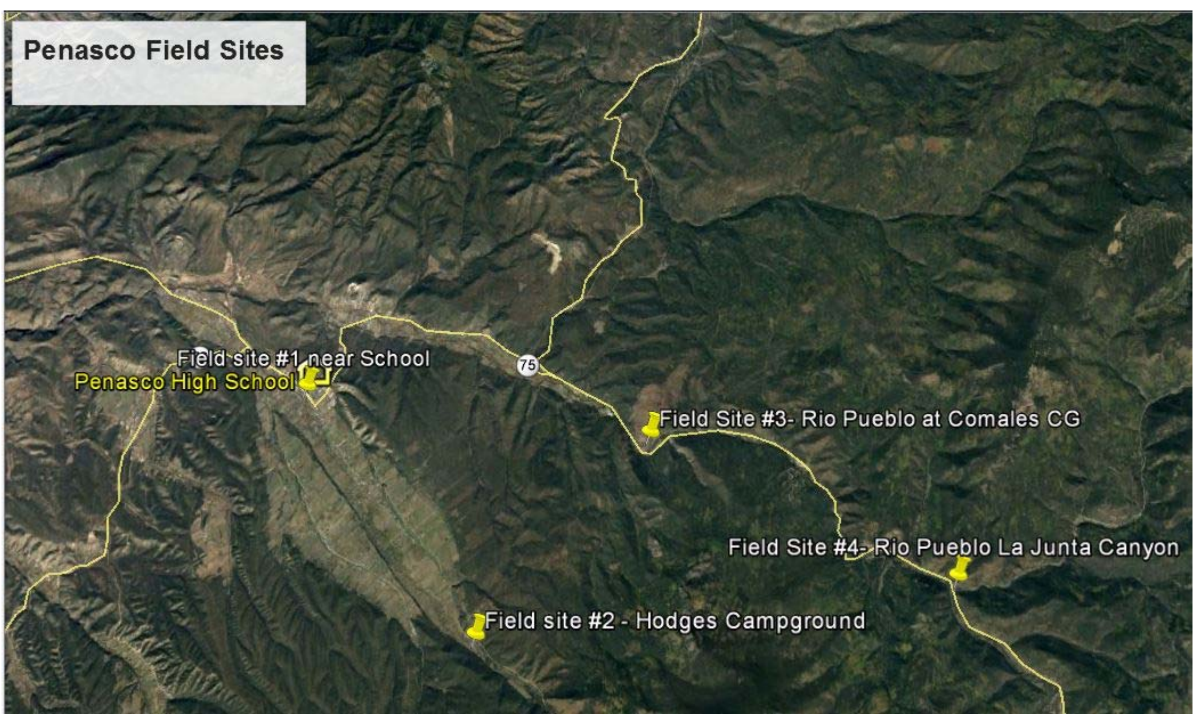
Connecting Youth with Watershed Science and Stewardship in the Headwaters

Final Report to Share with Wildlife, New Mexico Department of Game and Fish

Over the course of the 2016—2017 school year, the Truchas Chapter of Trout Unlimited worked with two teachers at Peñasco High School in the Santa Barbara/Rio Pueblo Watershed to connect youth with the importance of local fisheries, water quality, and protecting wilderness areas. The activities focused on increasing the ability of youth and adults to identify healthy streamside vegetation, understanding why water quality is important for healthy ecosystems, the importance of wetland vegetation for improving water quality and fish habitat, and learning about Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*).

Five field trips provided opportunities for collecting water quality and riparian habitat data, revegetating stream banks, and fishing skills experiences at four locations in the Rio Santa Barbara and Rio Pueblo de Picuris watersheds. Hands-on data collection activities involved measuring turbidity, pH, water temperature, nitrate sampling, reactive phosphorous, total dissolved solids, assessing riparian health, and measuring streamflow. The students also learned about the value of beaver ponds, how to plant willows, and fishing skills. Exposure to local water resources, recreation areas, and fisheries provided students with a broader picture of their local landscape, recreational opportunities, and conservation and resource management techniques. Monitoring at several locations provided students an opportunity to connect with the amazing and diverse resources, lands, and opportunities that are in close proximity to Peñasco High School.

Map 1 shows the four field locations



In-class presentations prepared students for field experiences and helped cement students' understanding about watersheds, watershed science, identification and classification of benthic macroinvertebrates, and how to interpret their water quality and ecological monitoring data. The students also sorted over 500 benthic macroinvertebrates to major groups. Near the end of the school year, River Source assisted the students in turning their water quality data and experiences into information with activities that helped them build graphs, compare their data to water quality standards, and create a presentation.

Truchas Chapter and Enchanted Circle members of Trout Unlimited assisted on several of the field trips. In addition, the Truchas Chapter administered the grant at no charge and provided $4,000 in cash donation to complete the project.

Date	Activity	# students & adults
9/12/2016	3 separate classroom sessions with high school students on watershed health, Rio Grande cutthroat, habitat needs for coldwater fish. Administered pre-test.	45
9/14/2016	Ecological monitoring at Rio Santa Barbara at Hodges on pH, temperature, dissolved oxygen, turbidity, nutrients, riparian area surveys, and sampling benthic macroinvertebrates	26
10/6/2016	2 classroom sessions with middle school students on watershed health, Rio Grande cutthroat, habitat needs for coldwater fish. These classes included water quality monitoring on the nearby acequia.	30
10/10/2016	Ecological monitoring at Rio Pueblo below Comales Campground with high schools students	15
10/24/2016	Ecological monitoring at Rio Santa Barbara with middle school students	35
11/16/2016	Ecological monitoring at Rio Santa Barbara Ditch by school plus benthic insect identification and sorting with 3 separate classes	15
11/19/2016	Additional benthic insect sorting lab plus water quality sampling in acequia	26
3/30/17	Ecological monitoring at Rio Santa Barbara at Hodges and at Rio Pueblo above La Junta Canyon and fishing day and willow planting	23/18 kids fishing
4/3/17	Data to information graphing, mapping, and developing presentations	15
4/8/17	Trout Unlimited Banquet where students presented to attendees	4

The fishing day on March 30 enabled 18 students to fish with one student successfully catching and releasing a fish. The students had a busy day that included conducted water chemistry sampling at two sites and planting willows. The full day allowed students to get a better understanding of aquatic and riparian systems and grasp the interconnectedness and interdependence of water quality, habitat, fisheries, and conservation.

Photos in attachment 1 show activities that the students engaged in. Please let River Source know if additional photos or digital copies are desired; these can be provided on CD.

The Truchas Chapter utilized River Source and its three staff to implement the program with the teachers and students. River Source also wrote a curriculum to utilize for the program (see attachment 2).

Pre-post test assessment of student learning

At the beginning of the year, students were given an assessment to test their current knowledge and understanding of ecological principles, local water resources, and the significance of water quality measurements and relationship to ecosystem health. In the pre-assessment, students scored an average of 29 percent of the answers correct.

At the end of the school year, students were given the same test to measure the change in their understanding and knowledge gained through the classroom sessions and field trips. The average score on the post-test was 82 percent, a 130% improvement. Areas where students showed a significant improvement were in the meaning, interpretation, and importance of ecological monitoring methods and techniques. In the post-test, ***all*** students provided meaningful examples of what they can do next to streams to improve water quality.

	Score 0-2		
Questions on pre-post test	**Before program**	**After program**	**% Change**
What is a watershed?	0.63	1.23	95%
Name two types of measurements and how they can be used to assess the health of a river/stream?	0.58	1.62	179%
How does water temperature affect the amount of oxygen in water and aquatic life?	0.32	1.62	412%
What gets collected with a kicknet? What does this tool help us learn about the stream?	0.58	1.31	126%
Name two benthic macroinvertebrate insects that you are likely to find in a New Mexico stream.	0.89	1.85	106%
Provide an example of something you can you do to ensure continued health of your local watershed.	0.83	1.50	80%
What is turbidity and why is it important to fish?	0.11	1.62	1435%
Why is streamside vegetation important to the health of fish and other aquatic organisms?	0.74	1.77	140%
What is the name of the fish that is the state fish of New Mexico?	0.53	1.92	265%
Provide an example of what you can do next to streams to protect water quality.	0.68	2.00	192%
average score out of 20 total	5.84	16.31	179%
Percent of total correct	29%	82%	

The commitment of the teachers and staff at Peñasco High School enabled River Source to have a great impact on student understanding of, and relationships, with their local lands, conservation efforts, and community resources. Both teachers said they are excited about continuing the program with new students next year.

Attachment 1: Photos of Student Activities

Photos Clockwise from upper left): Students measure streamflow. Students casting. Successful Peñasco student with catch of the day. Students present at Truchas Chapter Banquet. Students sort and identify benthic macroinvertebrates.

Truchas Chapter of TROUT UNLIMITED
CURRICULUM CONTENTS

Overview sheet

Curriculum

- In class presentation - slides
- Rio Grande Cutthroat Trout handout
- Laminated field cards – PDF version
- Field chemistry sheets
- Benthic lab
- Data to information sheets

Attachments

Curriculum alignment with Next Generation Science Standards

Pre- and post- test

Results of pre-test

CURRICULUM OVERVIEW

CLASSROOM PRESENTATIONS

Students participate in a presentation on river ecology, water chemistry measurements, fish habitat, natural history of the Rio Grande Cutthroat trout, and a description of the field trip which is the next activity. We provide a pre-test to assess student's level of understanding of the key themes and topics that will be presented. Important outcomes include making sure the students will come prepared for the field trip and familiarizing students with water quality equipment and Rio Grande Cutthroat Trout ecology.

FIELD TRIPS

Students participate in hands on trout ecology fishing experience at a local river or lake. The students participate in three activities throughout the field trip including: measuring streamflow, taking water chemistry measurements, and benthic macro-invertebrate collection and identification. The benthic macro-invertebrates will be used for an in-classroom benthic lab and water chemistry data will be used during the data to information and presentations lessons and activities.

BENTHIC LAB

Students sort, identify, and record benthic macro-invertebrates that were collected and preserved from the field trips. Students learn how to use a key, how the benthic macro-invertebrates relate to water chemistry, and how to calculate biodiversity indices.

HANDS-ON TROUT ECOLOGY & FISHING DAY

Students learn the importance of habitat, water quality, and fishing skills and how they relate to fishing in New Mexico and their region. During the day students are active in four stations including: learning how to fish, measuring and calculating streamflow, collecting and identifying benthic macro-invertebrates, and learning how to cast a fly wheel.

DATA TO INFORMATION

Over two classroom sessions students will learn methods to analyze scientific data including graphing and reporting in poster format and PowerPoint. Students will use data collected during field trips and the hands on trout ecology fishing day in addition to historic information to develop hypotheses, identify and investigate trends, and draw conclusions.

STUDENT PRESENTATIONS

Students will present their findings from the data to information lessons.

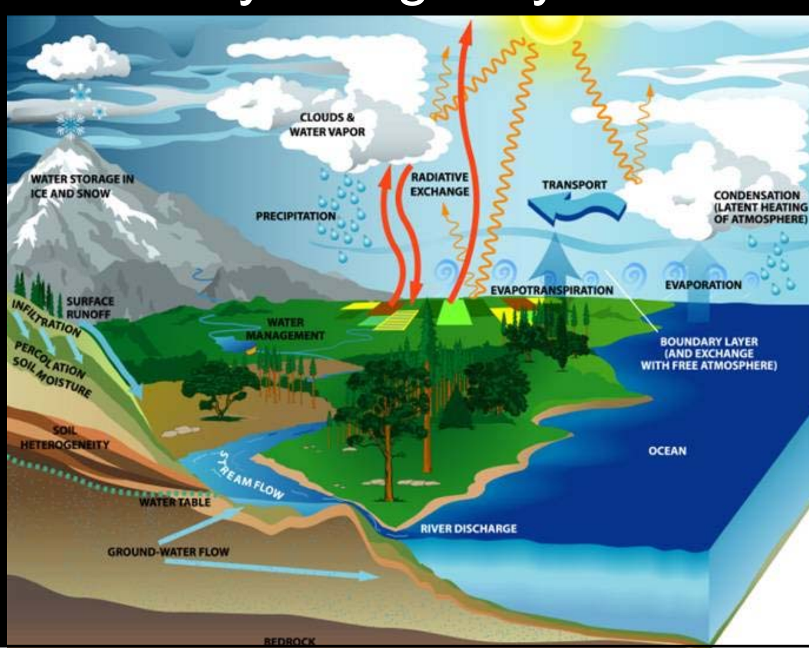
New Mexico Watershed Watch

Classroom Presentation

Peñasco Science

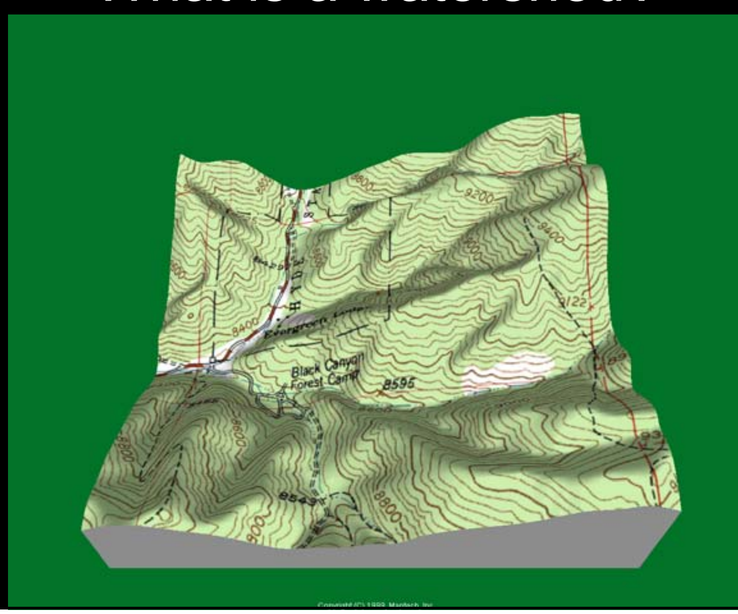
This project funded by the Truchas Chapter of Trout Unlimited and NM Department of Game & Fish

Hydrologic Cycle

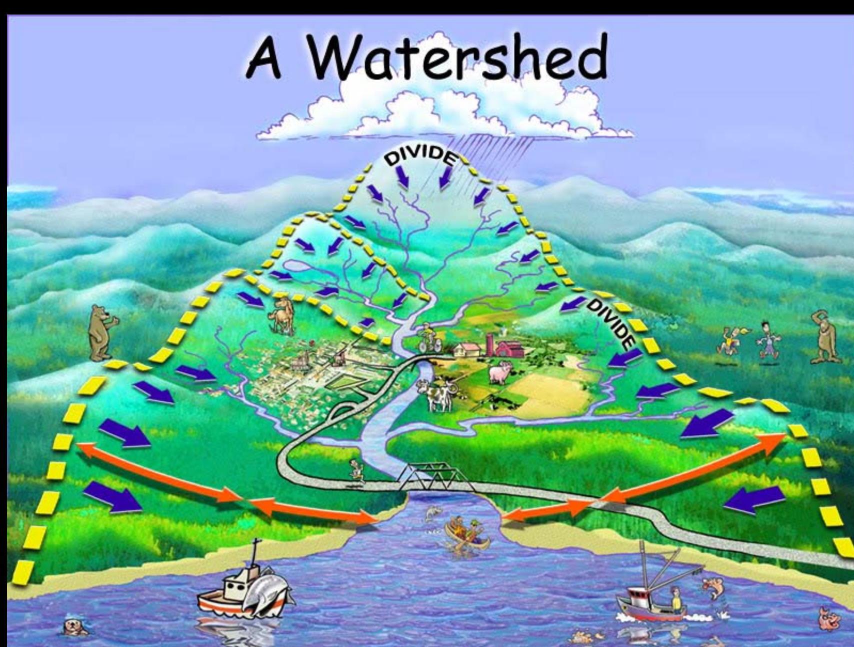


What is a watershed?

What is a watershed?



What is a watershed?



What is your watershed address?

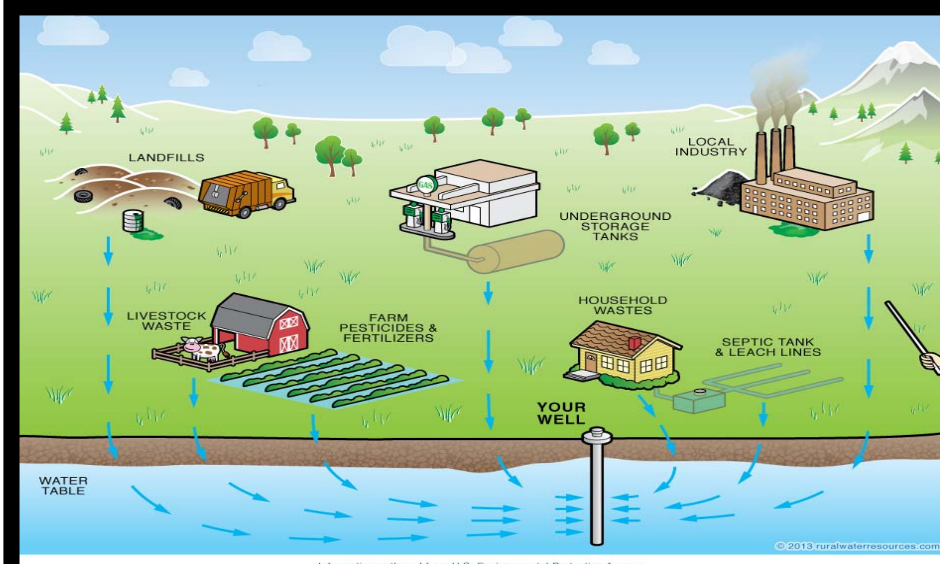
What types of connections exist within watersheds?

- Community settlement often near water sources
- Surface water and groundwater
- What people do upstream affects people downstream
- Rivers change naturally from upstream to downstream

Surface Water and Groundwater Connections

- Septic tanks can pollute groundwater
- Over-pumping from wells can diminish water in streams

Land Uses and Sources of Pollution



How might upstream users impact downstream users?



How might upstream users impact downstream users?



Las Conchas Fire – New Mexico 2011

High Intensity Forest Fire

Dramatic Water Quality Effects

Post-fire Summer Monsoon Flows

Flood Effects on River Water

Component	Normal	Floodwater
Tot. Susp. Solids (mg/L)	4	10,900
Conductivity (umhos)	72	352
Phosphorus (mg/L)	< 0.3	13
Total Nitrogen (mg/L)	< 0.3	23
Ammonia (mg/L)	< 0.1	1.65

Severe Erosion and Fish Kills

Indios Creek – July 29, 2011

Post-flood Fish Kills

Turning lemons into lemonade – Fire effects on New Mexico's water supply.

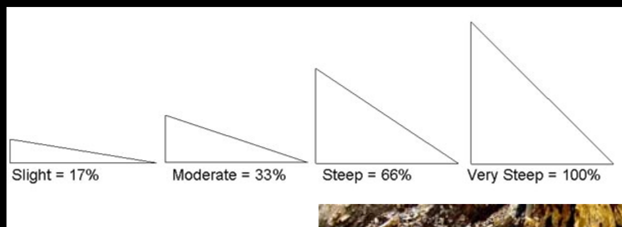
Rivers Change Naturally

River Continuum Concept – rivers change from upstream to downstream

Energy sources, types of plants and animals, shapes of river channel and the kinds of geologic materials you'll find

Seasons & Storms – how rivers change during the day, during the different seasons, and during storm events

Limits based on basic science *like steep slopes*



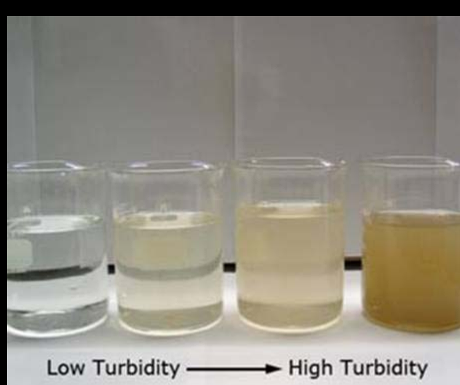
Watershed Management

- How do we assess and learn what is happening in our watershed?
  – How do we test if the watershed is healthy?

Chemistry

- Turbidity
- Temperature
- pH
- Total Dissolved Solids (TDS)
- Nutrients (Nitrogen and Phosphorus)

Turbidity



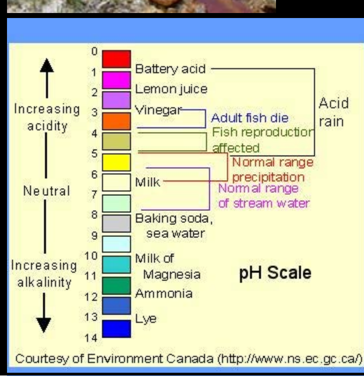
- Measurement of how clear or cloudy water is depending on suspended solids.
  - How much light is able to pass through?

Temperature

- Why is water temperature important to fish or other aquatic life?

pH

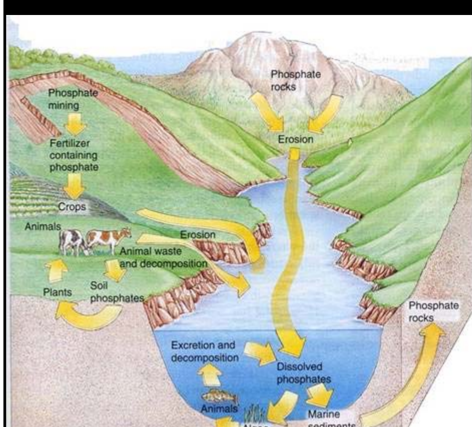
- Acidic vs basic
- Pure water = pH of 7.0
- Rainwater = pH of 5.6
- pH of 6.6 to 8.8 is optimal for most species



Total Dissolved Solids (TDS)

- Inorganic salts (calcium, magnesium, bicarbonates, etc)
- Organic matter
- Hard vs Soft water
- We measure TDS by looking at how water *conducts* electricity

Nutrients



- Nitrogen
- Phosphorus

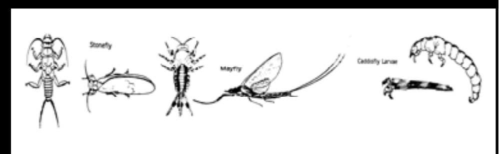
- *Too much* nutrients cause algae blooms
- When the algae die, oxygen gets *too low* for fish

Biology

- Benthic macro-invertebrates
- Vegetation diversity
- Vegetation buffer width

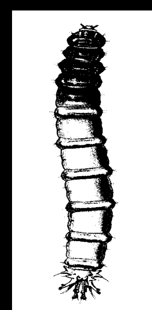
Benthic Macro-invertebrates (water insects)

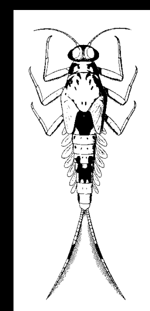
- Benthic = "bottom dwelling"
- Invertebrate = "without a spine"



- Some water insects are *very sensitive*, they can't handle pollution

they tell us if the water has been clean





Vegetation Diversity and Buffer Width

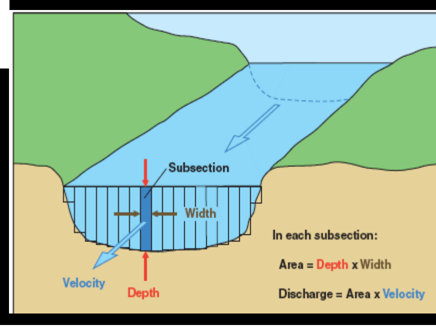
- Shading
- Filtration of erosion and other pollutants
- Bank stabilization
- Improved habitat

Physical

- Stream-flow/Discharge
- Distance of river to nearest disturbance
- Rock embeddedness

Stream-flow

- How much water (volume) is passing a point in time.
  - Cubic feet/sec; Cubic meters/sec



Be Prepared for Monitoring on the Rio Santa Barbara @ Hodges

- Warm clothing
- Good shoes
- Water bottle
- Hat
- Ready to have fun

Have fun & be safe!

Watershed & Environmental Science

- We are all connected!!!
- We can manage ourselves, how we use land, and forests to improve the security of our water for people and wildlife.
- Lots of fun, outdoor work, and jobs in watershed science!

Stay connected! www.riversource.net

Rio Grande Cutthroat Trout

Fast Facts

-The Rio Grande Cutthroat trout is the state fish of New Mexico.
-They have a yellowish green-gray to gray body with scattered black spots and densely spotted tail
-Adults grow up to 12-13 inches long.
-The fish is popular with the sport fishing community but requires special conservation practices in specified location such as "catch & release" practices.
-It is the only native cutthroat trout native to New Mexico.

-The fish is found in less than 7-10% of its historic range because of habitat degradation, predation from other fish such as German brown trout, and interbreeding with other fish such as Rainbow trout.

-They feed opportunistically on aquatic insects and terrestrial insects that fall into the water.

-With a New Mexico fishing license, you can catch 2 cutthroat per day except in specially designated waters.

Habitat and Range

Example of good habitat

-Habitat: The fish prefer clear, streams and lakes, a silt-free rocky substrate (streambed) in riffle-run areas. They require areas of slow, deep water; well vegetated stream banks; abundant in-stream cover, and relatively stable water flow and temperature regimes. Gravel substrates are required for spawning.
-Current Range: the Rio Santa Barbara has wild populations of Rio Grande Cutthroat trout on the upper forks of the river. Brown trout and some cutthroat trout can be found on lower portions of the Rio Santa Barbara.
-Historic Range: The Rio Grande Cutthroat Trout occupies all cool waters in the Rio Grande watershed, including the Chama, Jemez, and Rio San Jose drainages, and suitable waters of the Pecos and Canadian drainages.

Threats to population

- Non-native invasive species.
  - The Rio Grande Cutthroat trout can hybridize with non-native Rainbow trout. This depletes the gene pool and weakening the population.
  - Non-native German brown trout are piscivorous (they eat other fish), including our native cutthroat trout
- Whirling disease
  - This is a disease caused by a parasite that attacks spinal cartilage of trout and salmon. It affects fish's ability to swim, and as a result eat.
- Wildfires and debris flows
  - Debris flows from wildfires, increased stream temperature, and flooding threatens the fish's habitat.

Water Quality Monitoring Methods
New Mexico Watershed Watch

How to test 6 water measurements for Healthy Watersheds, Fisheries & Resilient Communities.

1. Streamflow
2. Temperature
3. pH
4. Total Dissolved Solids
5. Turbidity
6. Dissolved oxygen

For more information visit www.RiverSource.net
and
http://www.wildlife.state.nm.us/education

The following 13 pages are designed to be laminated into cards for field work

Streamflow or Discharge

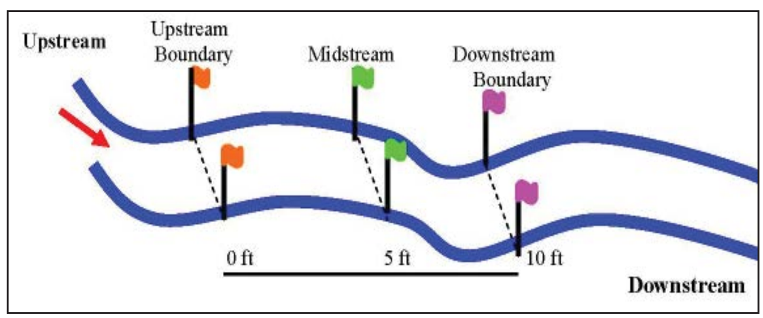
Streamflow is a measure of how much volume of water is passing by a point every second. Your results are recorded in cubic feet per second (CFS).

Streamflow or discharge of a river can fluctuate depending on:

- Season ~ extra runoff with snowmelt during the spring, less during the summer with increased evaporation and plant use
- Weather ~ streamflow increases during rainstorms, decreases during drought
- Irrigation ~ less streamflow during irrigation season for crops or fields
- Disturbances to the landscape ~ parking lots, roads, and other impervious surfaces create more peak runoff

Materials needed to measure streamflow include:

1. Tape measure
2. Yard stick
3. Stopwatch
4. Orange or piece of citrus (preferred) or a small but easy to identify floating object
5. 6 flags or sticks to mark channel banks
6. Calculator



To estimate streamflow (make sure to use a Watershed Watch field form):

1. Measure a 10ft straight section of stream with flags placed at the upstream (0ft), middle (5ft), and downstream end (10ft). The length can be adjusted for smaller or larger streams.
2. Measure the stream width (W) perpendicular the flags (upstream, middle, and bottom) and average your 3 measurements.
3. Measure the depth (D) at equal intervals across the channel along the width transects that appears the most typical of the 10 foot length of stream. Take a minimum of 9 measurements of depth and then average your results.
4. Multiply average stream width (W) times the average stream depth (D) to get a cross-sectional area in ft^2 (A=WxD).
5. Measure velocity by droppng your floating object upstream of the top flag and timing how long it takes to float 10 feet (or the distance from upstream to the downstream boundaries). Take the measurement a minimum of 3 times in the middle and on the sides of the stream. Average your results. Divide 10 feet (or the distance from upstream to the downstream boundaries) by your average time in seconds to get a measurement of velocity (V in feet per second).
6. Multiply your cross-sectional area (A) times your average velocity (V) to get streamflow in CFS

If the stream channel bottom is rough (e.g. lots of cobble or gravel) multiply your answer by 0.8. If the channel bottom is smooth (e.g. sandy or bedrock), multiply your answer by 0.9. These factors reduce your initial streamflow measurement to compensate for the velocity of the stream running slower than on the top of the stream where you took your veleocity measurements.

Standards and Methods for Interpreting Streamflow:

For mountain streams Barbour and Stribling (1991) consider that 2 cfs are necessary to support a high-quality, coldwater fishery.

Temperature

Temperature is a measure of water warmth or coldness. We record our results in degrees Celsius. Fish and other aquatic organisms have trouble getting enough oxygen at very warm temperatures.

Causes of increased temperature in water:

- Removal of riparian shade provided by trees, shrubs and grasses (such a willow canopy)
- Urban runoff from hot streets and sidewalks
- Increased turbidity (particles in water absorb sunlight and heats water)
- Warmer seasons (summer vs. winter) or lower elevations where it tends to be warmer
- Increased water surface area (e.g. wide and flat stream channel)
- Industries discharging warm water used to cool machinery

Why do we care about water temperature of our streams?

- Amount of dissolved oxygen in water (warm water holds less oxygen than cold water)
- The amount of energy used by (metabolism) of aquatic organisms
- Vulnerability of organisms to pollution, parasites, or disease
- The ability of fish and aquatic organisms to survive. Most fish, frogs, and macroinvertebrates are cold blooded. If the temperature changes rapidly their metabolism does not work well.

Measurement Method

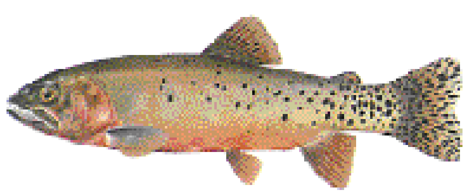
1. Ensure thermometer is functional (i.e. no bubbles separating the color indicator)
2. Find a shady spot to measure (use your own shadow if there isn't any shade)
3. Place thermometer completely in the running water and wait for the temperature to stop changing (at least 1 minute)
4. Read temperature while thermometer is underwater or immediately after taking it out of the water and record on the data sheet. Record temperature in degrees Celsius.

Standards and Methods for Interpreting

The New Mexico Water Quality Standards says " the introduction of heat by other than natural causes shall not increase the temperature, as measured from above the point of introduction, by more than 2.7˚C (5˚F) in a stream, or more than 1.7˚C (3˚F) in a lake or reservoir."

Does the water temperature protect desirable fish? New Mexico Water Quality Standards for Fisheries say that the temperature needs to be lower than:

≤20˚C (68˚ F), max temp 23˚C	High Quality Cold Water Fishery
≤25˚C (77˚ F)	Marginal Cold Water Fishery
≤32.2˚C (90˚ F)	Warm Water Fishery



Rio Grande Cutthroat Trout

pH

pH is a measure of how **acidic** or **basic** the water is. pH is measured on a scale of 0 to 14. Distilled water which has no impurities is **neutral** with a pH of 7. Numbers less than 7 are acidic and above are basic.

Causes of altered pH values in water:

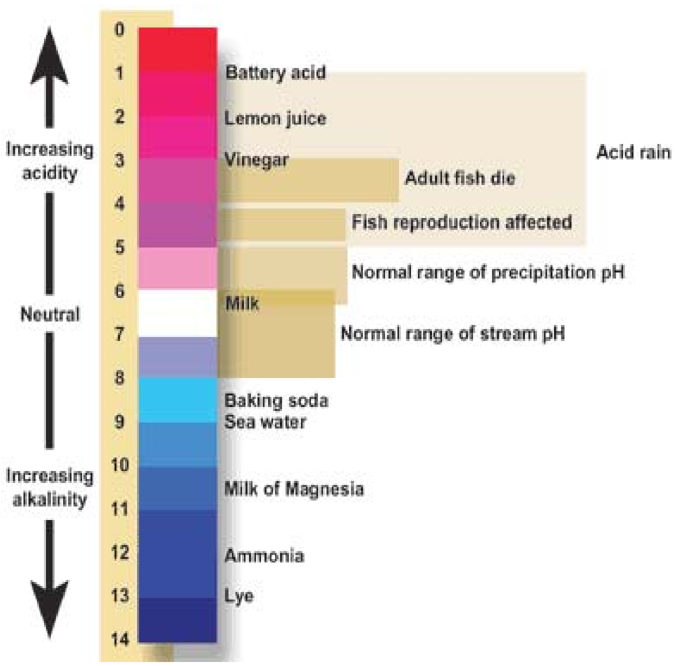
- Rainfall has pH value of around 5 to 6 due to carbonic acid picked up in the air.
- The pH of water in springs, streams, and lakes are influenced by the geology. In New Mexico limestone soils raise pH values of water - many New Mexico streams have basic pH (7 to 8.8).
- Plant photosynthesis removes carbon dioxide from water, raising pH of your stream. Expect the highest pH to occur in the early afternoon when the sun is highest.
- Mining exposes rocks to rain and produce a change in pH, often making the water more acidic.
- Dumping pollutants directly into streams can have intense and immediate changes in pH.
- "Acid rain" comes from sulfuric acid produced by coal burning. The basic soils of New Mexico help to decrease the effects of acid rain.

Why do we care about pH of our streams?

- Water with extremely high or low pH is deadly. A pH below 4 will kill most fish and very few animals can tolerate waters below pH of 3.
- Even moderately acidic waters (low pH) reduces the hatching success of fish eggs, irritate fish and aquatic insect gills and damage membranes.
- Amphibians are particularly vulnerable because their skin is so sensitive to pollution.

Measurement Method

- Make sure the pH meter been rinsed with distilled/demineralized water
- Uncap and turn on pH meter and dip meter in moving water
- Wait for reading to stabilize (wait at least one minute)
- Read and record pH measurement while meter is held in water
- Rinse the pH meter in distilled/demineralized water before capping



Standards and Methods for Interpreting

- The allowable range of pH is 6.6 to 8.8 in most streams in New Mexico. Some streams are allowed to range as high as 9.0.

- Water becomes unsuitable for most organisms at extremes less than 4.1 or greater than 9.5

Total Dissolved Solids (TDS)

TDS is a measure of dissolved (molecular, ionized, or micro-granular) inorganic and organic substances contained in a liquid. We use conductivity to estimate TDS, using an electrical current since the higher the concentration of dissolved ionized solids, the more electricity is conducted.

Causes of altered TDS values in water:

- Naturally occurring minerals such as calcium, magnesium, sodium, and other salts,
- Higher concentrations of TDS may come from runoff from agriculture or residential areas. Flood irrigation can flush salts from farm fields. Stormwater from city roads can wash salts into rivers.
- Nutrients from fertilizers can add excessive nitrate and phosphates to streams from runoff.

Why do we care about TDS in our streams?

- Rapid increases in TDS levels can be toxic for some aquatic organisms.
- Spawning fishes and juveniles appear to be more sensitive to high TDS levels.
- People prefer to drink and bathe in water with TDS levels lower than 500 mg/L.

Measurement Methods

- Ensure the TDS meter is calibrated and has been rinsed with distilled/demineralized water.
- Uncap and turn on the TDS meter.
- Dip the meter in moving or non-stagnant water.
- Wait for reading to stabilize (wait at least one minute).
- Read the TDS measurement while meter is held in water and record the result in mg/L.
- Rinse the conductivity meter in distilled/demineralized water before capping and storing in it's box.

Standards and Methods for Interpreting

- The standard for human drinking water is 500 mg/l which is an aesthetic standard (based on how salty the water tastes).
- There are standards for specific river segments in New Mexico based on the state water quality standards.
- Some species of fish have been shown to have impaired spawning at levels as low as 350 mg/L.

Turbidity

Turbidity is a measure of water transparency (i.e. water clarity or cloudiness).

Causes of Turbidity:

- Sediment from soil erosion that enters the stream and creates suspended particles.
- Algae growth, particularly in larger rivers that are wider, slower and more exposed to the sun.
- Forest fires, roads, or anything that removes plants that can help keep soil out of the stream.
- Good vegetation cover in the riparian areas near streams generally decreases turbidity.
- Pollutants from urban runoff such as oil and grease or nutrients (plant food) that increase algae.

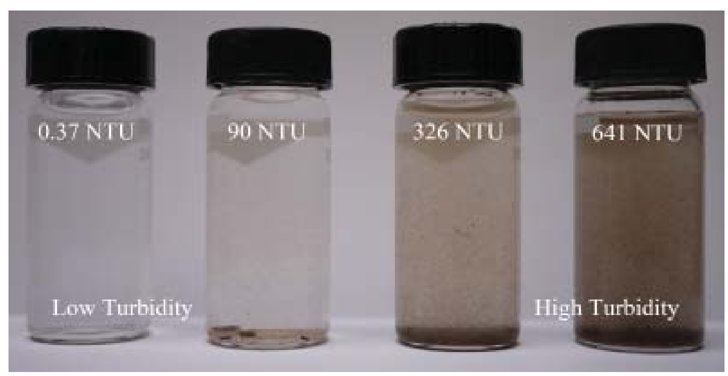
Why do we care about turbidity in our streams?

- Turbidity can raise the water temperature because suspended sediment absorbs heat.
- Suspended particles absorb sunlight which prevents aquatic plants from growing on the stream bottom.
- Sediments can clog fish gills and reduce visibility for fish to see prey and predators.
- Settling of sediment can bury organisms and spawning beds (areas where fish lay eggs).

Turbidity from a storm event

Measurement Methods

- Ensure turbidimeter is turned on and reads “0.00 NTU” (Nephelometric Turbidity Units)
- Take a clean vial and submerge in the water in a location that is near the middle of the stream 2 times and empty the bottle. On the third time take the sample that you'll measure.
- Make sure you collect your sample upstream of where people are walking in the stream and do not disturb site around sample site as this leads to higher measurement than actually exists.
- Seal sample, hold it by the lid, and gently wipe off glass with a soft cloth (remove water, fingerprints, oils, dirt)
- Open turbidimeter lid and place vial in carriage with diamond on vial facing towards turbidimeter buttons
- Close lid, press “Read,” and wait until turbidimeter provides a response
- Record number of NTUs, remove vial, pour out the sample, and repeat process 2 more times to get an average
- Rinse out the vial with distilled/demineralized water to remove sediment particles and make the vial ready for the next time it gets used



Standards and Methods for Interpreting

- Drinking water 0.5 NTU
- Activities shall not cause turbidity to increase more than 10 NTU over background turbidity (measured at a point immediately upstream of the activity) when the turbidity is 50 NTU or less.

Dissolved Oxygen

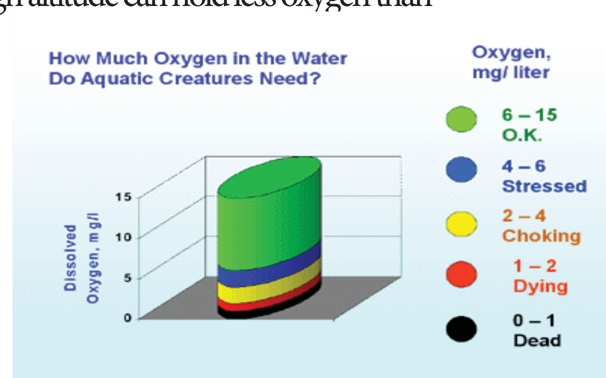
Dissolved Oxygen is a measure of gaseous oxygen in water that helps aquatic organisms survive.

Importance of Dissolved Oxygen (DO):

- Temperature Aquatic organisms require oxygen for survival. Changes in DO can impact organisms ability to grow and develop.

Factors Influencing Dissolved Oxygen

- Temperature--As temperature increases, the ability of water to hold oxygen is diminished (e.g. imagine a pot of boiling water, just before it starts to boil the tiny bubbles which form are oxygen coming out of solution). Vegetation shading a stream will help maintain healthly oxygen levels.
- Pressure--As air pressure increases the pressure of oxygen increases so water exposed to that air can absorb more oxygen. Thus water at high altitude can hold less oxygen than water of a similar temperature at sea level



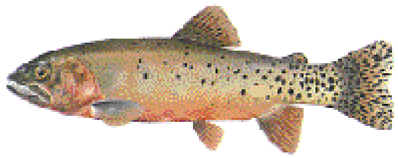
Measurement Methods

- Fill water sampling bottle to allow no air bubbles as they will give incorrect results.
- Add eight drops each of Manganous Sulfate Solution and Alkaline Potassium Iodide Azide to sample bottle, cap and gently mix.
- Allow precipitate to settle then add eight drops of Sulfuric Acid or one level 1g spoonfull of Sulfamic Acid Powder depending on which kit type you have. At this point the sample has been fixed and exposure to air will not affect the results.
- Cap and mix until reagent and precipitate dissolve.
- Fill test tube with 20mL of sample.
- Add eight drops of Starch Indicator.
- Fill Titrator with Sodium Thiosulfate.
- Slowly add Sodium Thiosulfate to test tube one drop at a time while gently swirling until blue color just disappears (Care should be taken to prevent adding to much Sodium Thiosulfate)
- Read result on titrator as ppm of Dissolved Oxygen.
- Dispose of the water with reagents in a well-capped bottle labeled "waste water".

Standards and Methods for Interpreting

•DO <2 ppm is fatal to most fish
•DO <3 ppm is stressfull to most fish
•DO above 6 ppm is sufficient for most species

Based on the temperatures and barometric pressures commonly found in New Mexico streams, the saturation point of DO in the water will rarely rise above 10ppm



(Rio Grande Cutthroat Trout)

Watershed & Stream Monitoring

Data Summary Form

New Mexico Watershed Watch –NMDGF

Location
Name ________________________________

____

GPS N______________ W______________

Recorder's Name:______________________
Date ______________________

Time Started__________Finished _______

			Standard								
	Parameter	***Device Calibrated?*** yes/no plus notes, date	High Quality Coldwater Fish (2001)	Human	My Results	Other Group's Results	Other Group's Results	Other Group's Results	Average Results	OK for Fish?	OK for Humans?
1	Streamflow	N/A	None *	None							N/A
2	Water Temp	Y N	< 20° C	None							N/A
3	TDS by conductivity meter **(Please note if results are in mg/L or µs/cm)**	Y N	None	500 ppm						N/A	
4	Turbidity	Y N	10 NTU	0.5 NTU							
5	pH	Y N	6.6 to 8.8								
6	Nitrate {NO_3}	Y N	None	10 mg/l						N/A	
7	Dissolved Oxygen	Y N	6.0 mg/l	None							N/A
8	Total Phosphorus {P} {PO_4^{3-}}	Y N	0.1 mg/l	None							N/A

PLEASE COMPLETE WEATHER INFORMATION ON EACH TRIP

	Precipitation Information	**Current**	**Past 48 hours (circle)**
10	Rain light	Yes No	Yes No Don't know
11	Rain showers	Yes No	Yes No Don't know
12	Rain heavy (thunder/lightning)	Yes No	Yes No Don't know
13	Snow	Yes No	Yes No Don't know

June 2012 by
River Source
for
NMDG&F

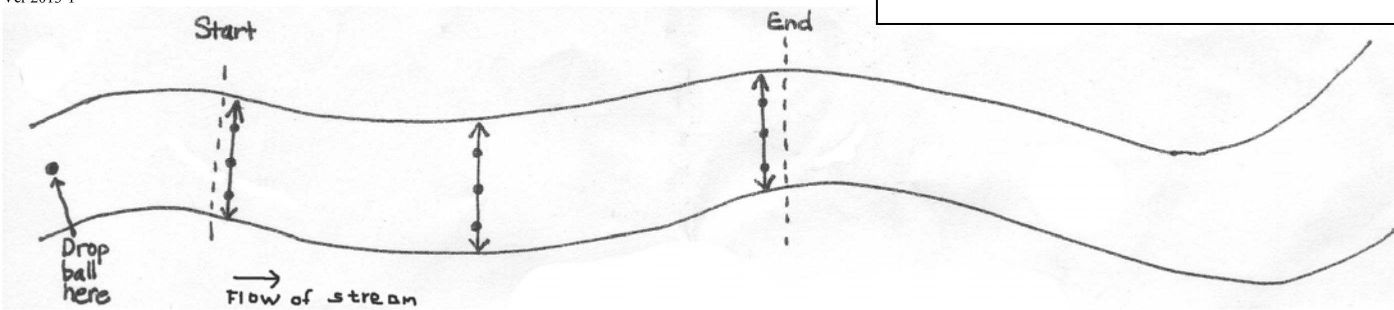
* Although there is no streamflow standard for fish, fish need some water to survive. > 2 cfs is optimal, <0.5 cfs is poor.
** The spectrophotometer may measure Copper in micrograms per liter (µg/L) instead of milligrams per liter (mg/L). Divide µg/L by 1,000 to get mg/L.

Show all units of measurement.

Date:
Location:
Recorder's name:

CALCULATING AND MEASURING STREAM FLOW

Ver 2013-1



Measuring

1. Find a fairly straight stretch of river where the water flows fast and the bottom is relatively flat. Measure a 3-meter section, marking where it begins and ends. Record this as the distance in column A.
2. Drop an object (lime is preferred) in the center of the river at least one meter upstream of the starting point. When the ball reaches the start point, begin timing in seconds. When the ball reaches the end point, stop the timer. Record the amount of seconds in column B. Repeat this step 4-5 more times at different places. (If the ball gets lodged in a rock or stuck in an eddy, begin the trial over.)
3. Measure the width of the river at the start point, at the end point, and at a point midway between the start and end. Record these measurements in column D. (See lines with arrows, above.)
4. Measure the depth of the river 3 times along each width line for a total of nine depth measurements. Record these measurements in column F. (See dots on lines with arrows, above.)

A	B		C	D	E	F			G
Distance (meters or feet)	Time (sec.)		Average Time (sec.)	Width of River at 3 points	Average Width of River	Depth of River at 9 points			Average Depth of River

Calculating

5. Calculate the averages for columns B, D and F and record the averages in columns C, E and G.
6. Now, divide the distance (column A) by the average time (column C) to obtain the velocity. Record this number in the equation below.
7. Multiply the average width (column E) by the average depth (column G) to obtain the area. Record this number in the equation below.
8. Multiply the velocity by the area to obtain the streamflow and record that in the equation below.

________________ x ________________ = ________________

velocity — area — streamflow

9. To calculate the final adjusted streamflow, you must multiply your result by a factor which takes into consideration the uneven surface bottom of your river or stream. For streams with rocky bottoms use a factor of 0.8, but for smooth bottomed streams, use a factor of 0.9.

________________ x ________________ = ________________

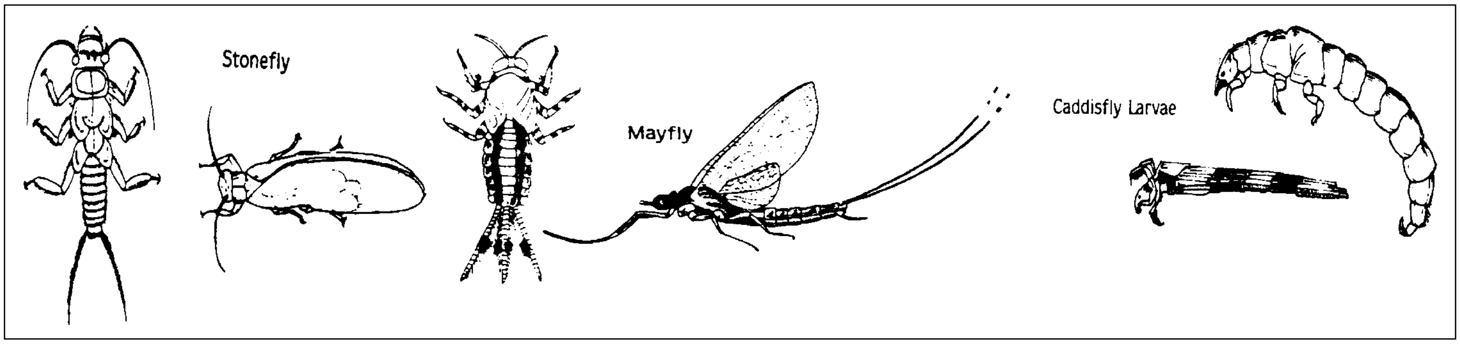
streamflow from — factor of 0.9 or 0.8 — Final Adjusted Streamflow

Fun Hands-on Science Education Doing.....
Benthic Macroinvertebrate Studies!!!

Getting to know the local benthic macroinvertebrates in your river is fun and a great way to learn about how healthy your river is. A river is a combination of physical, chemical and biological characteristics. Many chemical characteristics change overtime, sometimes very rapidly to natural and human-caused changes and still have very little cumulative effect on living organisms in rivers. Benthic and riparian area studies help us understand how aquatic communities respond to stress integrated over time whereas to chemical monitoring focuses on the stress and exposure characteristics of pollution. The aquatic insects may tell us more about the condition of rivers and streams than conventional chemical monitoring techniques. Studying river insects and riparian habitat tells us about changes that streamflow and chemistry monitoring may miss.

The health and integrity of the ecological community of insects can occur only when chemical, physical and biological **stressors** are negligible or minor. For instance, river insects that have preferred environmental conditions, such as stoneflies (Order: Plecoptera) that like cool, clear water with lots of oxygen, often disappear from the river community when urban development increases rapid water runoff and decreases water quality. For example, watersheds with historic and current overgrazing or urban areas with over 25% of impervious surface tend to have benthic communities that are less diverse and more dominated by pollution-tolerant insects than watersheds that are less disturbed by human communities (May et.al. 2000). The focus on benthic macrointebrates helps evaluate the chemical, physical, and biological characteristics and their cumulative effects in the health of many riparian-dependent organisms that need wet areas to survive.

The word “benthic” means bottom dwelling and refers to organisms that live on the bottom (substrate) of a river, stream or lake. The term “macroinvertebrate” means the organisms without a spine (invertebrate) that can be seen without the aid of a microscope or can be seen by the unaided eye.



Since aquatic insects provide great long-term markers / **indicators** of stream and watershed health you can use these activities to do your own investigations about river health. What kinds of questions do you have about your rivers health and how can studying benthic macroinvertebrates help you read the landscape and tell a story the health of your river?

River characteristics that affect benthic macroinvertebrate communities

This section briefly presents the physical, chemical, and biological characteristics of the river ecosystem and describes how these change upstream to downstream

1. Physical Characteristics

Elevation: The height above sea level impacts how far the river drops from source to mouth. This affects a number of characteristics such as gradient, temperature, and shading.

Gradient: The slope of the river determines the current velocity and bottom composition.

Flow: The amount of water in the river determines the amount of bottom covered by water. In New Mexico, drought and irrigation diversions can severely impact the benthic community and water quality of rivers by constraining the insects to stagnant pools or completely removing their habitat when rivers are dewatered.

Water clarity: The clarity or turbidity of the water affects the depths to which light can penetrate and stimulate biological activity. This is usually the result of road building and sediment being deposited in the stream.

Shading: The shade provided by trees, shrubs, and banks helps moderate stream temperatures in the summer and provides food for stream animals.

Temperature: Some macroinvertebrates and fish are very sensitive to temperature levels and fluctuations. It also affects the amount of oxygen that water can hold (cold water can hold more oxygen than warm water) and that is available to macroinvertebrates and fish.

Percent of area of impervious surface and disturbed soil and plant communities: Studies have shown that as the total impervious area in a watershed exceeds as little as 5%, the benthic and macroinvertebrate communities begin to degrade rapidly (May et.al, 2000). Large fires or extensive overgrazing can severely alter runoff quantity and quality and flow patterns, which can have negative effects on macroinvertebrate communities.

2. Chemical Characteristics

Nutrients (phosphorus and nitrogen): Phosphorus and nitrogen are essential plant and animal nutrients that, in excess amounts, can cause rapid increases in biological activity of plants and bacteria and in high enough amounts may become toxic. Excessive amounts of plants reduce the amount of habitat available to some macroinvertebrates, fish eggs and fish. This may disrupt the stream ecology so that certain biological communities experience severe mortality.

Dissolved oxygen (DO): Water contains oxygen in dissolved form. Oxygen is added to the water through turbulence, gas exchange at the water's surface, and as a by-product of plant photosynthesis. Oxygen gets removed from water by chemical oxidation, respiration of aquatic animals, and decomposition. Some aquatic life require high and stable levels in order to flourish.

3. Biological Characteristics

In-stream (autochthonous) versus Riparian (allocthonous) food production: This characteristic is the amount of living plant material produced in-stream versus that which drops in from the area along the stream. In-stream production depends on the availability of sunlight and the availability of nutrients. Some food types produced in the stream, like algae, are important food and habitat sources for some macroinvertebrates.

Behaviors and adaptations of invertebrates

Habitat
Refers to the place where an organism naturally lives and grows. Effected by the chemical and physical factors of a system, but organic substrates such as plants, logs, or detritus can be important biological components of habitat, running vs standing water, substrate size

Movement
Most freshwater invertebrates have special body shapes and behaviors that enable them to be in a place that meets their essential requirements for acquiring food and oxygen, avoiding competition with other invertebrates and hiding from predators. The major groups are clingers, climbers, crawlers, sprawlers, burrowers, swimmers, skaters.

Feeding invertebrate feeding is usually categorized according to the type of food that is consumed or how food is obtained. Typical foods for freshwater invertebrates are detritus, wood algae, live vascular plants, and other animals. Invertebrates are categorized but their body structure and behavioral habit they use to obtain their food. These categories are called functional feeding groups that include shedders, collectors, scrapers, piercers, engulfer-predators.

Breathing- Most kind of Fresh water invertebrates depend upon dissolved oxygen in the water for their breathing. Oxygen enters the organisms either thought their general body surface or through gills that are specialized for this purpose or both. These are referred to as closed breathing systems. Some invertebrate wiggle their bodies to increase oxygen diffusion.

Life history- Refers to biological events in an organism's life from birth to death. Reproduction usually involves mating by a male and female. There are also numerous examples of asexual reproduction among freshwater invertebrates. Most invertebrates hatch from eggs and are small immature forms that must undergo growth. These smaller growth forms are called larva, juveniles or, just immature. This is important to remember since most invertebrates will be studied in this larval or immature stage of development. They are only considered adults when they have developed structures and organs required for reproduction and laying eggs.

Stress tolerance- This term refers to the ability of organisms to withstand disturbances in their environment. There are many different types of disturbances that can occur in freshwater environments. Of these many are human caused others are forces of nature. These are often referred to as pollution by where substances or energy released into the environment that bring undesirable change or environmental stresses. Environmental stresses is a broader terms that refers to any action that bring about undesirable change. For the purpose of this lab groups will be rated according to NM Watershed Watch Order Key that rates them as pollution sensitive, somewhat pollution tolerant, or pollution tolerant.

Benthic macroinvertebrate collection and analysis methods

The workbook presents methods of collection and analysis of benthic macroinvertebrate samples.

Collection:
Frame dip-net sampling.

This method allows you to sample in several areas of the stream to create a composite sample that is more representative of the diverse **substrate** habitats than the kicknet sample.

Sorting:
1. Identification, sorting and counting to the taxonomic level of Major Groups which include some groups in Genus, Order and Class. This level of analysis provides a general idea of the richness of biodiversity of the benthic macroinvertebrate community. Key indicator insect groups include stoneflies, mayflies and caddisflies. This level of analysis is most appropriate for younger students and schools short on time in the field and class to identify, sort and count the insects.

Sample collection methods

When to Collect

Collect at least one sample per year during the fall after the summer monsoons have ended. Sample every year at about the same time to do a long-term study. This provides much more valuable information than data from one sample. Fall samples are valuable since they reflect the effects of summer high temperatures (and in some rivers, low flows) that place stress on organisms. If you have time, collect a second sample in the spring just before spring runoff occurs from snowmelt.

Where to sample

Where to sample depends on the purpose of your research. Sample in **riffles** if you want to learn the most information about the insects that have low tolerance to pollution. Over the years most schools and professionals in New Mexico have sampled in riffles. However, to learn about the broad diversity of benthic insects in your stream, you want to sample in a variety of habitats such as slow water areas, small logs, undercut banks, leaves, and in riffles using the dip net method in Collection Level 2.

Collection

Frame dip-net sampling.

This method allows you to create a composite sample from several areas of the stream that is more representative of the diverse **substrate** habitats than the kicknet sample. In addition, little sample gets lost around the sides if care is taken while scraping rocks.

__**Collection Steps**__

Assemble a team of three people, one to hold the kicknet and two to scrape all rocks in a 18 inch x 18 inch square area just upstream of the kicknet bar in the substrate. Make sure to bury the lower edge of the frame well (up to 2 inches once past the cobbles) into the substrate so that no specimens are lost under the net. Have two students turn over each rock in the sample area and then one student kick (more like do the "twist") inside the sample area. Carefully lift the frame and net bag towards the current to prevent sample loss.

Take the net and gently gather the sample in a five gallon paint bucket or white tray by pouring water through the net, gently scraping the net with a wide paint brush and finally picking the net with forceps. Pour the sample from the paint bucket through a sieve bucket lined with 500 µm (micron) net. Once the entire sample is in the sieve bucket, gently scrape the sample with fingers and the brush into a 1 quart Mason jar. Check the sides of the buckets for clinging critters during every transfer step. Remove these with forceps and place them into the sample.

Sample sorting methods in the field and in the classroom/lab

Analysis to the Orders and Classes

This level of analysis provides a general idea of the richness of biodiversity of the benthic macroinvertebrate community. Key indicator insect groups include mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Tricoptera). This level of analysis is most appropriate for younger students and schools short on time in the field and class to identify, sort and count the insects.

Order level analysis can be done in the field or in the classroom. Set students in groups of 2-3 people per workstation. Each work station needs to have the same number of forceps as students, a white tray filled with sample, and labelled petri dishes. The number of labelled petri dishes depends on the time you have to sort the sample and level of detail you expect for the research.

Site Instructions for Field Methods for Macro-invertebrate Collection and Sorting

I. Field Sampling

Choosing a site – This choice depends on the purpose of your study. You will be looking to compare riffle and pool sections of the same reach, to compare riffles and/or pools from different reaches of the same stream, to compare different streams, or to monitor the condition of your stream over time. Fall is the best time to collect samples if collecting on a yearly basis. You and your students should make a plan and consistently follow it.

Macro-invertebrate collection – If you are using a square net try to consistently collect from the same amount of river bottom area each time - 3 samples at a site that in total encompass approximately one square meter. Gently disturb the bottom material with your hands – large rocks with attached organisms should be carefully brushed to dislodge organisms for capture into the net. If performing Field sorting omit Storage handling and labeling instructions, unless sample will be preserved for later lab analysis.

II. Field Sorting

Equipment – magnifying tools, 2 trays, forceps, Petri dishes with names of Major groups, Pipets, 500 micron sieve, identification keys, ethyl and isopropyl alcohol, labels for vials, and much patience. [Vial labels should match sample labels – additionally include organism's identity i.e. mayfly]

First sort – Put entire bolus in a sampling tray. Have students sort through sample tray and pick out as many organisms as they can have them sort into a clean sample tray for easy identification. If the water is too cloudy, re-rinse the material. If there is much debris redistribute the sample into several trays. Retrieving insects is most efficient in a tray with clear water and a relatively white background for good contrast. As you carefully and systematically move bugs and debris from one side of the tray to the other remove each organism. Pay special attention to collect even the tiniest invertebrates, Allow adequate time to perform sorting making sure that at least 100 individuals are sorted. Identify major groups of Invertebrates and sort into corresponding petri dish. Utilize magnifying tool if required to see and identify smaller invertebrates. Record the information collected on recording sheet for analysis.

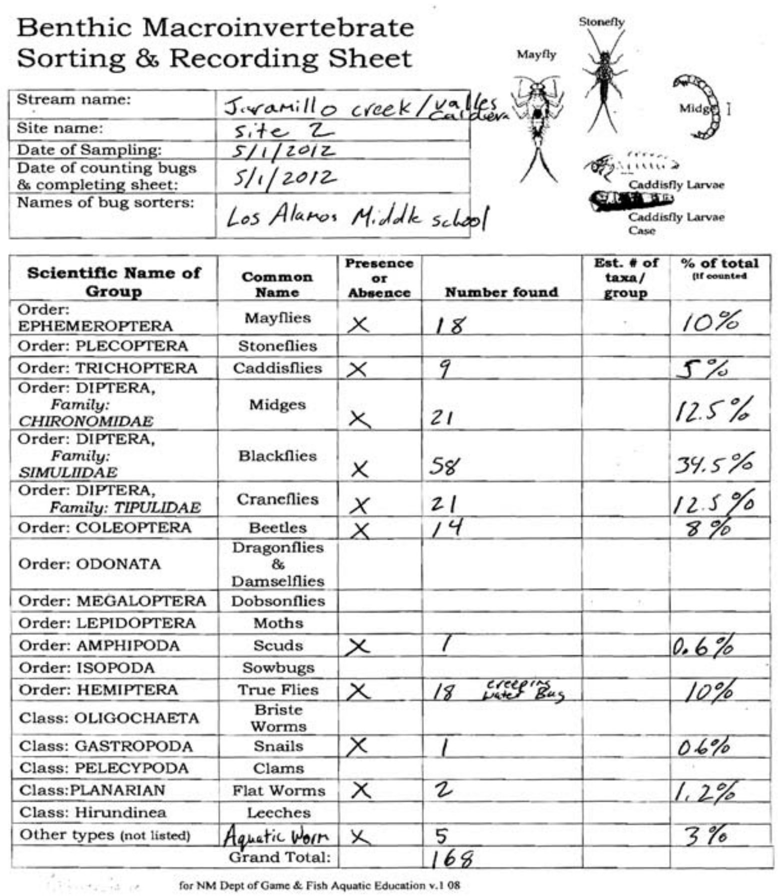
Common group names to label petri dishes

E	P	T	D	C	O
Ephemeroptera	Plecoptera	Trichoptera	Diptera	Chironomidae	Other
Mayfly	*Stonefly*	*Caddisfly*	*True Flies*	*Midge*	*Assorted*

III. Recording field data

Data –After performing identification according to New Mexico Watershed Watch Order key and counting the numbers of individuals in each major group, perform multiple sweeps over the trays to ensure a representative sample has been collected. Have you students determine whether major invertebrates are from Group One Taxa- Pollution sensitive, Group Two Taxa-Somewhat Pollution tolerant, or Group Three Taxa- Pollution tolerant. Compare the numbers of individuals and percentages within each group to determine what is the most dominant group represented at the site. This will give you a rough idea as to the quality of the water. Calculate Water Quality Value According to Watershed Watch group tolerance index score.

I.III Sample Storage



Benthic Macroinvertebrate Sorting & Recording Sheet

Stream name:	Jaramillo creek / Valles Caldera
Site name:	Site 2
Date of Sampling:	5/1/2012
Date of counting bugs & completing sheet:	5/1/2012
Names of bug sorters:	Los Alamos Middle school

Scientific Name of Group	Common Name	Presence or Absence	Number found	Est. # of taxa/ group	% of total (if counted)
Order: EPHEMEROPTERA	Mayflies	X	18		10%
Order: PLECOPTERA	Stoneflies				
Order: TRICHOPTERA	Caddisflies	X	9		5%
Order: DIPTERA, *Family: CHIRONOMIDAE*	Midges	X	21		12.5%
Order: DIPTERA, *Family: SIMULIIDAE*	Blackflies	X	58		34.5%
Order: DIPTERA, *Family: TIPULIDAE*	Craneflies	X	21		12.5%
Order: COLEOPTERA	Beetles	X	14		8%
Order: ODONATA	Dragonflies & Damselflies				
Order: MEGALOPTERA	Dobsonflies				
Order: LEPIDOPTERA	Moths				
Order: AMPHIPODA	Scuds	X	1		0.6%
Order: ISOPODA	Sowbugs				
Order: HEMIPTERA	True Flies	X	18 creeping water Bugs		10%
Class: OLIGOCHAETA	Bristle Worms				
Class: GASTROPODA	Snails	X	1		0.6%
Class: PELECYPODA	Clams				
Class:PLANARIAN	Flat Worms	X	2		1.2%
Class: Hirundinea	Leeches				
Other types (not listed)	Aquatic Worm	X	5		3%
	Grand Total:		168		

for NM Dept of Game & Fish Aquatic Education v.1 08

Storage and handling – Carefully sieve the organisms (and probably debris) from each sampling and place in a 1 quart freezer bag. Try not to include much water. Add 90% ethyl alcohol to cover and preserve the organisms. The three sample bags should be stored together in a 1 gallon freezer bag for that site. Make sure to add enough alcohol to cover entire sample. Recheck, mix, and add additional alcohol to the sample to adequately fix the sample.

Labeling – Put a composite sample in one bag or keep riffle samples separate from multi-habitat samples. Each sample must be properly labeled with a tag inside the bag – remember to use a pencil to ensure the labeling survives the alcohol solution. Each label should record:

River
Location id/ sample #
State
County
Collector
Date

Example

Santa Fe River
La Bajada riffle/ samp 2
New Mexico
Santa Fe County
C Herrera
4 Sept 08

IV. Lab Work

Work on each sample bag separately – the data from all three samples can be combined for analysis.

Equipment – magnifying tools (especially dissecting microscopes), trays, forceps, tiny water color brushes, good lighting, Petri dishes, 500 micron sieve, identification keys, 6 stoppered vials, ethyl and isopropyl alcohol, labels for vials, and much patience. [Vial labels should match sample labels – additionally include organism's identity i.e. mayfly]

First sort – Carefully rinse the contents of a sample in the sieve with cold water to remove the alcohol. Put the organisms and debris in a tray and cover with several centimeters of water. If the water is too cloudy, re-rinse the material. If there is much debris redistribute the sample into several trays. Retrieving insects is most efficient in a tray with clear water and a relatively white background for good contrast. As you carefully and systematically move bugs and debris from one side of the tray to the other remove each organism and place into the appropriate vial. Vials should be designated for each of the six major groups including Mayfly, Stonefly, Caddisfly, True flies, Midges, and Other assorted.

Each vial should be half-filled with ethyl alcohol and when finished insert the appropriate label. Collect all the macro-invertebrates in the sample. If the quantity of certain organisms is exceptionally high you may have to do an appropriate subsampling. Sieve the remaining debris and return to the original freezer bag with label. Re-preserve this with 70% isopropyl alcohol and save.

V. Analysis / Interpretation

Preliminary analysis – At this point you have performed a rough separation into 5 taxa – Ephemeroptera (order level), Plecoptera (order), Trichoptera (order), Diptera (order), and Chironomidae (family level). Count and record the organisms at this level. Notice that taxa refer to two different levels of identification – taxon is flexible term that refers to the level of identification made – for example if you were to further identify mayflies to families you would have additional taxa and not count the order Ephemeroptera as a taxon. The "Other" vial's contents can be separated into taxa – i.e. orders and in some cases classes. Record your results on the appropriate data collection sheet.

Advanced sorting and analysis – From this starting point samples may be further identified to family, genus and species levels, thus yielding additional data and allowing more advanced analysis. (see Benthic Macroinvertebrate Metrics guidance).

Water Quality Biotic Index
Use the benthic macroinvertebrate sorting and recording sheet to complete Biotic Index Calculation Sheet. This will give you a score between 0 and 3 with 3 representing good

Name: _______________________ Date: __________________

Benthic Macroinvertebrate Adaptations & Behavior

Select two organisms from the Watershed Watch Order Key, draw each in the boxes including key features. Then research or use your imagination to identify the behaviors and adaptions. Use **Reese Voshell** Jr's book *A Guide to Common Freshwater Invertebrates of North America* as a primary reference, if possible. Check the box to right with your best estimate.

Moving
___ Jumper, ___ Floater, ___ Climber, ___ Skater, ___ Swimmer,
___ Crawler, ___ Burrower, ___ Clinger

Eating Style
___ Scraper, ___ Shredder,
___ Collector (filterer), ___Predator

Place in Food Chain
___ Herbivore (eats plants), ___ Carnivore (eats animals), ___ Omnivore (eats plants and animals), ___ Detrtivore (eats dead and decaying matter)

Tolerance to Pollution
___ Intolerant (suggests good water quality),
___ Somewhat tolerant(wide range of quality
___ Tolerant (suggests poor water quality)

Moving
___ Jumper, ___ Floater, ___ Climber, ___ Skater, ___ Swimmer,
___ Crawler, ___ Burrower, ___ Clinger

Eating Style
___ Scraper, ___ Shredder,
___ Collector (filterer), ___Predator

Place in Food Chain
___ Herbivore (eats plants), ___ Carnivore (eats animals), ___ Omnivore (eats plants and animals), ___ Detrtivore (eats dead and decaying matter)

Tolerance to Pollution
___ Intolerant (suggests good water quality),
___ Somewhat tolerant(wide range of quality
___ Tolerant (suggests poor water quality)

Benthic Macroinvertebrate Biotic Index Calculation Sheet

Data Collector's Names____

Date__________________________ Begin Time________________ End Time________________

Sensitive Groups		*Somewhat Sensitive Groups*		*Tolerant Groups*	
	Put a "X" if found		Put a "X" if found		Put a "X" if found
Caddisfly larvae	______	Clams larvae	______	Aquatic worms	______
Mayfly larvae	______	Crane fly larvae	______	Blackfly larvae	______
Stonefly larvae	______	Crayfish	______	Leeches	______
Dobsonfly larvae	______	Damselfly larvae	______	Midge Fly Larva (Red)	______
Riffle beetle larvae	______	Dragonfly larvae	______	Pouch/pond snail	______
Gilled snails larvae	______	Scuds	______	Tubificid worm	______
Water penny larvae	______	Sowbugs	______		
		Midge fly larvae (not red)	______	Total # of animals with "X"	______
Total # of animals with "X"	______				
	x 3=______	Total # of animals with "X"	______		x 1=______
			x 2=______		
Group score:		Group score:		Group score:	

a) Total # sensitive _____ + Total # somewhat sensitive _____ + Total # tolerant _____ = ______________
Total # of animals (a)

Sensitive Group Score___ + Somewhat Sensitive Group Score____ + Tolerant Group Score______=____________
Total value (b)

Divide total value (b) ________ ÷ total # of animals ___________ = ___________ for water quality index score

How healthy is the stream?

Excellent ………….. .2.3 – 3.0

Good ………………. 1.5 - 2.2

Fair ………………… 0.8- 1.4

Poor …………………0.0 - 0.7

Activity for Students to See Patterns in Data & Turn Data into Information

1. **Why turn your data to information?** Analyzing river ecology data completes the learning process by comparing data results with your predictions of what you expected, looking at data gaps and other data sources, and reporting your findings to the community. In New Mexico Watershed Watch we start by comparing results to aquatic health and human standards. Your task is to weave the field experiences & analysis into a story that compels people to become engaged in the monitoring process and find ways to adopt healthy watershed management practices.

2. **How**

- Introduce students to river ecology concepts, river measurement methods and get students to make predictions of what they expect to see for the data.
- Have students focus on two parameters.
- Teacher needs to arrive at classroom with copies of this worksheet, graph paper and colored pencils, and a tabular form of the all the data (sometimes highlighting the data students will analyze for their convenience).

3. When to do this

At the end of the first semester or at a minimum during April for an end-of-the-year presentation. Your curriculum approach will dictate when in the class cycle you do this but it's always going to take place prior to making your community presentation. Consider giving yourself 2 class periods if you only have 1 hour-long classes. Begin organizing and graphing data to start comparing data at same site over several months as soon as time allows.

The overall objective is to play with the data and see what story it tells, or doesn't, and make recommendations. The activities to achieve this include:

a. Assess results in context with River Continuum Concept (see attachment) and how data changes from upper sites to lower sites.
b. Graph the data over time or space (site 1-3 done on the same day on the same river).
c. Compare the values to a benchmark or water quality standard if it exists
d. Calculate summary statistics such as the maximum, minimum, range, mean, median, and IQ ranges (interquartile).
e. Record observations and findings
f. Provide conclusions and recommendations – ask students who may be presenting as a final assessment to take their preliminary data set and present it to the class as a draft.

2. Class Time. Each parameter group (like Temperature and DO) will present their conclusions and recommendations. Discussion will follow. Weave in concepts such as:

- Stressor, exposure, response
- Exceedances of water quality standards related to frequency, duration, magnitude, and natural vs. human causation.

4. What to provide students/participants

- A set of data for one or two parameters with dates when it was gathered
- Graph paper
- Background material on the parameter on what, why, and how it is measured and what the water quality standard is for the river (or have them do their own research and writing on this topic).
- A set of data interpretation worksheets (see attached).

Name: ____

Data Interpretation Worksheet

1. Names of the two parameters you'll analyze?

   For each parameter, list one reason it is important to measure for aquatic life or human health.

2. How you would expect the results to change from upstream to downstream taking the River Continuum Concept and land use in the watershed into consideration?

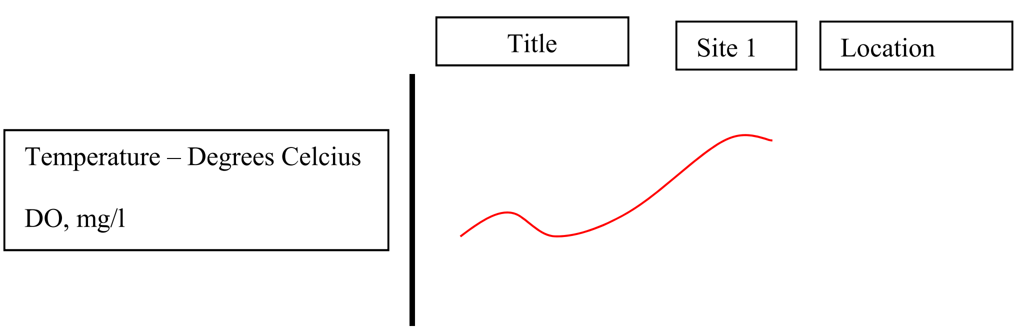
Parameter	Change Upstream to Downstream?	Why?

Name: ____

3. For each parameter, record how you predict this parameter changes daily or with a summer rainstorm?

Parameter	↓↑ OR Neutral *Daily* Change?	↓↑ OR Neutral *Rainstorm* Change?

4. Graph the two parameters at the location. Connect each point by parameter to make a line with distinct colors. Label each axis appropriately and give the graph a legend & title that is clear. See example below.



Name: ____

5. For each parameter, is there a standard or benchmark that should not be exceeded? (look on your datasheet) Add benchmark if you have them and also to your graph.

Parameter	Benchmark Y or N	If Benchmark what is it?

6. For each parameter, calculate the following summary statistics and put the results in the following table.

   Maximum data point (highest value in dataset)
   Minimum data point (lowest value in dataset)
   Range (maximum to minimum values)
   Why?

Parameter	**Max (which site & what date & time of day?)**	**Min (which site& what date & time of day?)**	**Range**	**Why was there variation?**

Name: ____

7. Calculate summary statistics that represent the spread or diversity of the data set.

Parameter	Mean	25% IQ Range	Median	75% IQ Range

8. Record you findings and observations. Just list them. The tools you have include:
   - The River Continuum concept, daily and rainstorm predictions of what these parameters "should" do
   - The graph of what each parameter "did" do this year. How does it compare with your predictions? Are there any patterns between parameters or within parameters?
   - If you have a benchmark, was the benchmark exceeded? If so what might this mean? If not what might that mean?
   - Does the maximum, minimum, range and mean look like it would be okay for aquatic life? Human health?

9. Summarize your conclusions and make a recommendation. This is what you will present to the group in one minute as a "dry run". Do a role play pretending that you have been hired to evaluate this data set for a client-- what would you tell them?

Name: ____

River Continuum Concept – Longitudinal River View

The River Continuum Concept (RCC) (Vannote et al, 1980) is the concept that a river is a predictable physical, chemical and biological continuum of attributes. Stream order can illustrate this. Visualize how physical habitat can change from upstream to downstream. For example, as the stream widens downstream, it gets deeper, the velocity slows, the gradient lessens, and discharge increases.

Chemical attributes change as you travel downstream. Some of these changes can include: chemistry parameters:

- temperature increases
- dissolved oxygen decreases
- turbidity goes up and clarity goes down
- pH remains about the same (it may increase some)
- most chemical variables increase

One common physical attribute in rivers is pool/riffle ratio. Pools are deep areas in the river where water slows and gathers. Riffles are shallow fast moving areas in the river that produce riffles in the water. The larger the river, the larger the pool/riffle ratio.

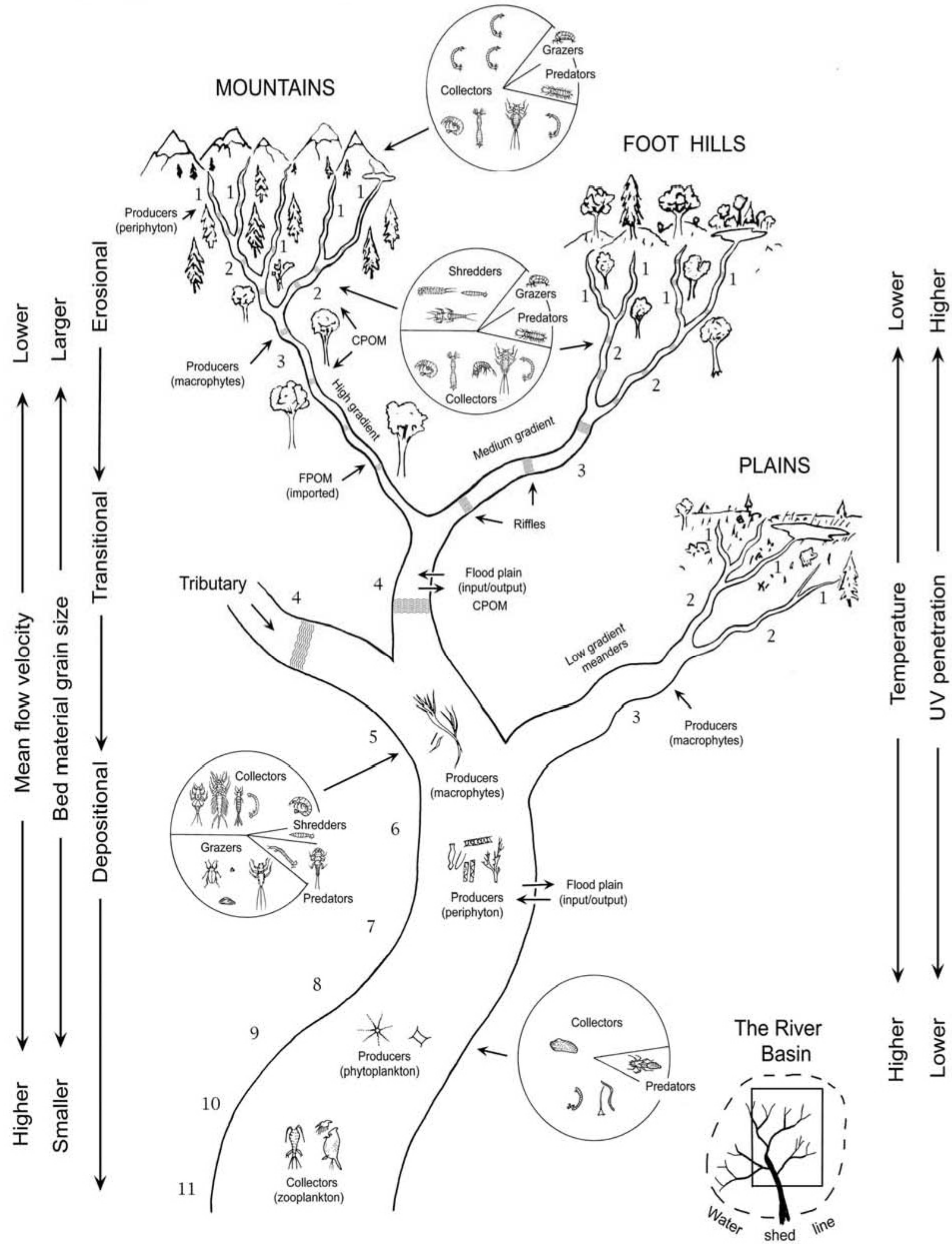
Pool/riffle ratio in small streams is less than one because there are more riffles. In medium streams the ration is 1:1, equal. In large streams the pool riffle ratio is greater than one as the river becomes a moving lake.

For biological attributes, the types of organisms might be the same. For example, there will always be micro and macro organisms, aquatic vegetation and fish, but the species might vary. In Colorado, fish species range from cutthroat trout, to brook trout, rainbow and brown trout, suckers, longnose dace, and sculpin, to warm water species like creek chubs, shiners, daces, and catfish. Colorado does not have large enough rivers to support large communities of zooplankton. Zooplankton occurs in our rivers as escapees of reservoirs or lakes.

For macroinvertebrates we have the three indicators of clean cold water, mayflies, stoneflies and caddisflies in small and medium streams, disappearing in large streams. For macroinvertebrates we also can look at the continuum of their feeding niches, how they obtain food. Based upon millions of years of evolution, macroinvertebrates developed different feeding niches, such as predators, grazers (little cows on the rock grazing Periphyton), collectors (build nets and the like to collect food) and shredders. In small rivers the food and energy source is Coarse Particulate Organic Matter (CPOM), debris and vegetation from the riparian zone. Thus, there are many shredders (like your tomato plant eaten by an insect), few grazers because the stream is cold, often shaded, days are short, growing season short, not much primary productivity to produce any fine organic matter for food. Conversely, in medium size streams, the stream opens, primary productivity produces plenty of Fine Particulate Organic Matter (FPOM). Thus the mayflies, stoneflies and caddisflies are all there, but specialize more in grazing and collection methods for FPOM. There are still shredders, just not as many. Finally, in large rivers the macroinvertebrate community is primarily collectors and predators. Micro invertebrates change from primarily attached algae and mosses to aquatic plants, less attached algae, to floating phytoplankton.

RCC then also explains the primary energy sources for small, medium and large streams. Small streams are primarily heterotrophic, or they do not have enough photosynthesis and primary productivity to sustain itself, they are dependent upon the surrounding watershed and allocthonous (non-native material, coming in from outside like leaves and twigs) or CPOM material. Medium streams are wider, lower elevation and warmer. Primary production and photosynthesis increase in response, sufficient enough to sustain itself, thus medium streams are autotrophic (self) and major energy source is the algae and aquatic plants reduced to FPOM. Large streams return to heterotrophic, because they tend to be turbid and sunlight only penetrates in the top few meters. Thus, their primary energy source is not the surround watershed like small streams but all the CPOM and FPOM from the small and medium size streams that flow into it. See Figure 1A and 1B to illustrate the RCC.

Name: ____


MOUNTAINS
Grazers
Predators
Collectors
FOOT HILLS
Producers (periphyton)
Shredders
Grazers
Predators
Collectors
CPOM
Producers (macrophytes)
High gradient
Medium gradient
FPOM (imported)
Riffles
PLAINS
Tributary
Flood plain (input/output)
CPOM
Low gradient meanders
Producers (macrophytes)
Collectors
Shredders
Grazers
Predators
Producers (macrophytes)
Producers (periphyton)
Flood plain (input/output)
Producers (phytoplankton)
Collectors
Predators
Collectors (zooplankton)
The River Basin
Water shed line
Lower
Mean flow velocity
Higher
Larger
Bed material grain size
Smaller
Erosional
Transitional
Depositional
Lower
Temperature
Higher
Higher
UV penetration
Lower

ATTACHMENTS:
#1 CURRICULUM ALIGNMENT WITH NEXT-GENERATION SCIENCE STANDARDS

Performance Expectation Code	Performance Expectation	Curriculum Activity
HS-Ps1-5 Chemical Reaction	HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]	*Students consider relationship between temperature and turbidity or temperature and dissolved oxygen *Students use meters to collect water quality data. Students analyze water samples using a colorimeter, D.O. winkler titration, TDS and pH measurements
HS-LS2-4 Matter and Energy in Organisms and Ecosystems	Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]	*Students are introduced to nutrient cycling, food webs in aquatic and terrestrial systems *Students learn River Continuum Concept and apply to a local study area *Students introduced to photosynthesis and oxygen cycling in aquatic systems *Students measure nitrogen and phosphorous in streams and water bodies and investigate sources and impacts
HS-LS2-1 Matter and Energy in Organisms and Ecosystems	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered	*Students sample and identify aquatic organisms and investigate relationship between temperature, dissolved oxygen, habitat, and fish and aquatic life *Students use current and historic data sets to evaluate benthic macroinvertebrate population trends

	from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]	
HS-LS2-2 Matter and Energy in Organisms and Ecosystems	Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]	*Students graph historic and current data for water quality metrics and population samples and identify relationships and trends for changes in biodiversity and populations *Students calculate stream discharge from local river *Students collect, sort, and calculate diversity indices for benthic macroinvertebrates and compare to historic data
HS-LS2-6 Matter and Energy in Organisms and Ecosystems	Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]	*Students graph historic and current data for benthic macroinvertebrate populations, identify trends, and use water chemistry data to inform causes to any changes
HS-LS2-7 Matter and Energy in Organisms and Ecosystems	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]	*Land use and resource management approaches are taught including dams, diversions, agriculture, urbanization, grazing, hunting and fishing. *Students discuss causes and solutions to water quality and quantity issues using local case studies and locations.
HS-LS4-5 Natural Selection and Evolution	Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]	*Students identify benthic macroinvertebrate species and classify based on species sensitivity to pollutants and environmental conditions *Students describe the presence or absence of sensitive or insensitive species to levels of water pollution and water quality metrics *Students hypothesize cause and effect relationships for changes in populations and water quality metrics
HS-ESS2-2 Earth's systems	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth	*Students learn how changes in riparian vegetation influences the aquatic system

	systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]	*Students learn how increases in turbidity increases water temperature through sampling and testing *Students learn how changes in upland vegetation impacts soil erosion and turbidity, and aquatic life. *Students learn how forest fires (low and high intensity) change the water cycle in a watershed.
HS-ESS3-5 Earth's systems	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]	*Students consider relationship between decreasing precipitation, changes in seasonality of rain or snow, and increasing temperatures will effect regional ecosystems and the local water cycle.
HS-ESS3-1 Human sustainability	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]	*Students describe how local communities, pueblos, and towns decided where to locate based on resource availability and climate and how changes in climate and water availability align with historic conditions *Students research and discuss intense forest fires and how fire and fuels management have changes how and where people live in a watershed.

HS-ESS3-3 Human sustainability	Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]	*Students learn about average per capita consumption of water resources *Students compare land management strategies and impacts to water resources
HS-ESS3-4 Human Sustainability	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]	*Students identify strategies to improve water quality, habitat, and biodiversity for local ecosystems and rivers *Students research and discuss local, state, national, and international watershed issues

#2 PRE AND POST TEST AND RESULTS

New Mexico Watershed Watch - 2016

Name: ____ School:______________

Date:______________________

1. What is a watershed?

2. Name two types of measurements and how they can be used to assess the health of a river/stream?

3. How does water temperature affect the amount of oxygen in water and aquatic life?

4. What gets collected with a kicknet? What does this tool help us learn about the stream?

5. Name two benthic macroinvertebrate insects that you are likely to find in a New Mexico stream.

6. Provide an example of something you can you do to ensure continued health of your local watershed.

7. What is turbidity and why is it important to fish?

8. Why is streamside vegetation important to the health of fish and other aquatic organisms?

9. What is the name of the fish that is the state fish of New Mexico?

10. Provide an example of what you can do next to streams to protect water quality.

TU-PENASCO PRE-TEST RESULTS

Average score for 10 question (20 point) pre-assessment was 29%. Students were most familiar with actions that they can take to ensure a healthy watershed and descriptions of benthic macro-invertebrates. There is significant room for improvement.

Evaluator: SBG	watershed	water measurements; assess health	temperature and oxygen	Kicknet	Benthic Insects	Ensure continued health of watershed	Turbidity	Why is streamside vegetation important	NM state fish	example of improving water quality	**Student Score**	**Student %**
Score range	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	**0-20**	
student#/ Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
1	0	0	0	0	2	0	0	0	0	0	**2**	**10 %**
2	2	0	0	1	2	2	0	0	2	2	**11**	**55 %**
3	0	0	0	0	2	0	0	0	0	0	**2**	**10 %**
4	2	2	0	0	2	2	0	2	2	0	**12**	**60 %**
5	2	0	2	2	1	2	0	2	2	2	**15**	**75 %**
6	0	0	0	0	2	0	0	0	0	0	**2**	**10 %**
7	1	2	0	0	2	0	0	0	0	0	**5**	**25 %**
8	1	0	0	2	0	1	0	0	0	0	**4**	**20 %**
9	0	1	1	2	2	2	0	2	0	1	**11**	**55 %**
10	0	2	0	0	2	0	0	2	2	2	**10**	**50 %**
11	1	0	0	0	0	2	0	2	0	2	**7**	**35 %**
12	0	2	0	0	0	2	0	2	2	0	**8**	**40 %**
13	0	2	1	0	0	2	0	2	0	2	**9**	**45 %**
14	1	0	0	0	0	0	0	0	0	0	**1**	**5 %**
15	0	0	0	0	0		0	0	0	0	**0**	**0 %**
16	0	0	0	0	0	0	0	0	0	0	**0**	**0 %**
17	0	0	2	2	0	0	0	0	0	2	**6**	**0.3**
18	1	0	0	0	0	0	0	0	0	0	**1**	**0.05**
19	1	0	0	2	0	0	2	0	0	0	**5**	**0.25**
average	0.6315789	0.5789474	0.3157895	0.5789474	0.8947368	0.8333333	0.1052632	0.7368421	0.5263158	0.6842105	**5.8421053**	**29 %**