water quality standards are to set goals, limits and rules for each water body. They also determine which waters must be cleaned up, how much they must be cleaned up.

The standards that your part of the river must achieve are based on the segment's *designated use*. Designated uses include human uses such as fish consumption, drinking water supply, primary contact recreation and secondary contact recreational uses. In addition, New Mexico standards define aquatic life uses such as for fisheries, agricultural uses and wildlife habitat.

The state of New Mexico uses the Water Quality Control Commission (WQCC) as the administrative body to update the water quality standards every three years (called a triennial review). The **Standards of Interstate and Intrastate Surface Waters** lists the water quality standards by designated use and describes the designated uses by stream segment for every river in New Mexico. Each teacher should get a copy of this document to find the appropriate standards for your school's stream segment (go to www.nmenv.state.us/swqb/ssstop).

Summary of Relevant Designated Uses

Domestic Water Supply

Waters designated for domestic water supplies shall not contain ***concentrations*** that create lifetime cancer risks greater than one cancer per 100,000 exposed persons. The numeric standards in table 4-4 shall not be exceeded.

Fishery Standards

There are New Mexico state standards for:

- High Quality Coldwater Fisheries (HQCF)
- Coldwater Fisheries (CF)
- Marginal Coldwater Fishery (MCF)
- Warmwater Fishery
- Limited Warmwater Fishery

Most of the schools in the program are designated for HQCF, CF, or MCF. The highest standards to achieve are for HQCF. A summary of these standards

Table 4- 3: Water Quality Standards for fisheries

Parameters for different fisheries	**High Quality Coldwater**	**Marginal Coldwater**	**Warm Water**
Temperature	$\leq 20^{o}$ C	$\leq 25^{o}$ C	$\leq 32^{o}$ C
pH	6.8 - 8.8	6.6 - 9.0	6.6-9.0
Conductivity (at 25 C)/1	300 -1500 µs/ cm	N/A	N/A
Turbidity (NTU = nephlo- metric turbidity units)	10 NTU	N/A	N/A
Dissolved oxygen	$\geq$ 6.0 mg/L	$\geq$ 6.0 mg/L	$\geq$ 5.0 mg/L

Ammonia is a gas (NH3) that is very soluble in water and toxic to fish at quite low concentrations. However, it easily reacts with water to form ammonia (NH3) and the ammonium ion (NH4+), which is not toxic. Because the test we do with the Nessler method measures total ammonia, the result is a combination of ammonia and ammonium, with most of it ammonia (98%) at pH levels of 7 or 8 and normal stream temperatures. When streams become more basic, at pH levels of 9 or higher, as much as half of the total ammonia may be in the toxic form (NH3). Tables 4-5 and 4-6 on page 3-22 indicate levels of total ammonia which are harmful because of the percentage of NH3 present at various pH and temperature conditions.

Table 4- 4: Water Quality Standards for water supply and fisheries. Many fisheries standards for metals depend on hardness of the water. These fisheries standards assume that hardness is 80 mg/L which not uncommon for upper elevation streams in the mountains.

Chemical Name	Drinking Water Supply (in mg/L)	Fisheries - Acute (in mg/L)	Fisheries - Chronic (in mg/L)
Total phosphorus	N/A	0.1	N/A
Dissolved nitrate (as N)	10	N/A	N/A
Dissolved copper	N/A	0.014	0.001
Dissolved zinc	N/A	0.097	0.088
Dissolved aluminum	N/A	0.75	0.087
Total ammonia	N/A	see table 3	see table 3
Dissolved arsenic	0.05	N/A	N/A
Dissolved barium	1.0	N/A	N/A
Dissolved cadmium	0.01	0.003	0.001
Dissolved chromium	0.05	N/A	N/A
Dissolved lead	0.05	0.0615	0.0024
Total mercury	0.002	0.024	0.000012
Dissolved selenium	0.05	0.02	0.002
Dissolved silver	0.05	0.0277	N/A
Dissolved cyanide	0.2	N/A	N/A
Dissolved uranium	5.0	N/A	N/A

Table 4-5 Total Ammonia (mg/L as N), Coldwater Fisheries:

Acute Standards

Temperature °C	pH										
	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00
0	29	26	23	19	14	10	6.6	3.7	2.1	1.2	0.70
1	28	26	23	19	14	9.9	6.5	3.7	2.1	1.2	0.70
2	28	26	22	18	14	9.7	6.4	3.6	2.1	1.2	0.69
3	28	25	22	18	14	9.6	6.3	3.6	2.0	1.2	0.69
4	27	25	22	18	14	9.5	6.2	3.5	2.0	1.2	0.69
5	27	25	22	18	13	9.4	6.1	3.5	2.0	1.2	0.68
6	27	24	21	18	13	9.3	6.1	3.5	2.0	1.1	0.68
7	26	24	21	17	13	9.2	6.0	3.4	2.0	1.1	0.68
8	26	24	21	17	13	9.1	6.0	3.4	1.9	1.1	0.68
9	26	24	21	17	13	9.0	5.9	3.4	1.9	1.1	0.68
10	25	23	21	17	13	8.9	5.9	3.3	1.9	1.1	0.68
11	25	23	20	17	13	8.9	5.8	3.3	1.9	1.1	0.68
12	25	23	20	17	13	8.8	5.8	3.3	1.9	1.1	0.69
13	25	23	20	16	12	8.7	5.7	3.3	1.9	1.1	0.69
14	25	23	20	16	12	8.7	5.7	3.3	1.9	1.1	0.70
15	24	23	20	16	12	8.6	5.7	3.3	1.9	1.1	0.70
16	24	22	20	16	12	8.6	5.7	3.3	1.9	1.1	0.71
17	24	22	20	16	12	8.5	5.6	3.2	1.9	1.1	0.72
18	24	22	19	16	12	8.5	5.6	3.2	1.9	1.2	0.73
19	24	22	19	16	12	8.5	5.6	3.2	1.9	1.2	0.74
20	24	22	19	16	12	8.5	5.6	3.2	1.9	1.2	0.75
21	22	20	18	15	11	7.9	5.2	3.0	1.8	1.1	0.71
22	21	19	17	14	10	7.3	4.9	2.8	1.7	1.0	0.68
23	19	18	15	13	9.7	6.8	4.5	2.7	1.6	0.98	0.65
24	18	16	14	12	9.0	6.4	4.2	2.5	1.5	0.93	0.62
25	17	15	13	11	8.4	6.0	4.0	2.3	1.4	0.88	0.59
26	16	14	13	10	7.9	5.6	3.7	2.2	1.3	0.84	0.56
27	14	13	12	9.6	7.3	5.2	3.5	2.1	1.2	0.79	0.54
28	13	12	11	9.0	6.9	4.9	3.3	1.9	1.2	0.76	0.52
29	13	12	10	8.4	6.4	4.6	3.1	1.8	1.1	0.72	0.50
30	12	11	10	7.8	6.0	4.3	2.9	1.7	1.1	0.69	0.48

Table 4-6 Total Ammonia (mg/L as N), Warmwater Fisheries:

Acute Standards

Temperature °C	pH										
	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00
0	29	26	23	19	14	10	6.6	3.7	2.1	1.2	0.70
1	28	26	23	19	14	9.9	6.5	3.7	2.1	1.2	0.70
2	28	26	22	18	14	9.7	6.4	3.6	2.1	1.2	0.69
3	28	25	22	18	14	9.6	6.3	3.6	2.0	1.2	0.69
4	27	25	22	18	14	9.5	6.2	3.5	2.0	1.2	0.69
5	27	25	22	18	13	9.4	6.1	3.5	2.0	1.2	0.68
6	27	24	21	18	13	9.3	6.1	3.5	2.0	1.1	0.68
7	26	24	21	17	13	9.2	6.0	3.4	2.0	1.1	0.68
8	26	24	21	17	13	9.1	6.0	3.4	1.9	1.1	0.68
9	26	24	21	17	13	9.0	5.9	3.4	1.9	1.1	0.68
10	25	23	21	17	13	8.9	5.9	3.3	1.9	1.1	0.68
11	25	23	20	17	13	8.9	5.8	3.3	1.9	1.1	0.68
12	25	23	20	17	13	8.8	5.8	3.3	1.9	1.1	0.69
13	25	23	20	16	12	8.7	5.7	3.3	1.9	1.1	0.69
14	25	23	20	16	12	8.7	5.7	3.3	1.9	1.1	0.70
15	24	23	20	16	12	8.6	5.7	3.3	1.9	1.1	0.70
16	24	22	20	16	12	8.6	5.7	3.3	1.9	1.1	0.71
17	24	22	20	16	12	8.5	5.6	3.2	1.9	1.1	0.72
18	24	22	19	16	12	8.5	5.6	3.2	1.9	1.2	0.73
19	24	22	19	16	12	8.5	5.6	3.2	1.9	1.2	0.74
20	24	22	19	16	12	8.5	5.6	3.2	1.9	1.2	0.75
21	24	22	19	16	12	8.4	5.6	3.2	1.9	1.2	0.77
22	24	22	19	16	12	8.4	5.6	3.3	1.9	1.2	0.78
23	24	22	19	16	12	8.4	5.6	3.3	1.9	1.2	0.80
24	24	22	19	16	12	8.4	5.6	3.3	2.0	1.2	0.81
25	24	22	19	16	12	8.4	5.6	3.3	2.0	1.2	0.83
26	22	20	18	15	11	7.9	5.2	3.1	1.9	1.2	0.80
27	20	19	17	14	10	7.3	4.9	2.9	1.8	1.1	0.76
28	19	18	15	13	9.7	6.9	4.6	2.7	1.7	1.1	0.73
29	18	16	14	12	9.1	6.4	4.3	2.6	1.6	1.0	0.70
30	17	15	13	11	8.5	6.0	4.1	2.4	1.5	0.97	0.68

Calculation of Metal Standards in New Mexico Accounting for Water Hardness

1. Acute Standards.

Dissolved aluminum	750	µg/l
Total mercury	2.4	µg/l
Total recoverable selenium	20.0	µg/l
Dissolved silver	e(1.72[ln(hardness)]-6.52)	µg/l
Dissolved cadmium	e(1.128[ln(hardness)]-3.828)	µg/l
Dissolved copper	e(0.9422[ln(hardness)]-1.464)	µg/l
Dissolved lead	e(1.273[ln(hardness)]-1.46)	µg/l
Dissolved nickel	e(0.8460[ln(hardness)]+3.3612)	µg/l
Dissolved zinc	e(0.8473[ln(hardness)]+0.8604)	µg/l

2. Chronic Standards.

Dissolved aluminum	87.0	µg/l
Total mercury	0.012	µg/l
Total recoverable selenium	2.0	µg/l
Dissolved cadmium	e(0.7852[ln(hardness)]-3.49)	µg/l
Dissolved chromium	e(0.819[ln(hardness)]+1.561)	µg/l
Dissolved copper	e(0.8545[ln(hardness)]+1.465)	µg/l
Dissolved lead	e(1.273[ln(hardness)]-4.705)	µg/l
Dissolved nickel	e(0.846[ln(hardness)]+1.1645)	µg/l
Dissolved zinc	e(0.8473[ln(hardness)]+0.7614)	µg/l

If you want to estimate hardness from your stream based on your conductivity data, multiply your conductivity value by 0.3. Then use the formulas in the table above to estimate the acute standards for dissolved metals.