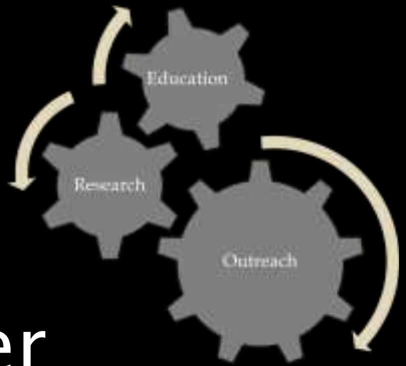
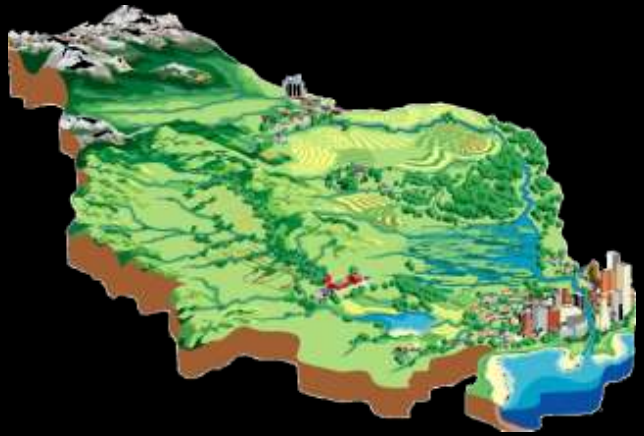
Water Quality 101 Webinar
key concepts for surface water monitoring

April 25th, 2024





Dr. Adam Sigler

Extension Water Quality Specialist, Assistant Professor
Land Resources & Environmental Sciences, MSU
Water Committee Chair, MWCC

Abbie Ebert

Senior Water Quality Monitoring Scientist
Montana Department of Environmental Quality
Water Committee Co-Chair, MWCC

Talk Themes

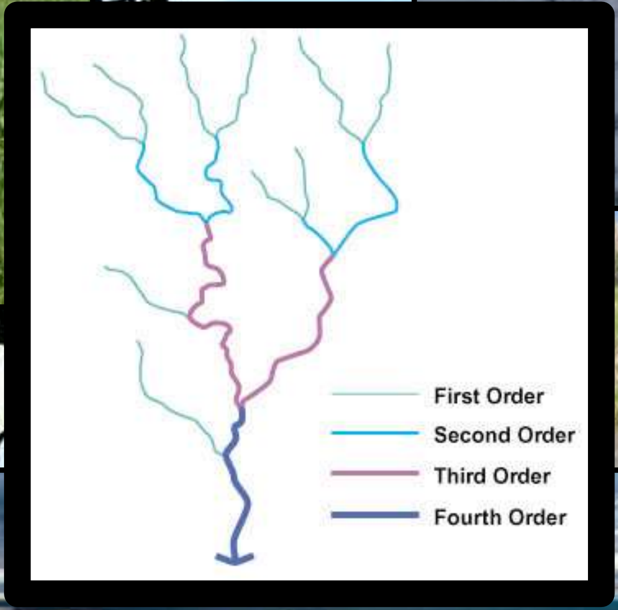
1. Watersheds and background
2. Law and policy
3. Common analytes and monitoring
4. Controls on water quality and addressing pollution
5. Sample analysis plans and resources

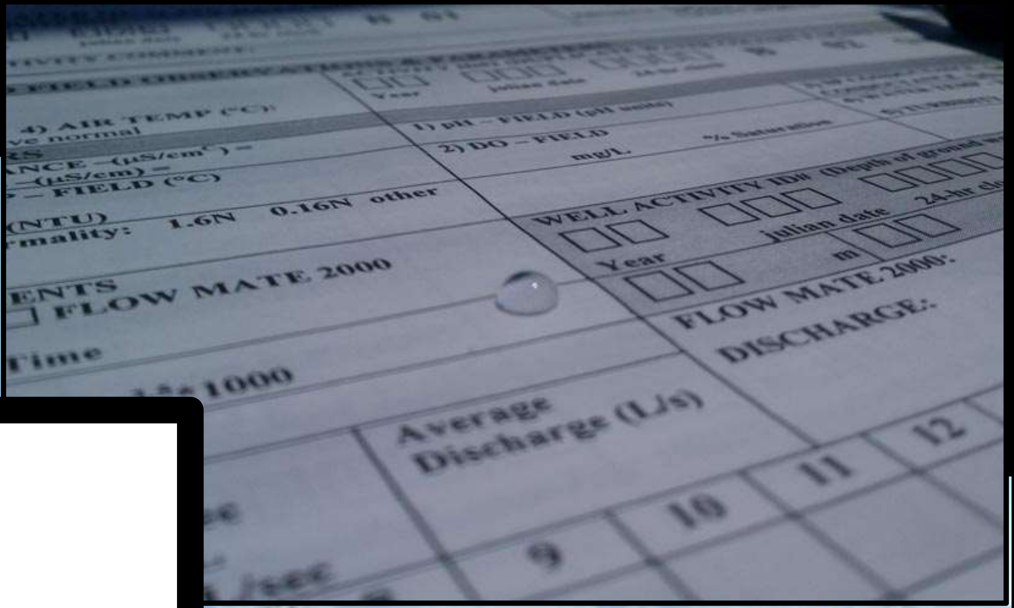
In coordination with

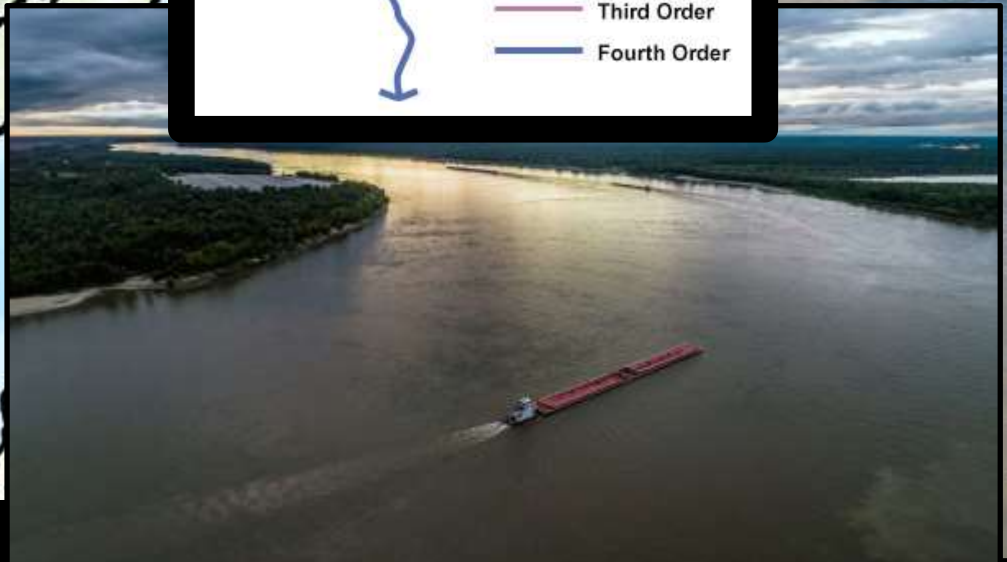
Dr. Rachel Malison, Monitoring Montana Waters
Montana Watershed Coordination Council

Watersheds

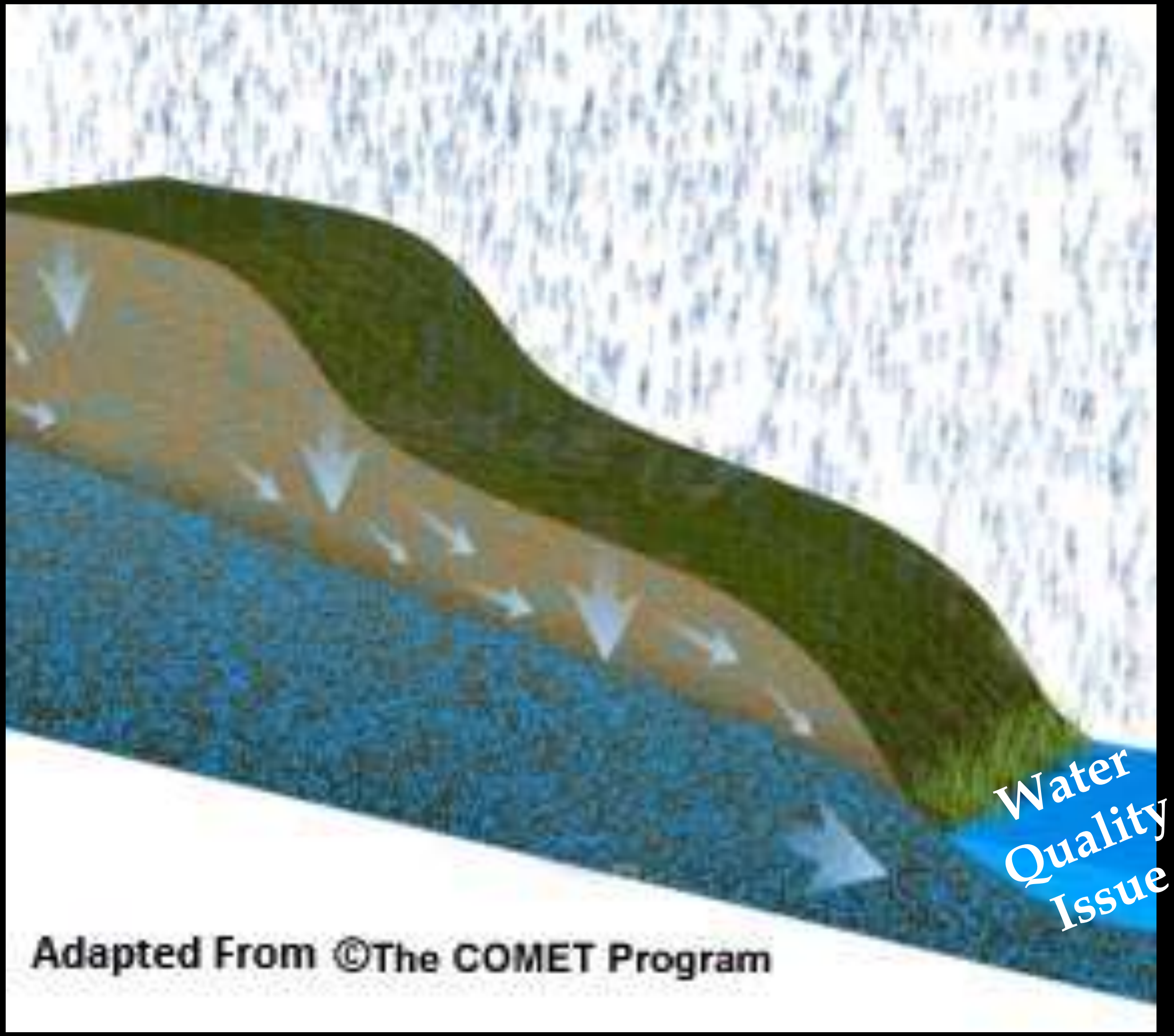

Edmonton
Calgary
UNITED STATES
Denver
St Louis
Los Angeles
Monterrey
MÉXICO
Guadalajara


First Order
Second Order
Third Order
Fourth Order


AIR TEMP (°C)
1) pH - FIELD
2) DO - FIELD
mg/L
% Saturation
1.6N
0.16N
other
WELL ACTIVITY ID#
julian date
Year
FLOW MATE 2000
FLOW MATE 2000:
DISCHARGE:
Average
Discharge (L/s)
9
10
11
12



Water Quality Issues in a Landscape Context



What do we need to know to make management decisions to address the water quality issue?

Historic Roots of Water Quality Law

Photo from the Cleveland State University, Michael Schwartz Library, Special Collections

Cuyahoga River on Fire

Time Magazine:

“the river that oozes rather than flows”

Clean Water Act 1972

The "Fishable and Swimmable" Standard

- 303: Water Quality Standards
- 319: Nonpoint sources
- 402: Point sources

Safe Drinking Water Act 1974

Health based drinking water standards

- Drinking Water Standards
- Source water protection

How do we define: High Quality Water

- Bottled Mineral Water
- Distilled Water
- Disinfected water
- Water with a pH of 7
- Water with low calcium and magnesium (hardness)

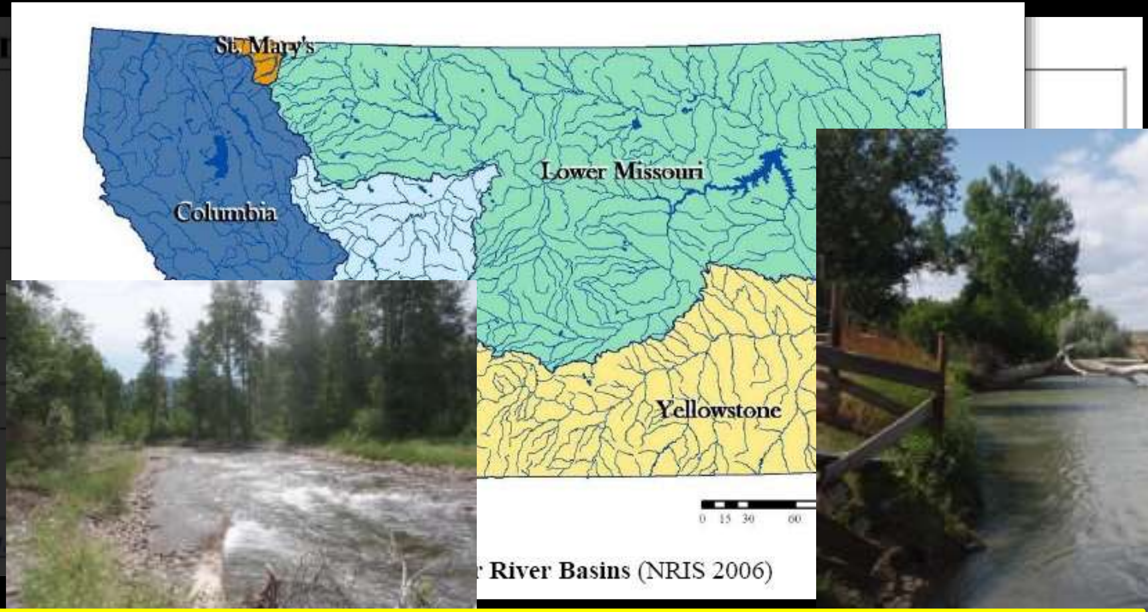
Can't answer the question in the absence of a beneficial use (it is subjective)

Clean Water Act 1972

Water Quality Standards

Need to account for natural variability to understand human caused issues

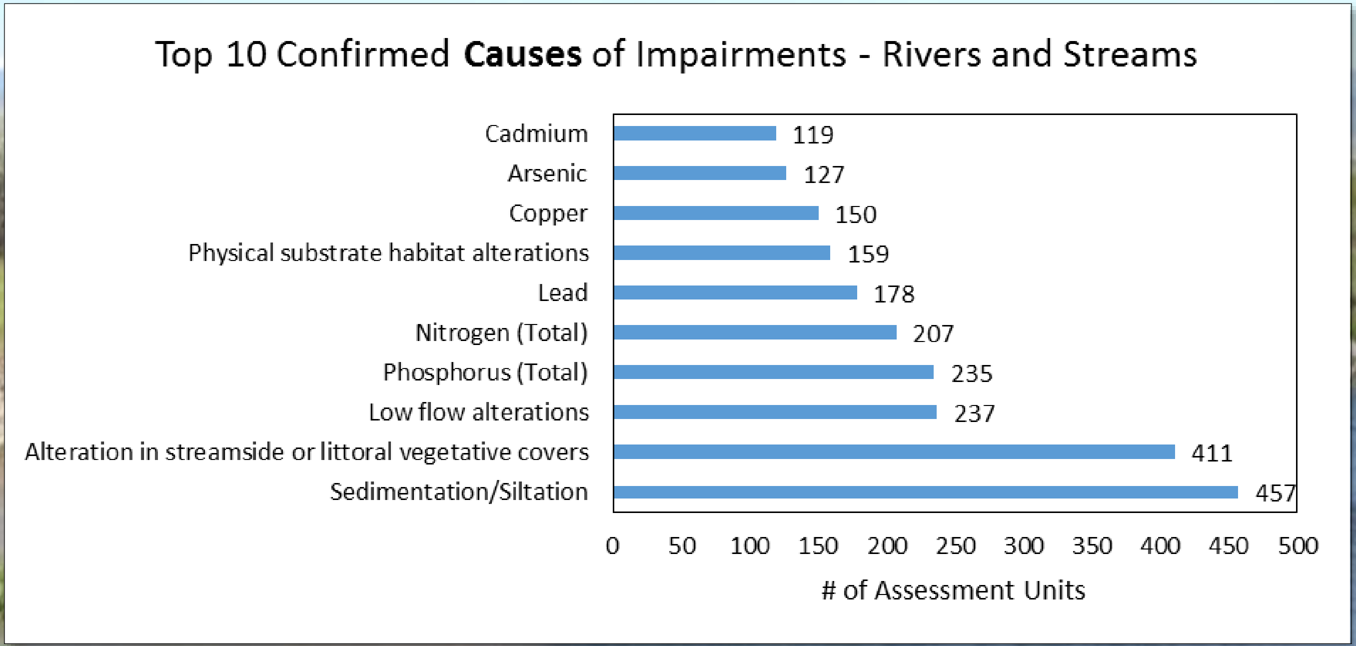
State-Designated Use
Agricultural
Aquatic Life
Cold Water Fishery
Warm Water Fishery
Industrial
Drinking Water
Primary Contact Recreation

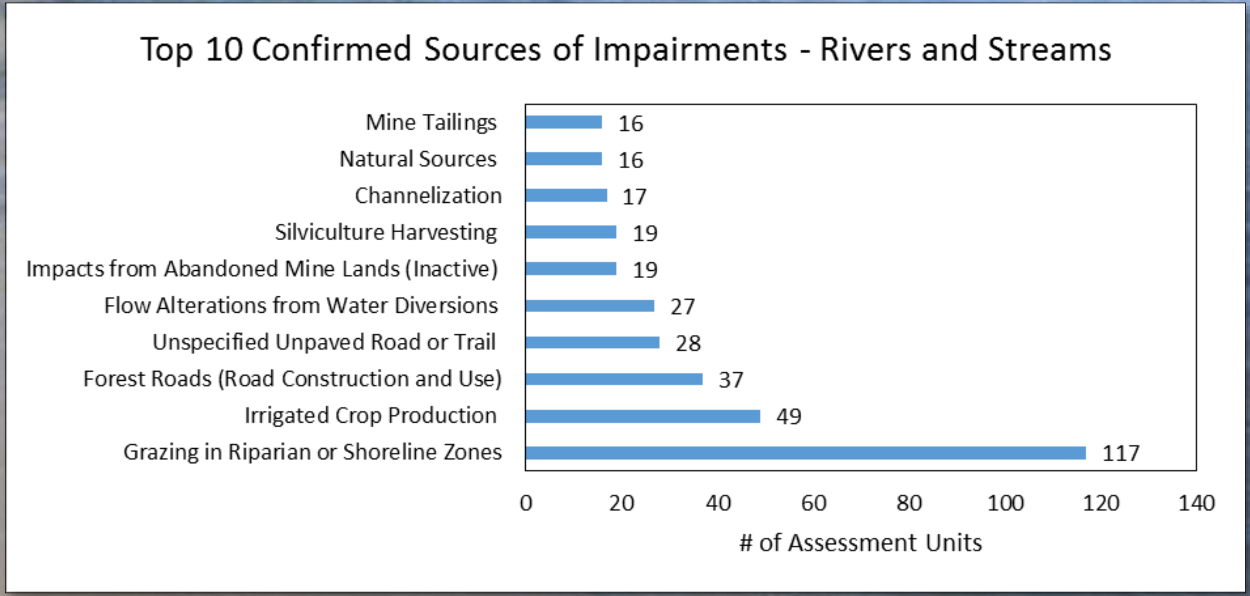


Standards Incorporate: Use & Stream Classification

- Narrative Standard for Sediment
  - "No increases are allowed above **naturally occurring** concentrations of sediment, settleable solids, oils or floating solids, which will or are likely to create a **nuisance** or render the waters harmful, detrimental, or **injurious** to **public health**, recreation, safety, welfare, **livestock**, wild animals, birds, fish, or other **wildlife**"
- Numeric –
  - Specific metrics (concentrations or other things you can put a number on)

Impairment of Montana Streams and Rivers





Point vs. Nonpoint Source Pollution

Section 402

National Pollution Discharge Elimination System

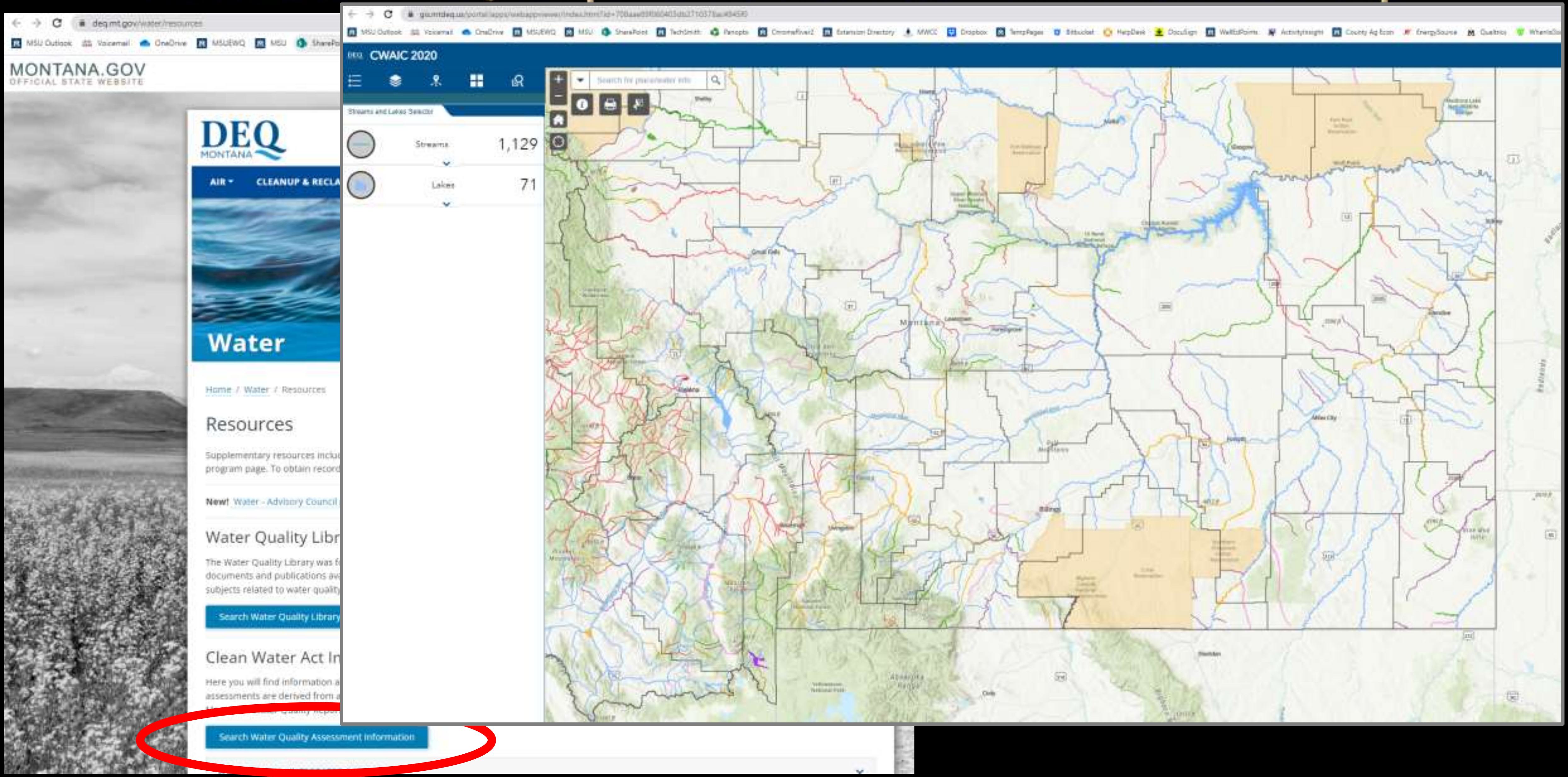
Permit System

Section 319

Non-Point Source Pollution

Voluntary

Montana DEQ Impaired Stream Interactive Map



Impairment Information

Probable Cause			TMDL Completed
Alteration in stream-side or littoral vegetative covers	Agriculture, Ar Shoreline Zon		N/A
Escherichia coli	Grazing in Ripa		Yes
Low flow alterations	Irrigated Crop		N/A
Nitrogen (Total)	Unspecified Unp Land), Grazing i Access		Yes
Other anthropogenic substrate alterations	Agriculture, Chan		N/A
Phosphorus (Total)	Unrestricted Cattl Production (Crop Zones		Yes
Physical substrate habitat alterations	Grazing in Ripariar		N/A
Sedimentation/Siltation	Unrestricted Cattle Natural Sources		Yes

Montana Department of
ENVIRONMENTAL QUALITY

Lower Gallatin Planning Area TMDLs & Framework Water Quality Improvement Plan

March 2013

Steve Bullock, Governor
Tracy Stone-Manning, Director DEQ

Document Number M05-TMDL-02aF

Total Maximum Daily Load (TMDL)

Current Annual Load = 650 kg/yr
Annual Load Limit = 450 kg/yr
Required reduction = 200 kg/yr

Forest road and upland erosion
Contributing 100 kg/yr

Eroding stream banks
Contributing 300 kg/yr

Municipal Storm Water Runoff
Contributing 100 kg/yr

Waste Water Treatment Plant
Contributing 50 kg/yr

Natural Background
Contributing 100 kg/yr

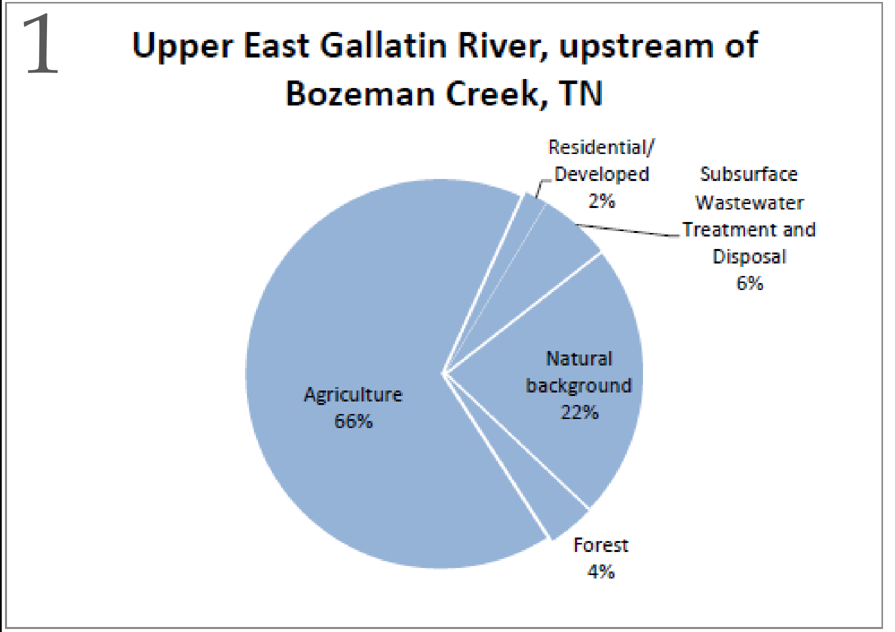


Figure 6-7. Existing TN sources for Upper East Gallatin River upstream of Bozeman Creek

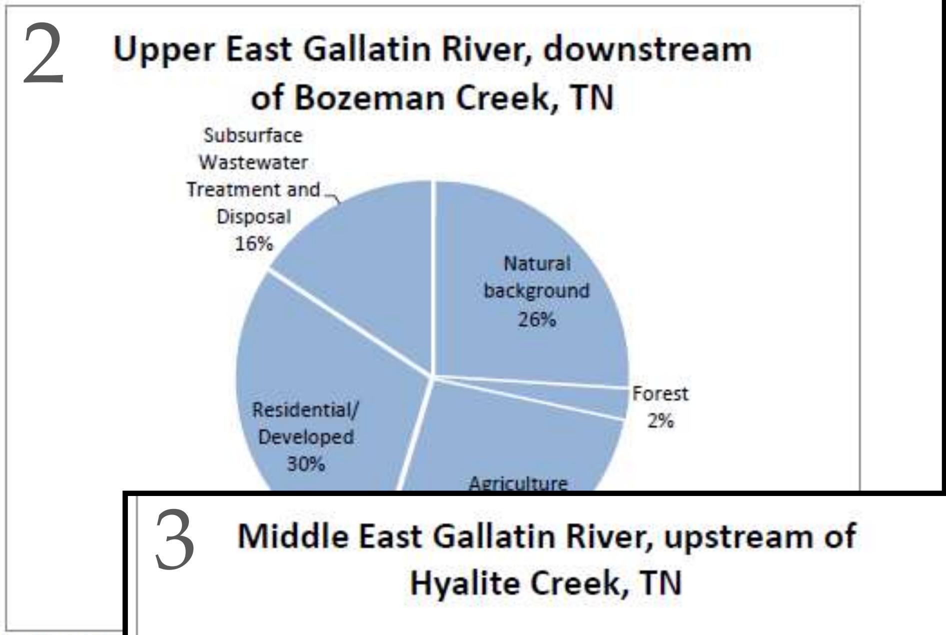
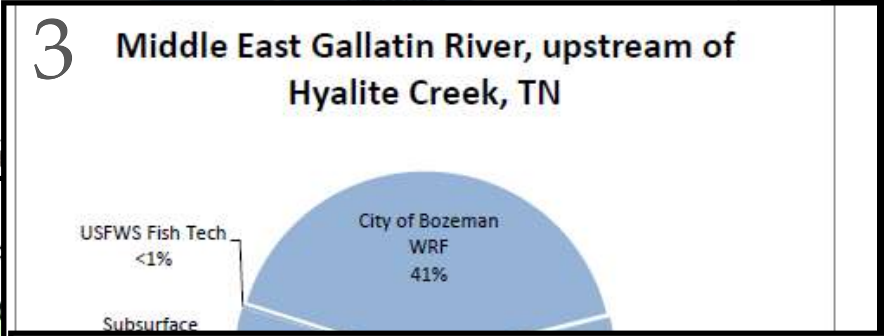


Figure 6-8.



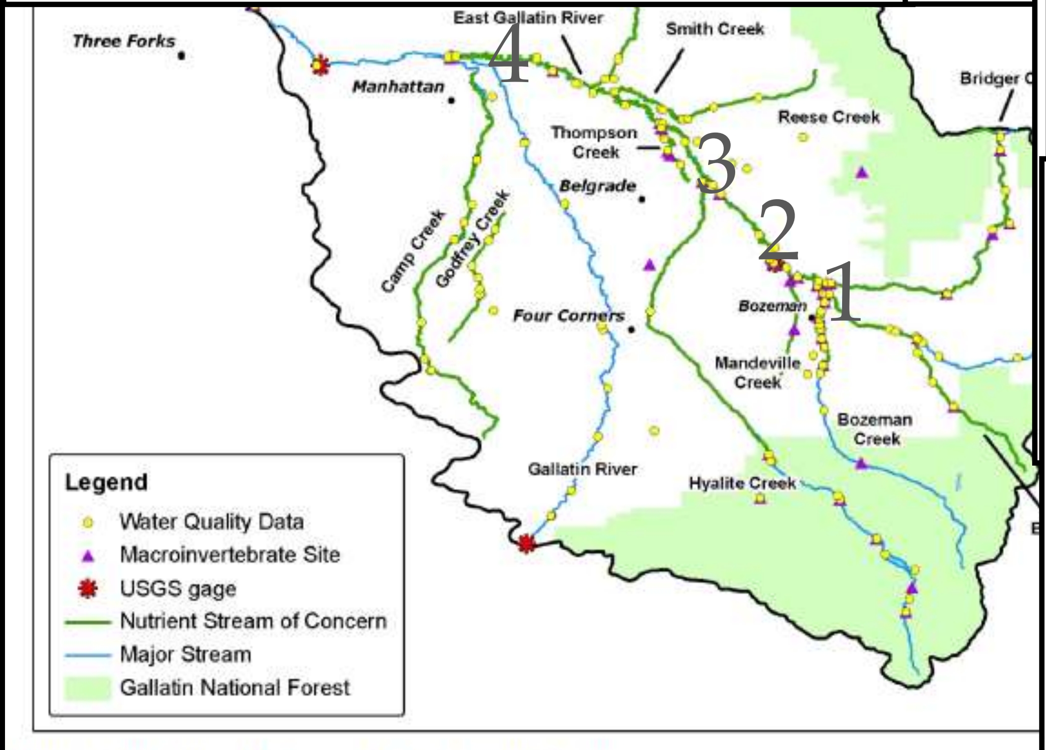


Figure 6-1. Nutrient sampling sites on the streams of concern

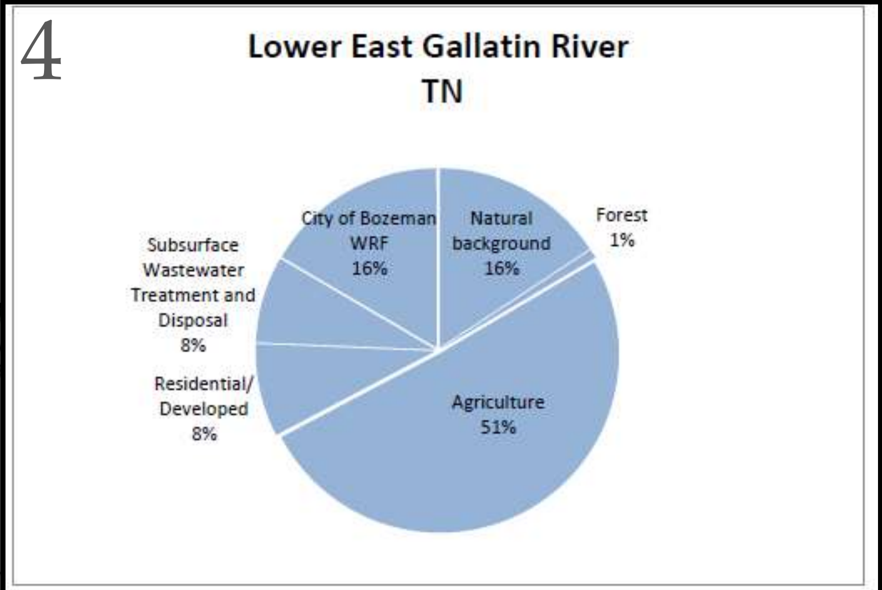
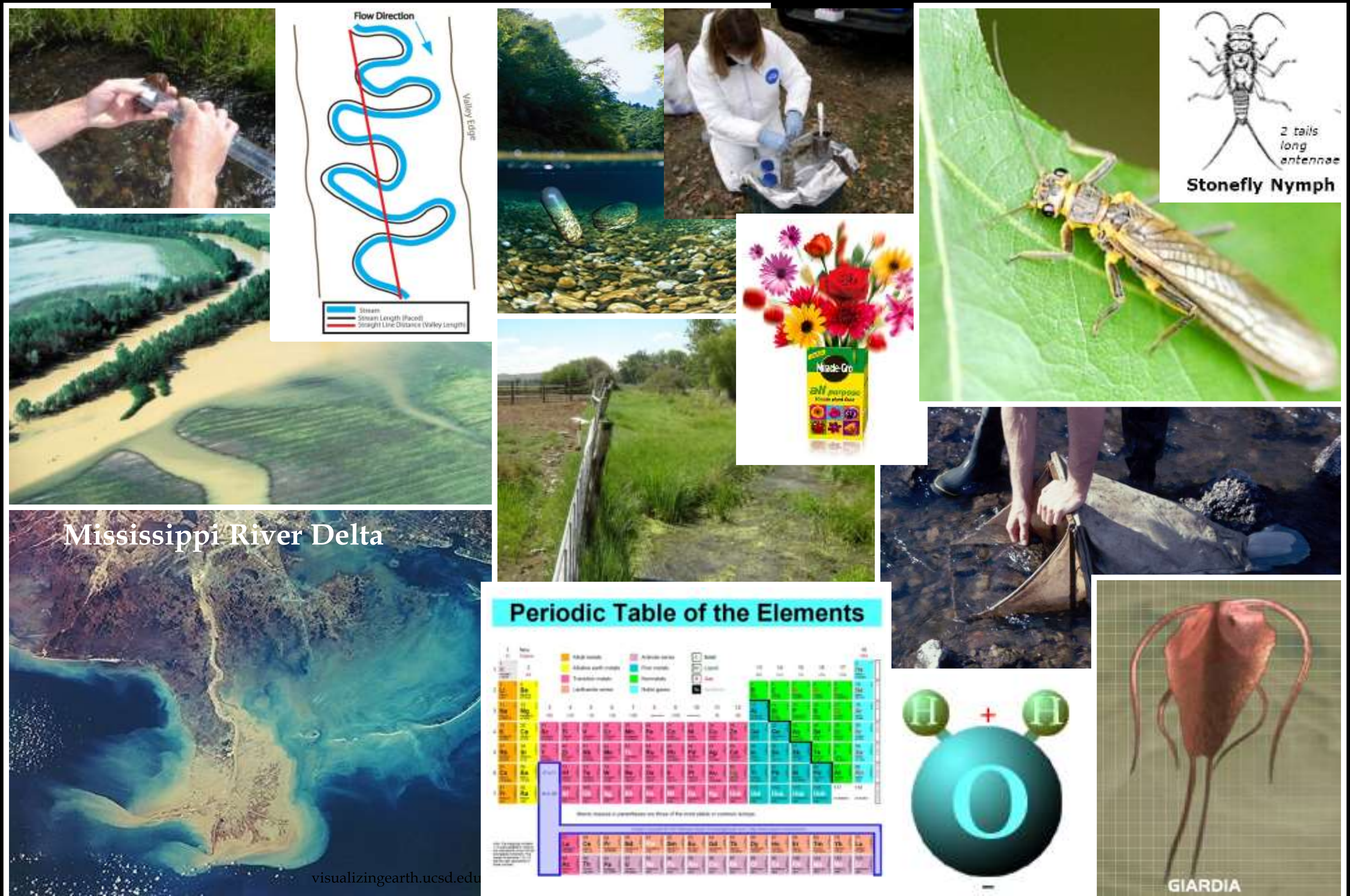
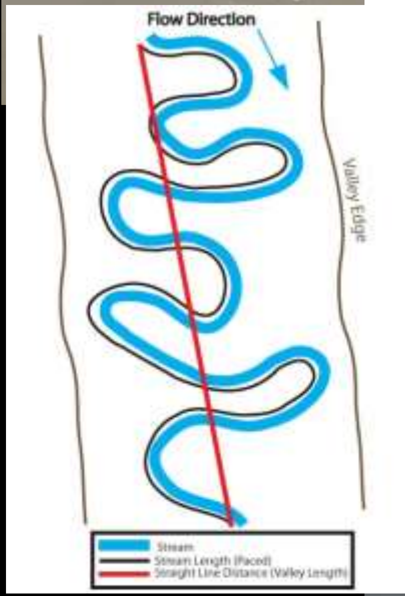


Figure 6-11. Existing TN sources for Lower East Gallatin River

Physical Chemical Biological



Sediment – What and Why



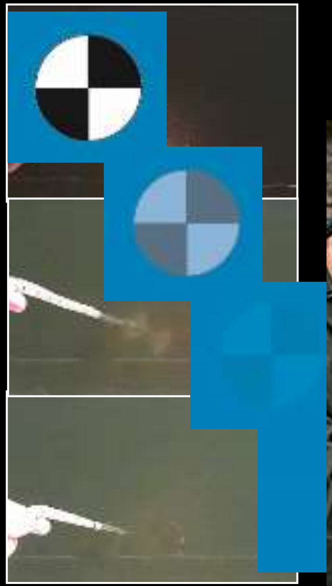
Cover streambed gravels

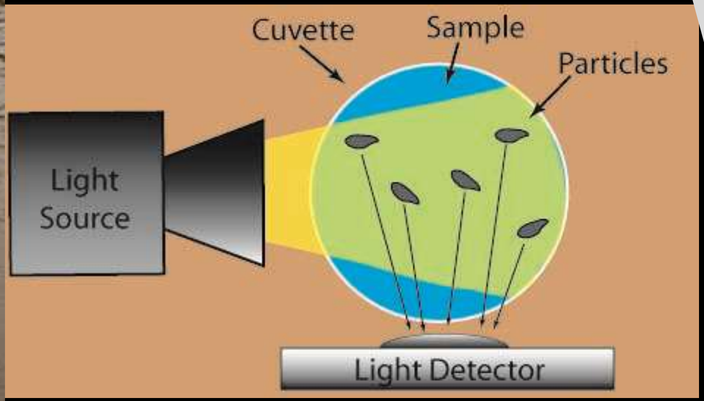
Images/graphics from : Adam Sigler; Stanley Szczytko; NRCS; State of CA

Sediment – methods summary

Grab Samples (Water Column)

Turbidity





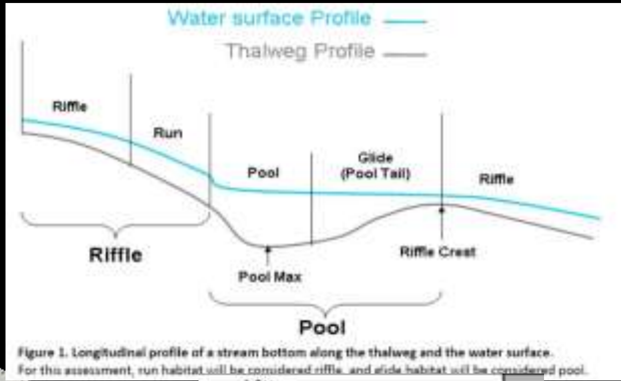
Nephalemetric Turbidity Units (NTUs)

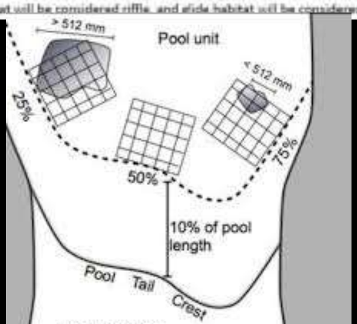
Channel Substrate

Pebble Counts

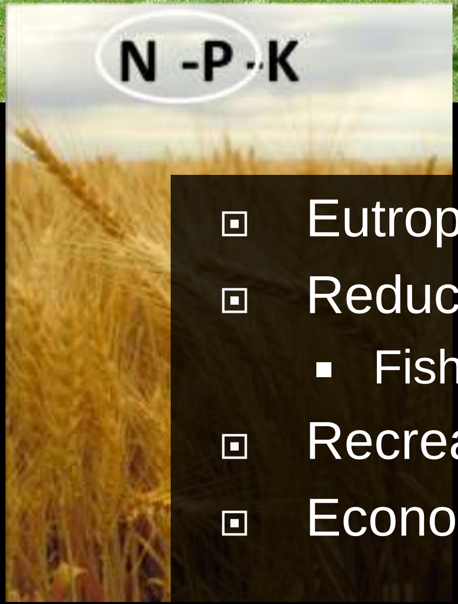
Gravelometer

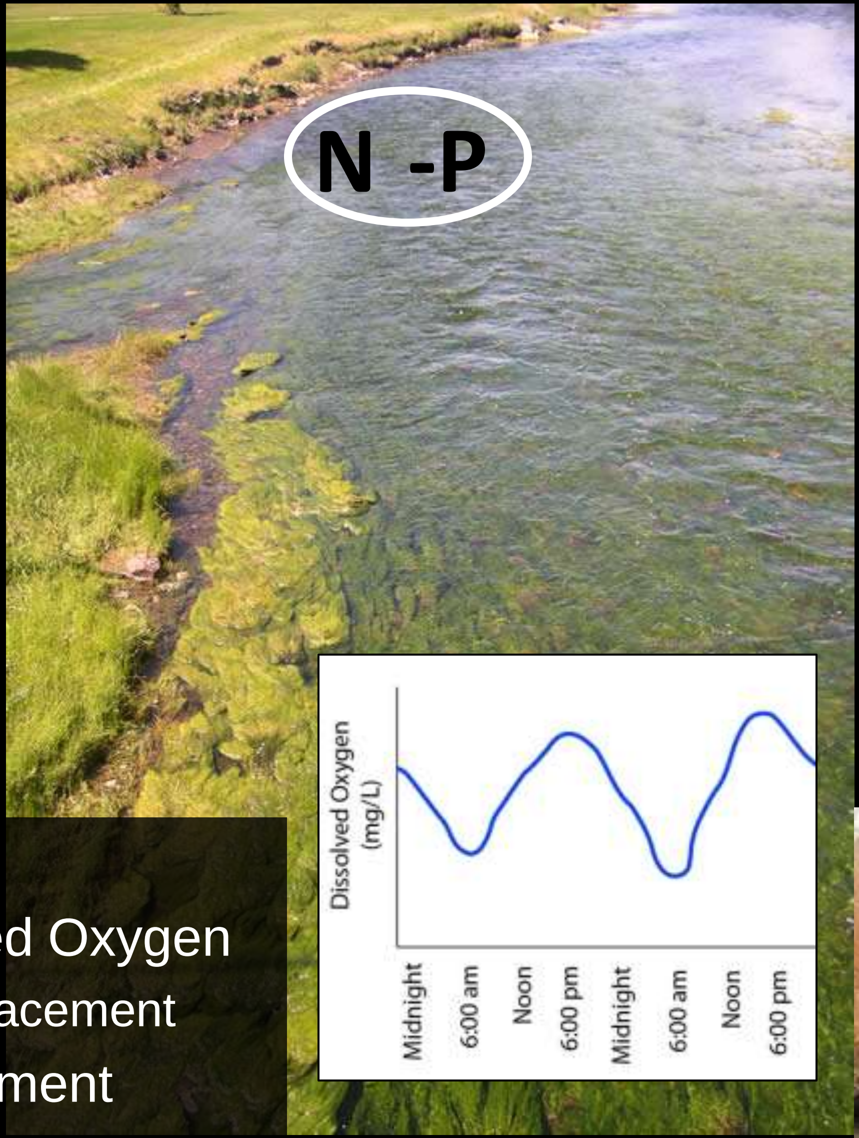
Pools Tail Fines





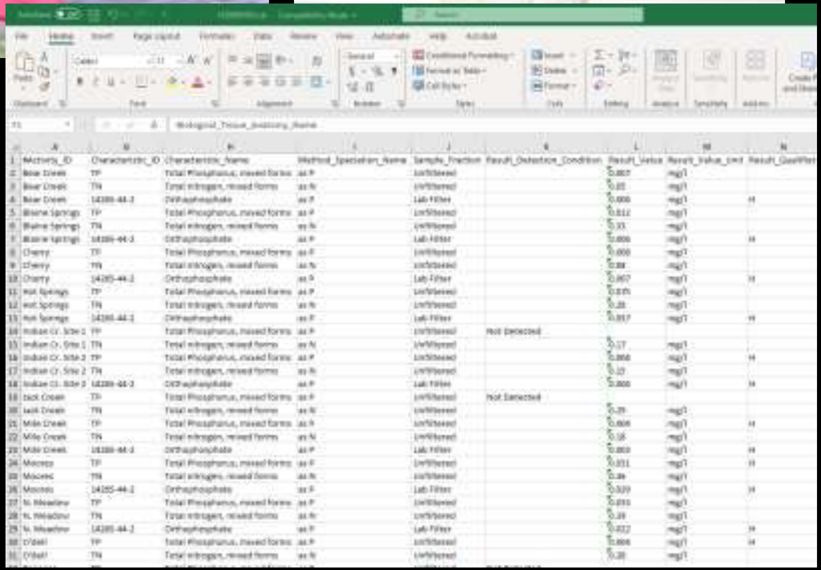
Nutrients – What and Why





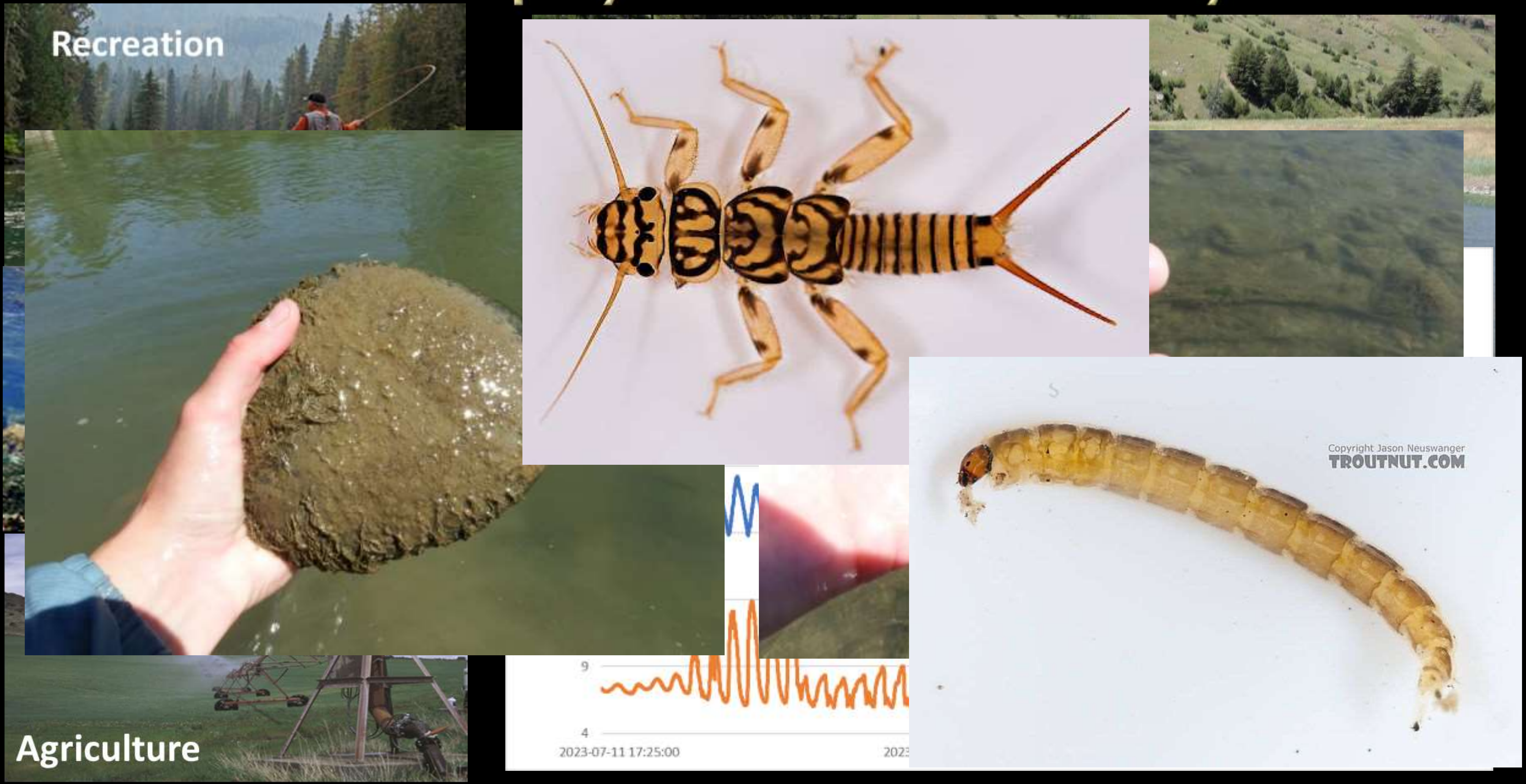
- Eutrophication
- Reduced Dissolved Oxygen
  - Fish kills or displacement
- Recreation Impairment
- Economic Impacts

Nutrients – methods summary



How to collect a grab sample: MSUEWQ YouTube

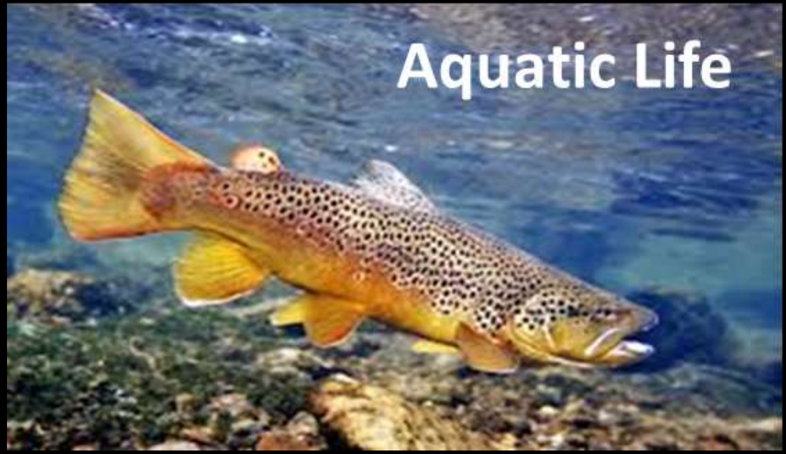
Chlorophyll – What and Why



Chlorophyll – methods summary

Metals – What and Why

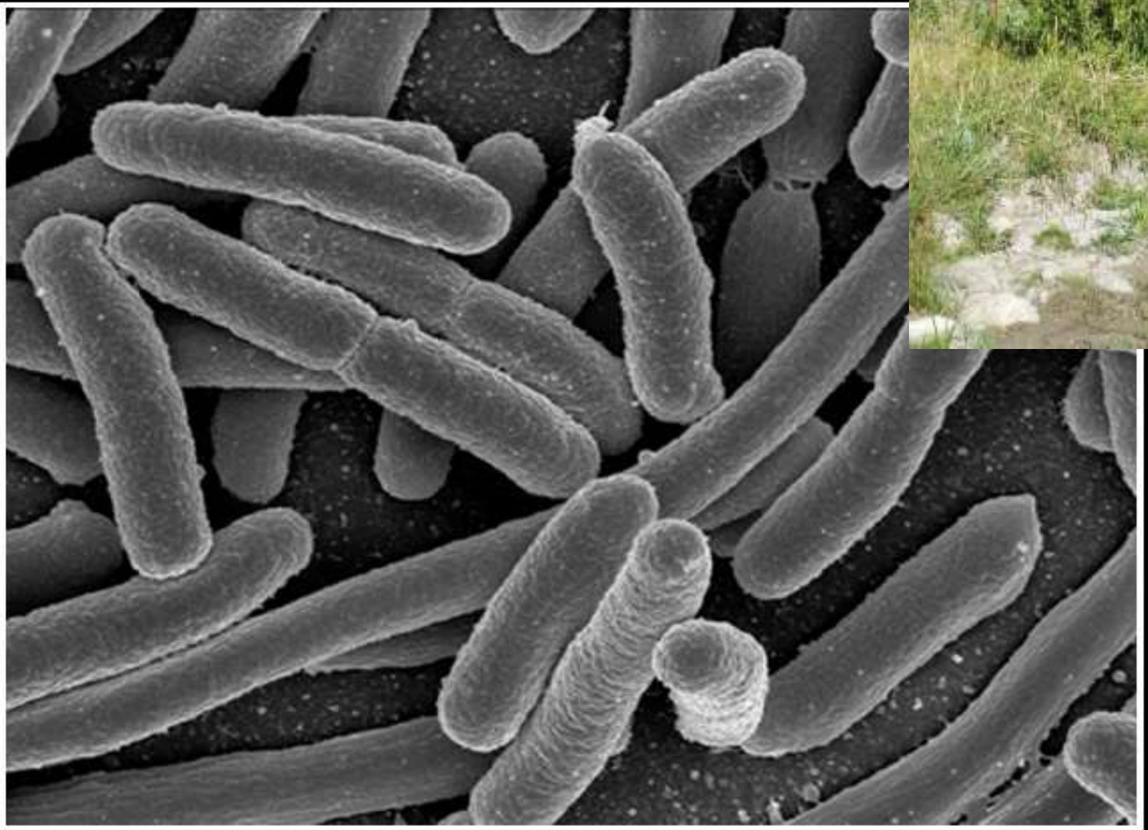
- DEQ-7
- Chronic Standards
- Acute Standards



Metals – methods summary

E. coli – What and Why

- Escherichia coli
- Fecal indicator bacteria



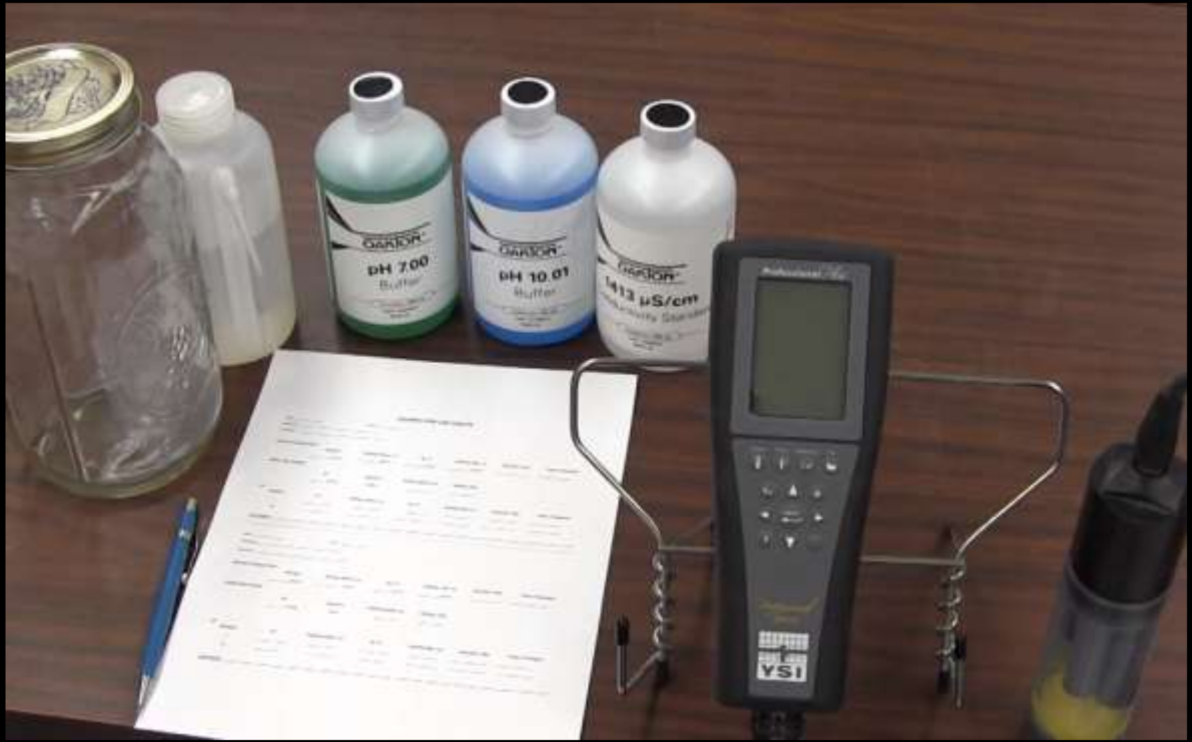
E. coli – methods summary

- Impacted by weather, light and other factors.
- Grab sample
- Short hold time

Field Parameters – What and Why

- Temperature
- pH
- Dissolved Oxygen
- Specific Conductivity

Field Parameters – methods summary

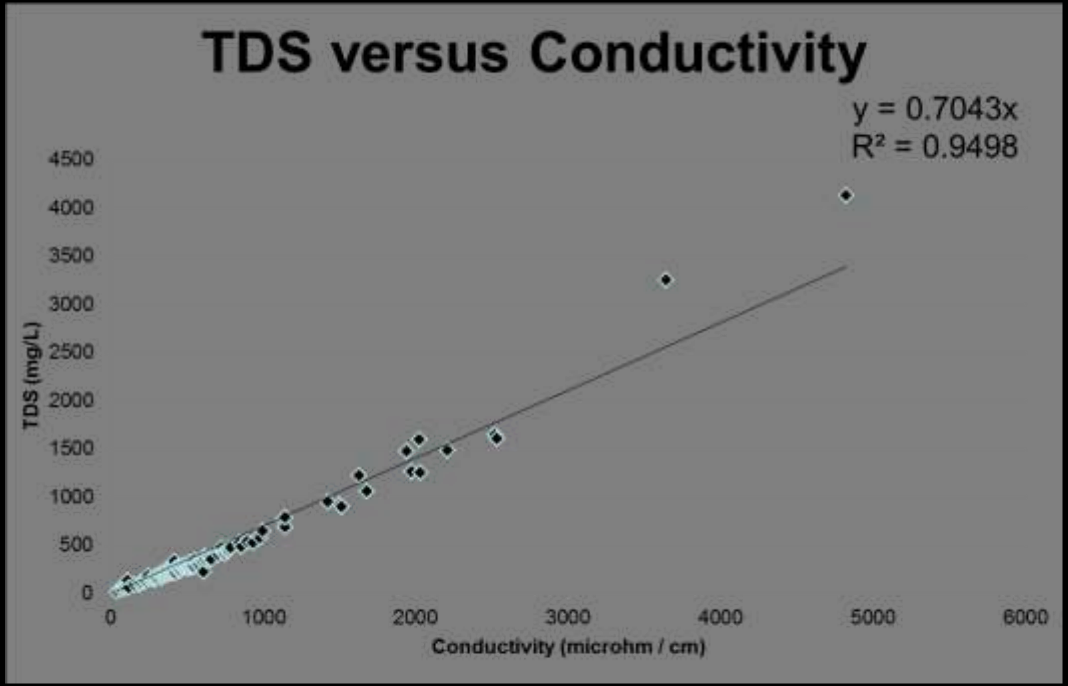


Calibration and maintenance = most important part

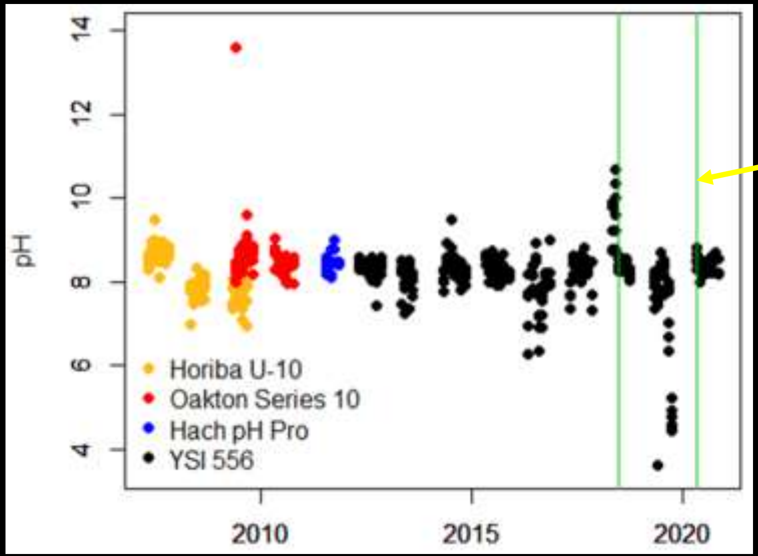
How to Calibrate a YSI Pro Plus Meter: MSUEWQ YouTube

Field Parameters – specific conductance

- How much electricity does a water sample conduct?



Field Parameters – pH challenges

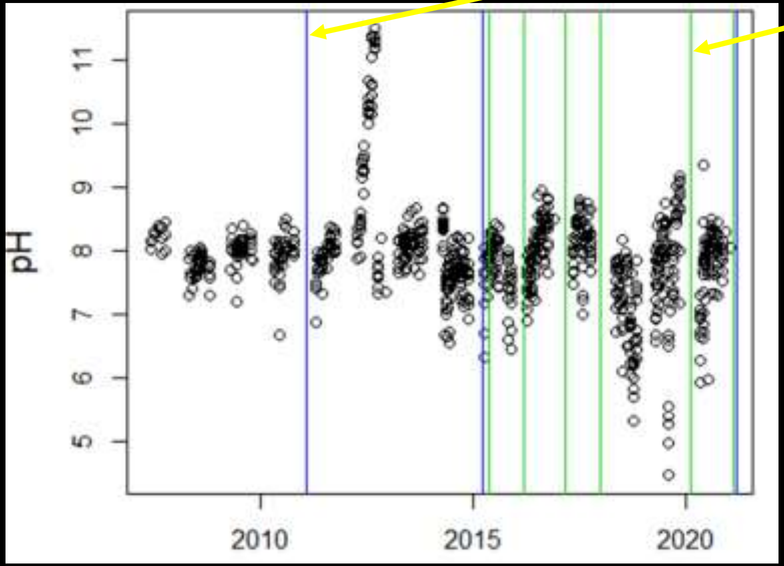


pH data from long-term monitoring

probe replacement

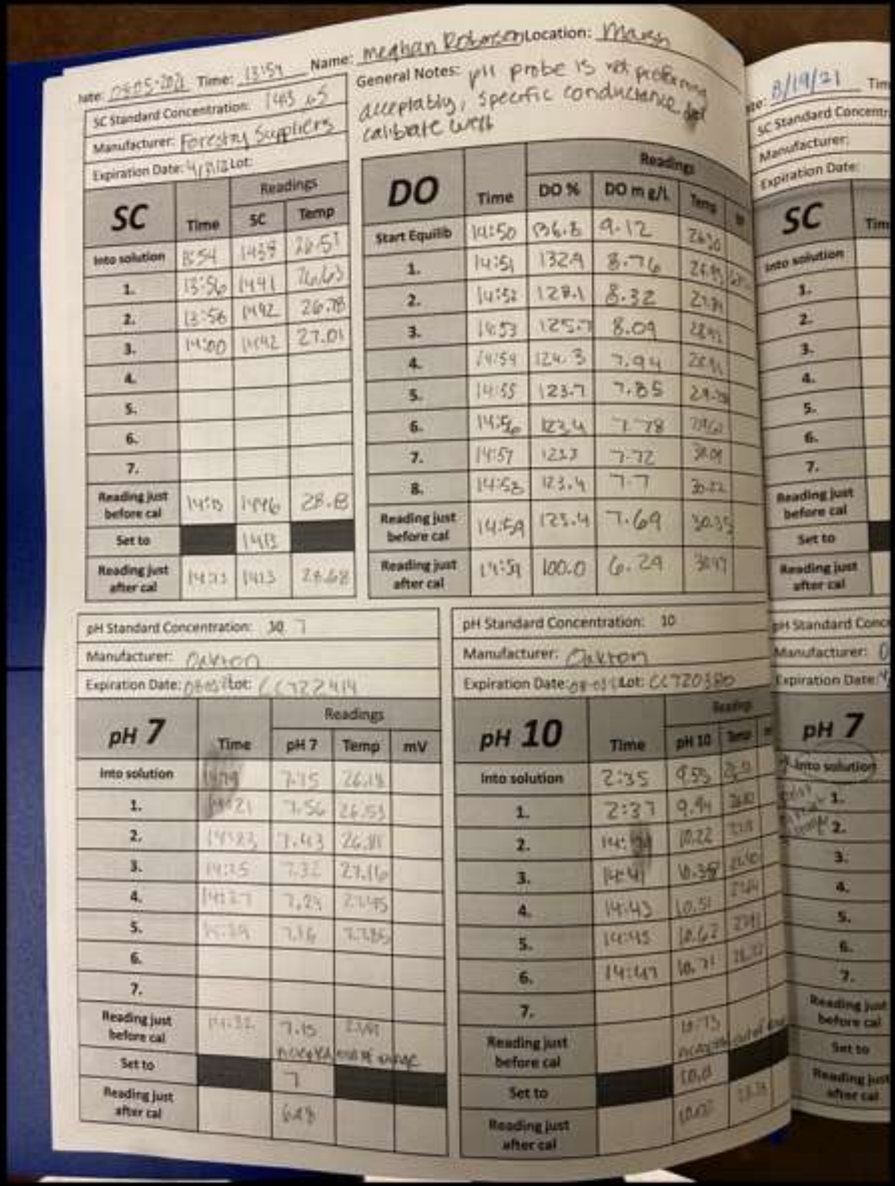
Blue = probe replacement

Green = calibration & maintenance

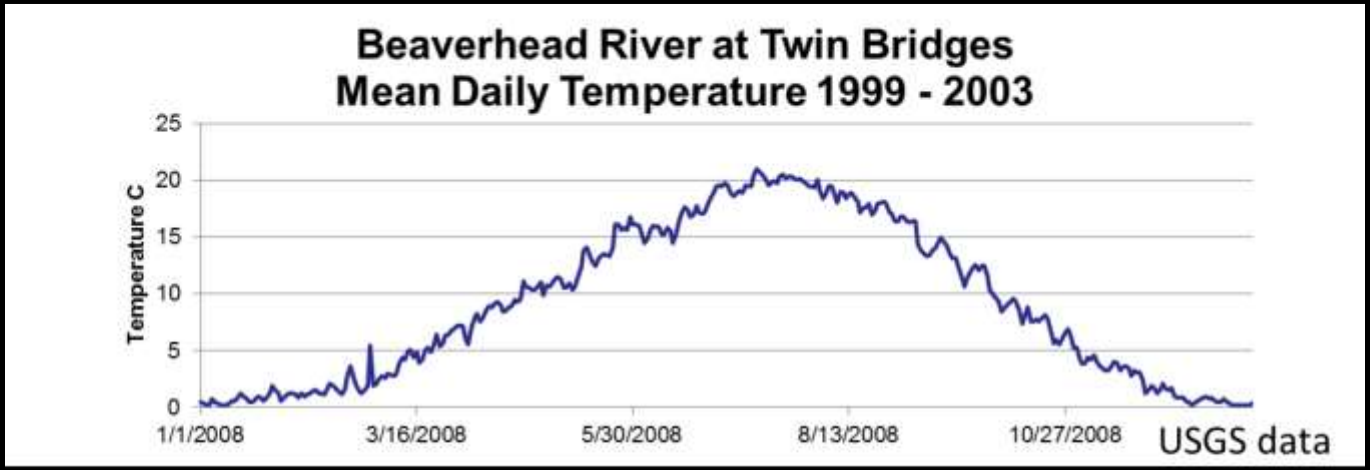


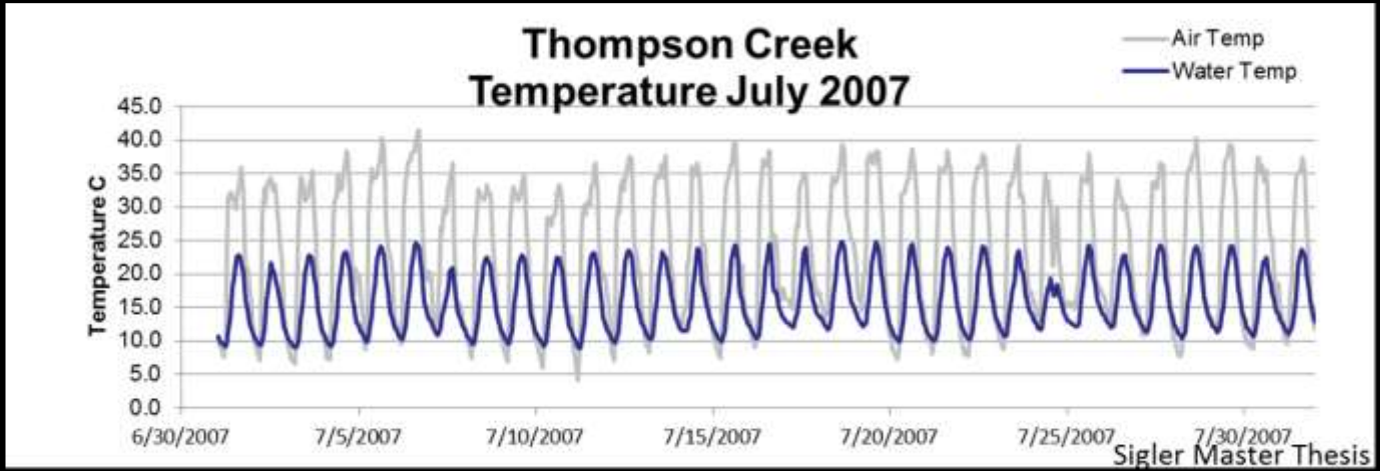
Similar issues pH issues with another program

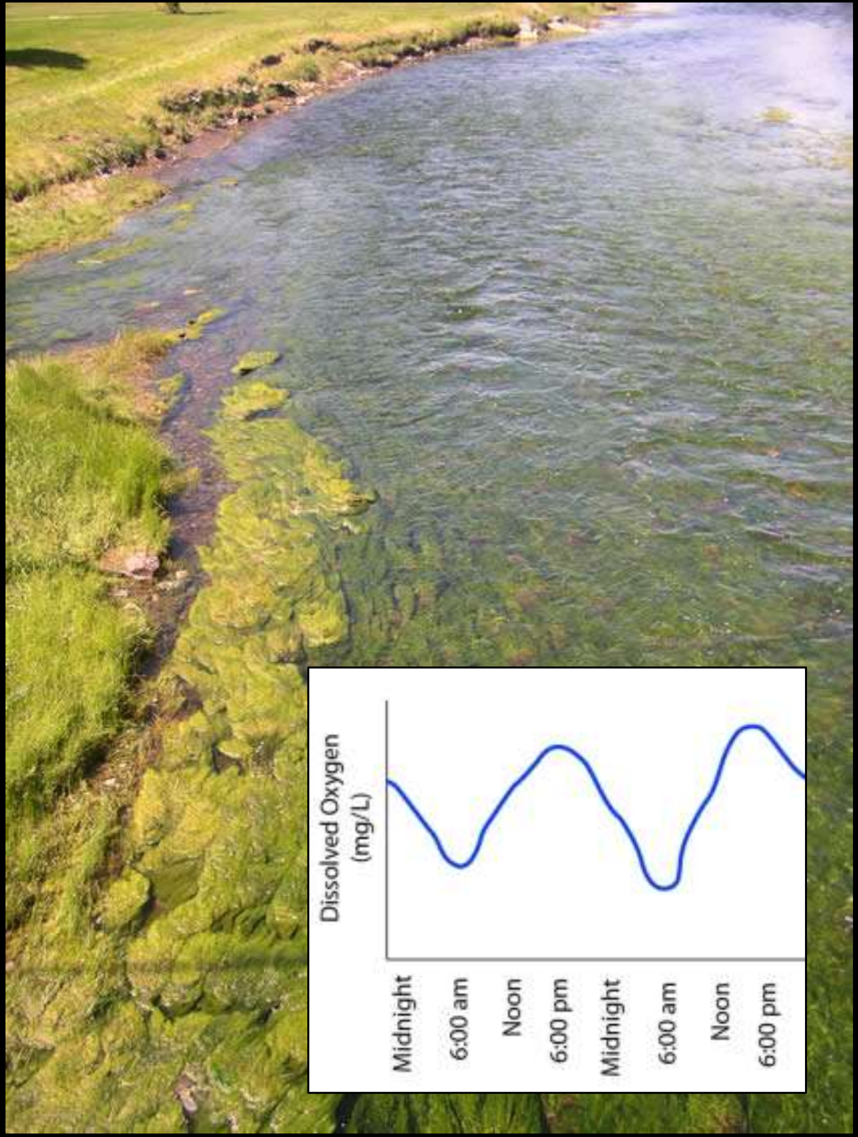
Detailed calibration log with time to pH equilibration



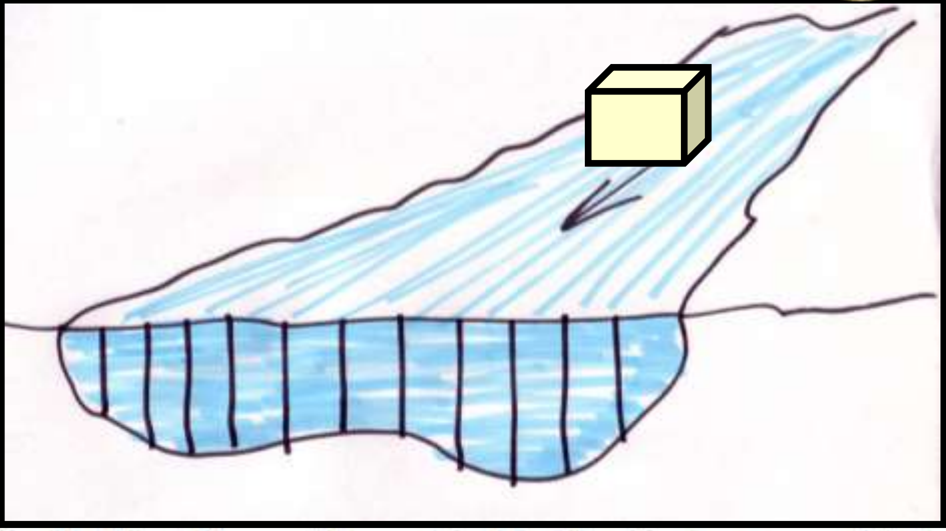
Field Parameters – diel variation

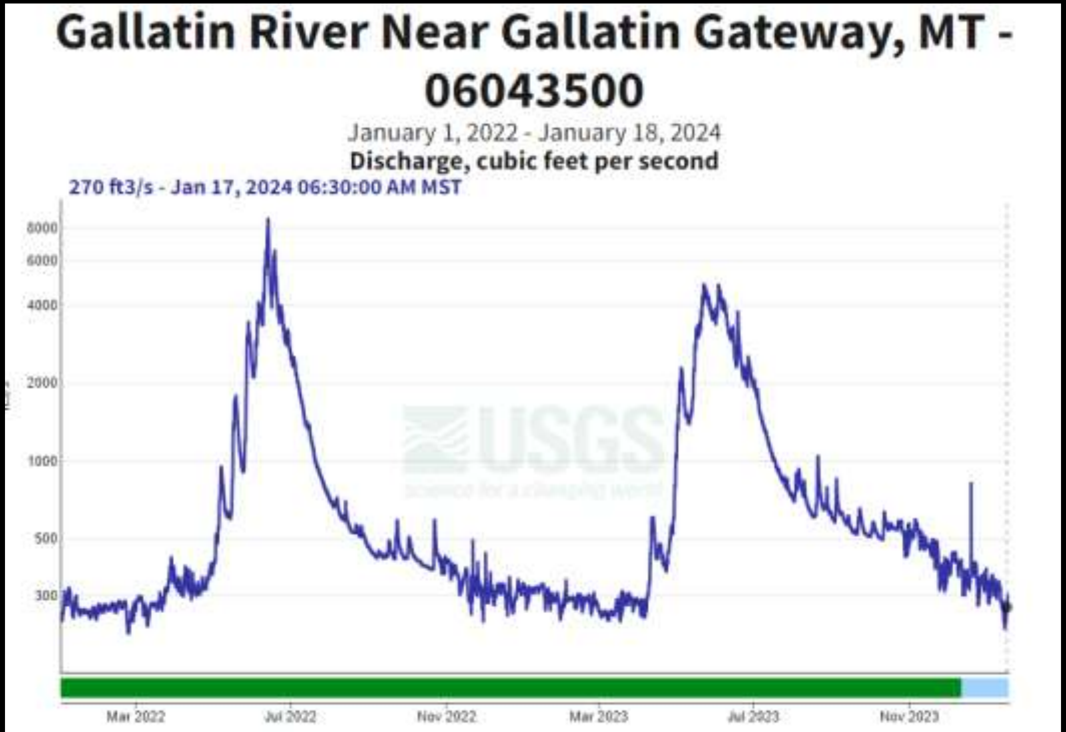


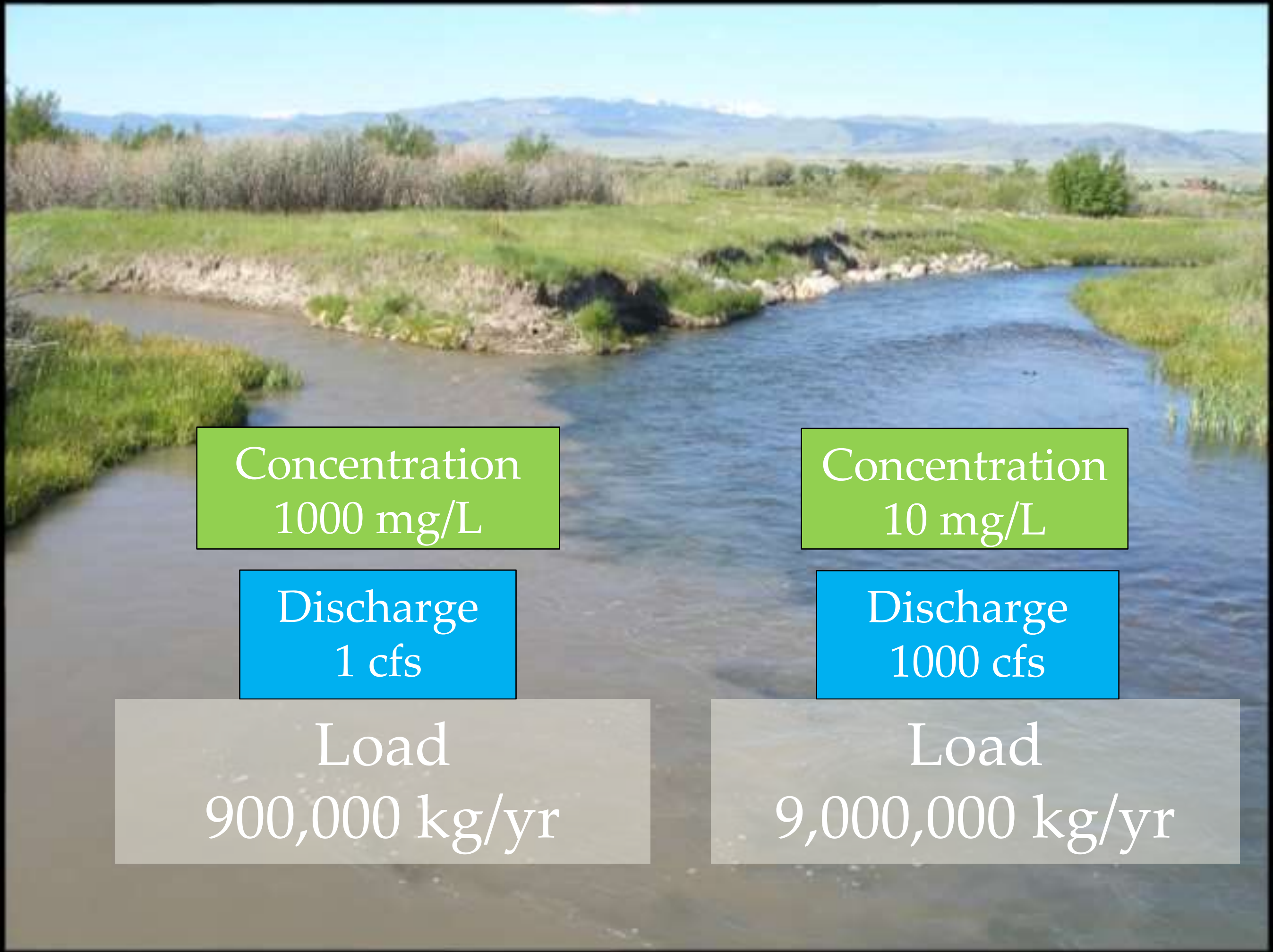




Discharge – What and Why



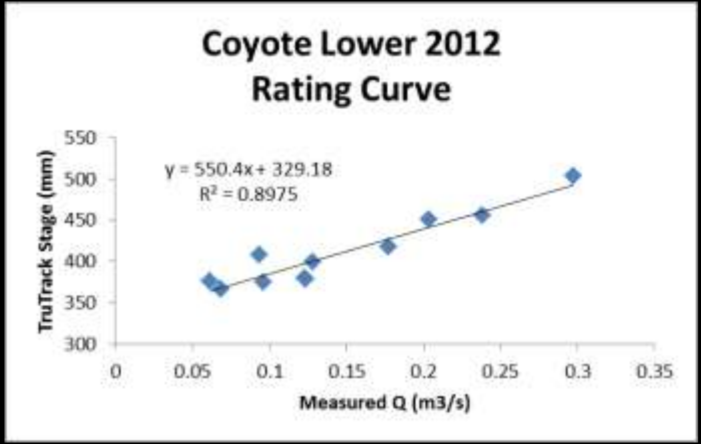


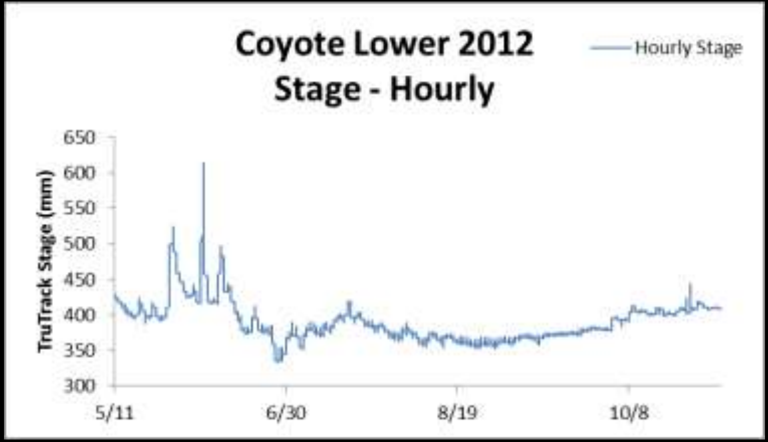


Discharge – methods summary

Rating Curves and Hydrographs

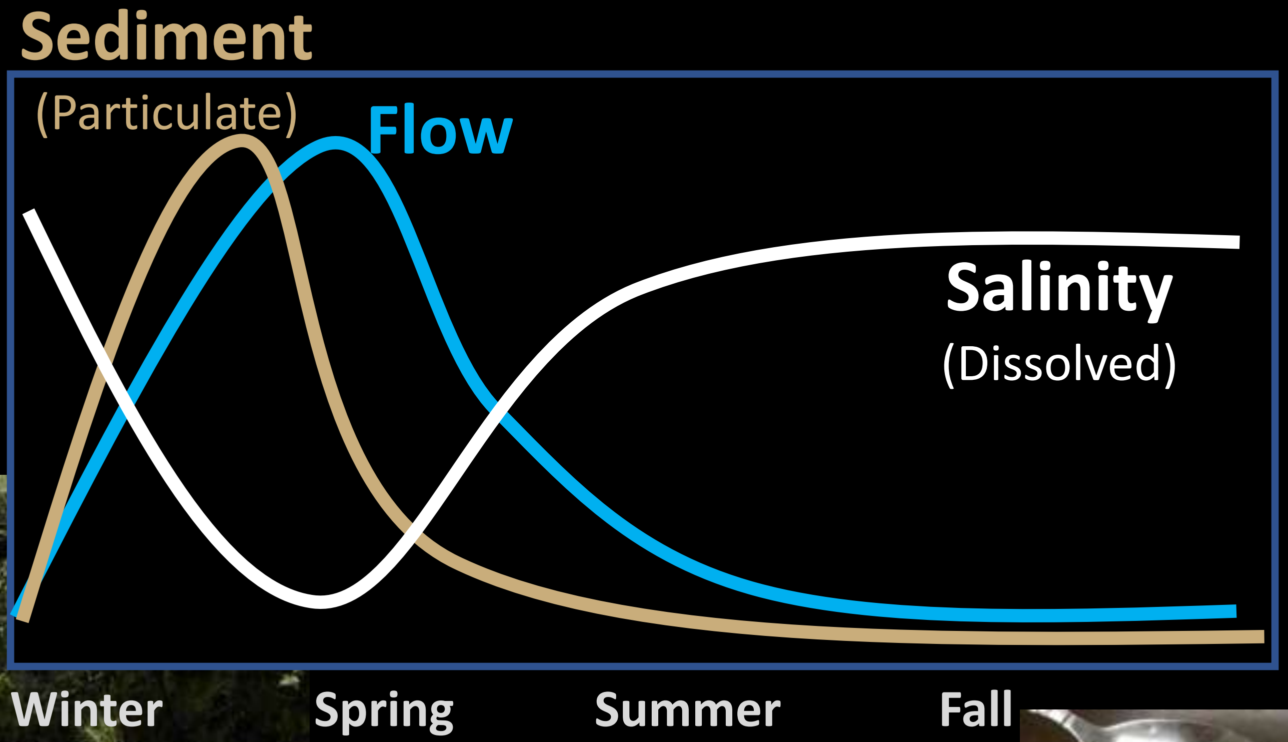
Date	Time	Q measured (m^3/s)
5/17/2012	12:50	0.1285125
5/22/2012	17:15	0.1775925
5/30/2012	11:30	0.238431
6/6/2012	12:30	0.297165
6/12/2012	8:50	0.20349
6/19/2012	13:30	0.123012
6/26/2012	17:15	0.12363
7/11/2012	10:10	0.061506
8/8/2012	12:30	0.068563
9/23/2012	11:00	0.096135
11/4/2012	10:30	0.0935

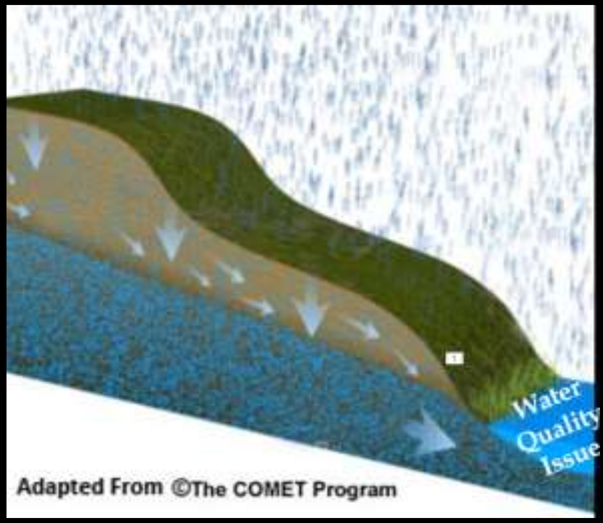


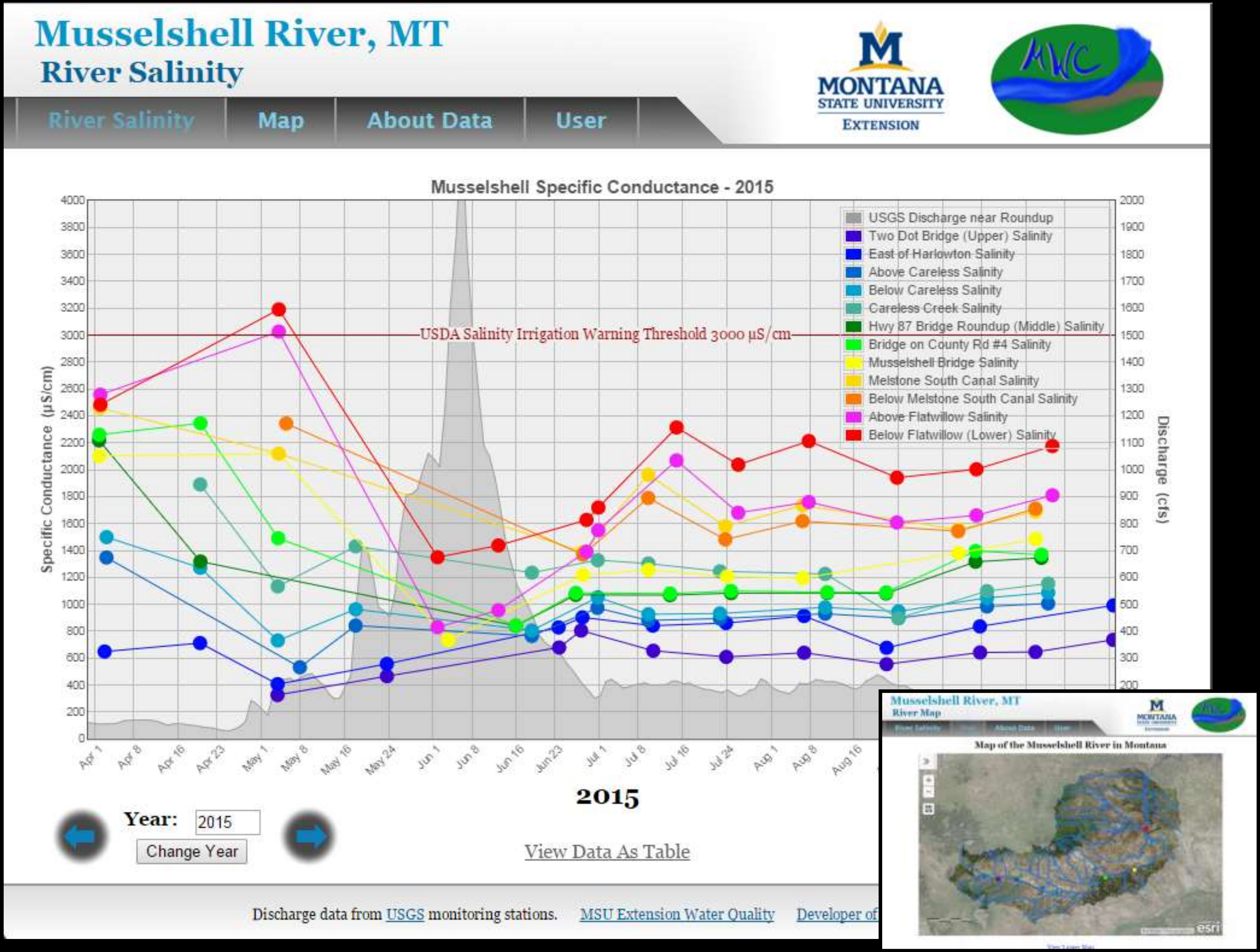


Float Method

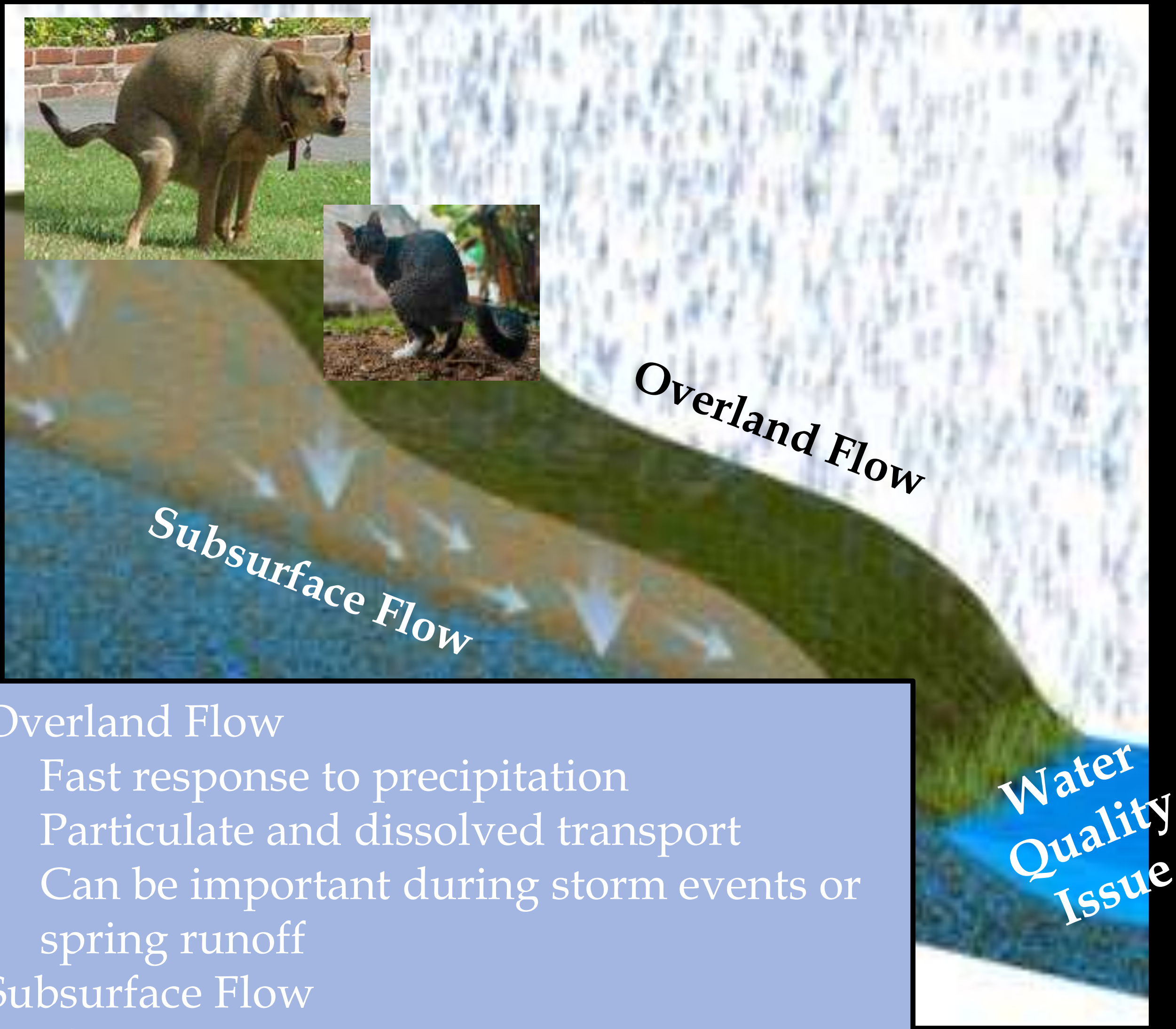
Water Quality - Patterns in Nature





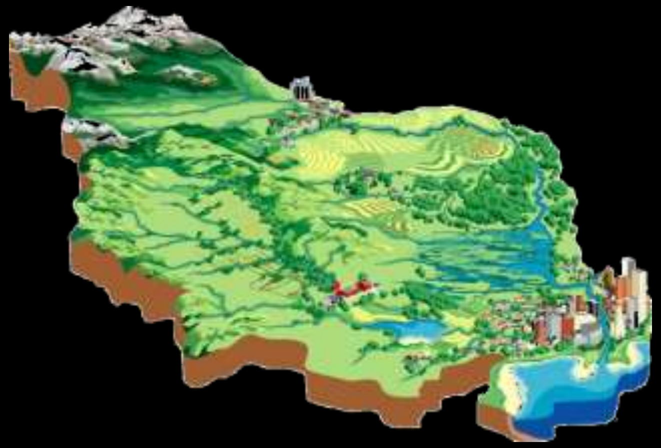

Musselshell River, MT
River Salinity
River Salinity
Map
About Data
User
MONTANA STATE UNIVERSITY EXTENSION
MWC
Musselshell Specific Conductance - 2015
USGS Discharge near Roundup
Two Dot Bridge (Upper) Salinity
East of Harlowton Salinity
Above Careless Salinity
Below Careless Salinity
Careless Creek Salinity
Hwy 87 Bridge Roundup (Middle) Salinity
Bridge on County Rd #4 Salinity
Musselshell Bridge Salinity
Melstone South Canal Salinity
Below Melstone South Canal Salinity
Above Flatwillow Salinity
Below Flatwillow (Lower) Salinity
USDA Salinity Irrigation Warning Threshold 3000 µS/cm
Specific Conductance (µS/cm)
Discharge (cfs)
Apr 1
Apr 8
Apr 16
Apr 23
May 1
May 8
May 16
May 24
Jun 1
Jun 8
Jun 16
Jun 23
Jul 1
Jul 8
Jul 16
Jul 24
Aug 1
Aug 8
Aug 16
2015
Year:
2015
Change Year
View Data As Table
Discharge data from USGS monitoring stations.
MSU Extension Water Quality
Developer of
Musselshell River, MT
River Map
MONTANA
Map of the Musselshell River in Montana
esri

Water Quality Issues in a Landscape Context



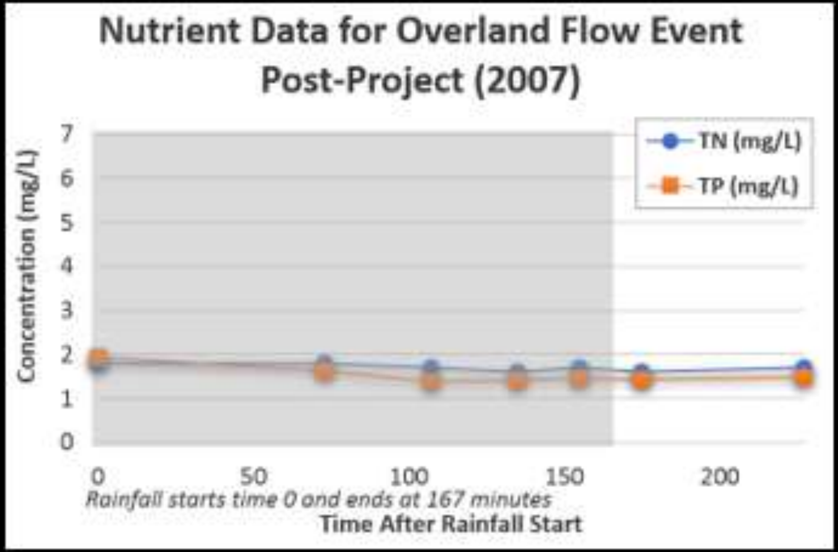
Overland Flow
- Fast response to precipitation
- Particulate and dissolved transport
- Can be important during storm events or spring runoff

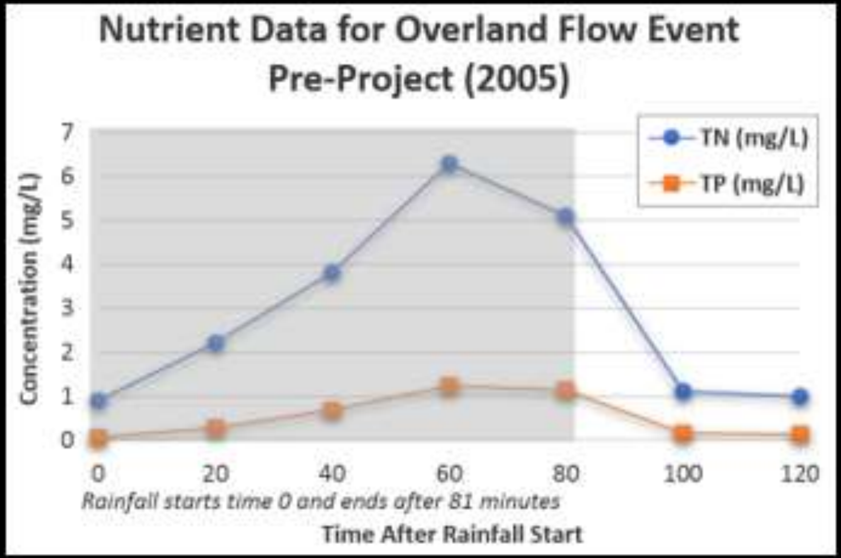
Subsurface Flow
- Slow response to precipitation
- Dissolved transport
- The source of discharge during baseflow



1. Primary sources?
2. Spatial distribution of sources?
3. Pathways of delivery to receiving water?
4. Timing of delivery to receiving water?
5. Driver of the issue –what is the causal mechanism that links the above elements to explain the root of the issue?

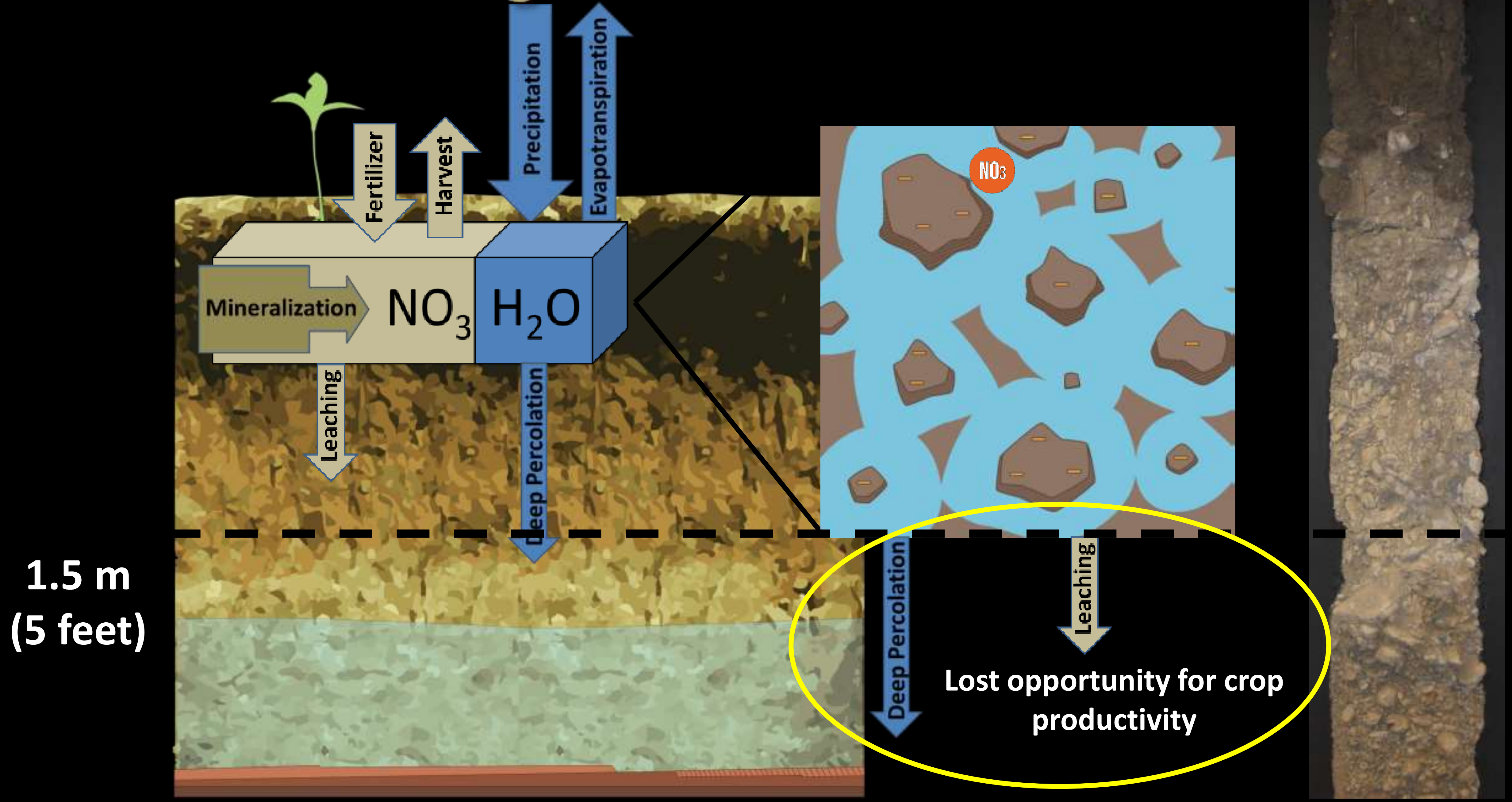
Riparian Vegetation = Natural Pollution Filtration



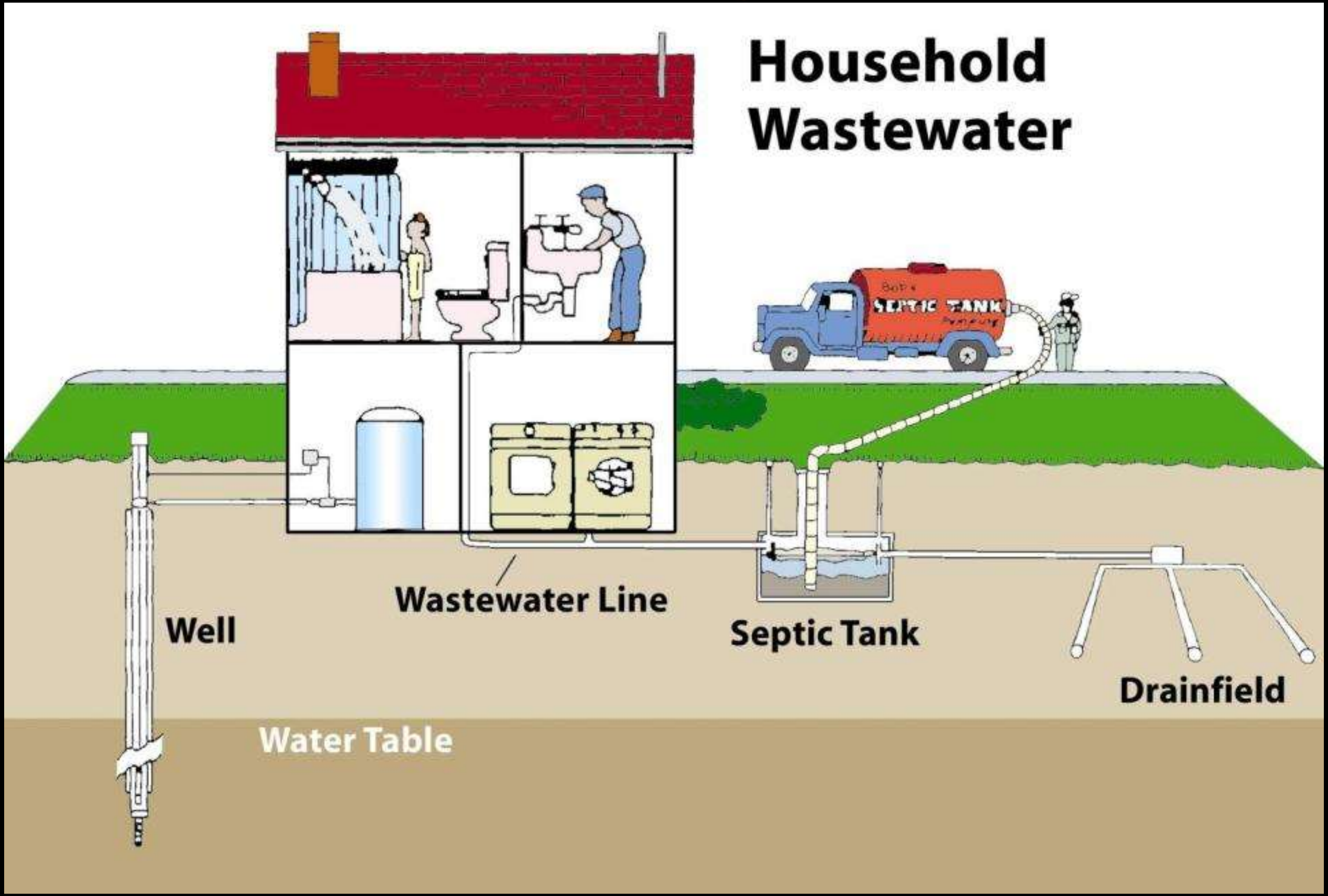


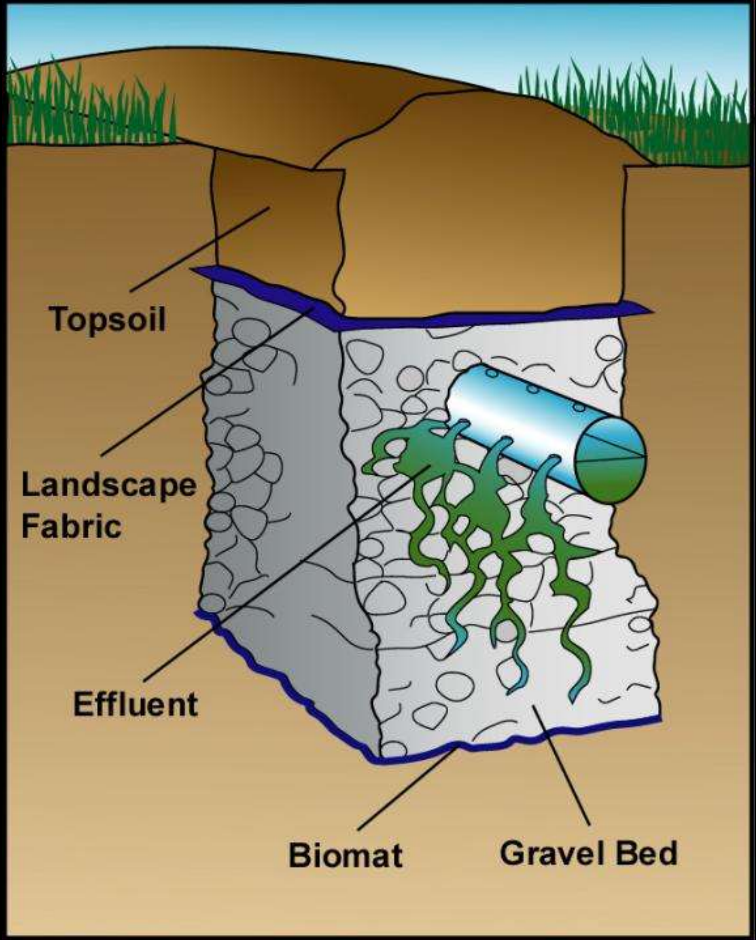
Photos from Adam Sigler

Water and Nitrogen in Soil

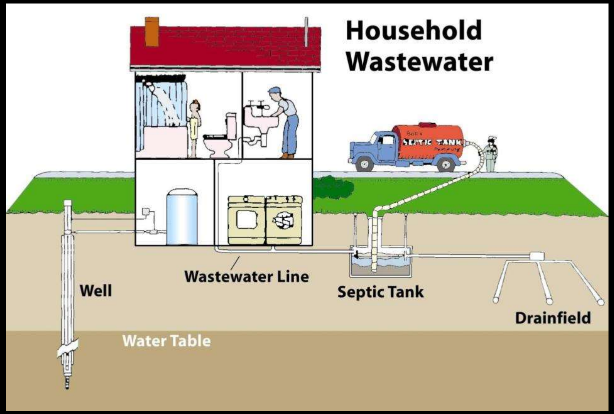


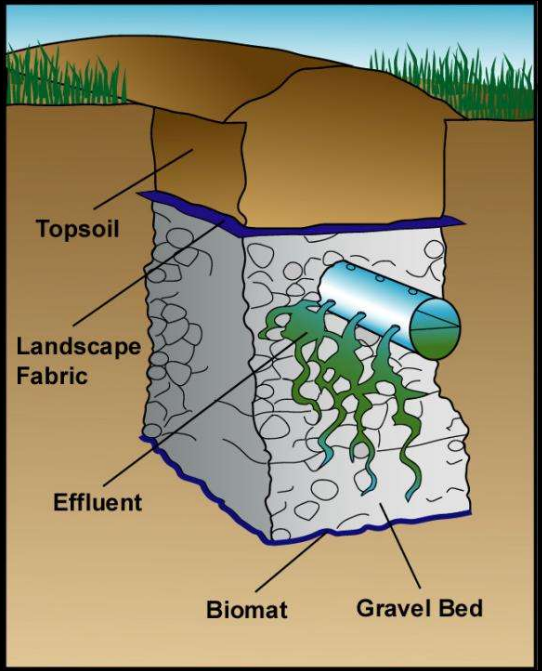
Well and Septic Owner Education



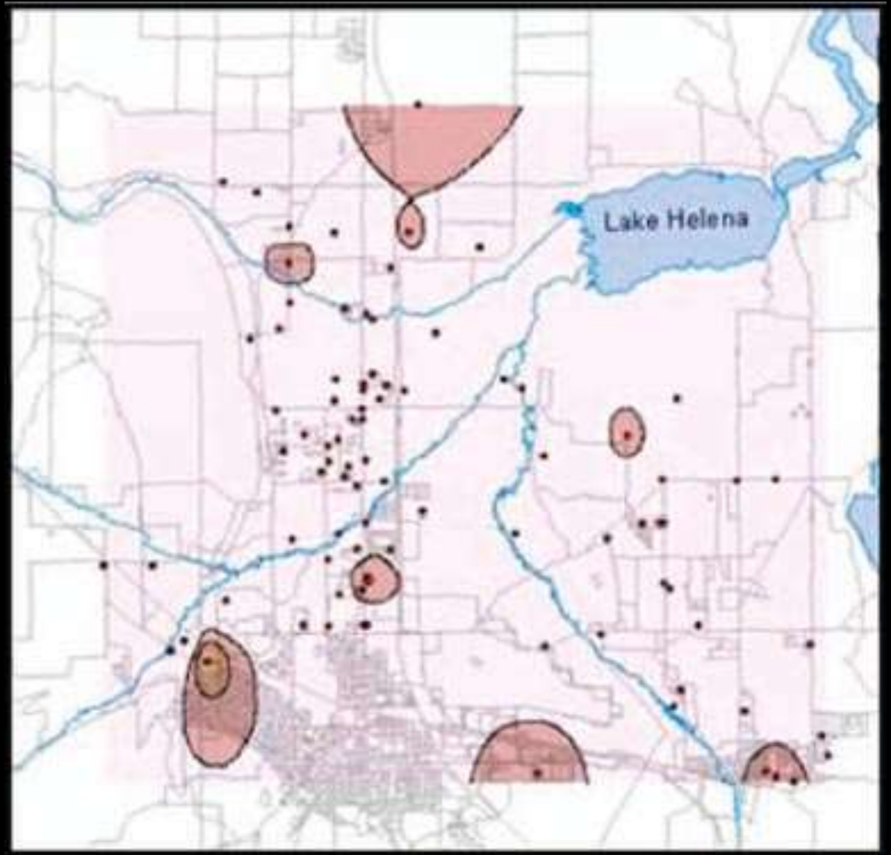


Helena Nitrate Map Study

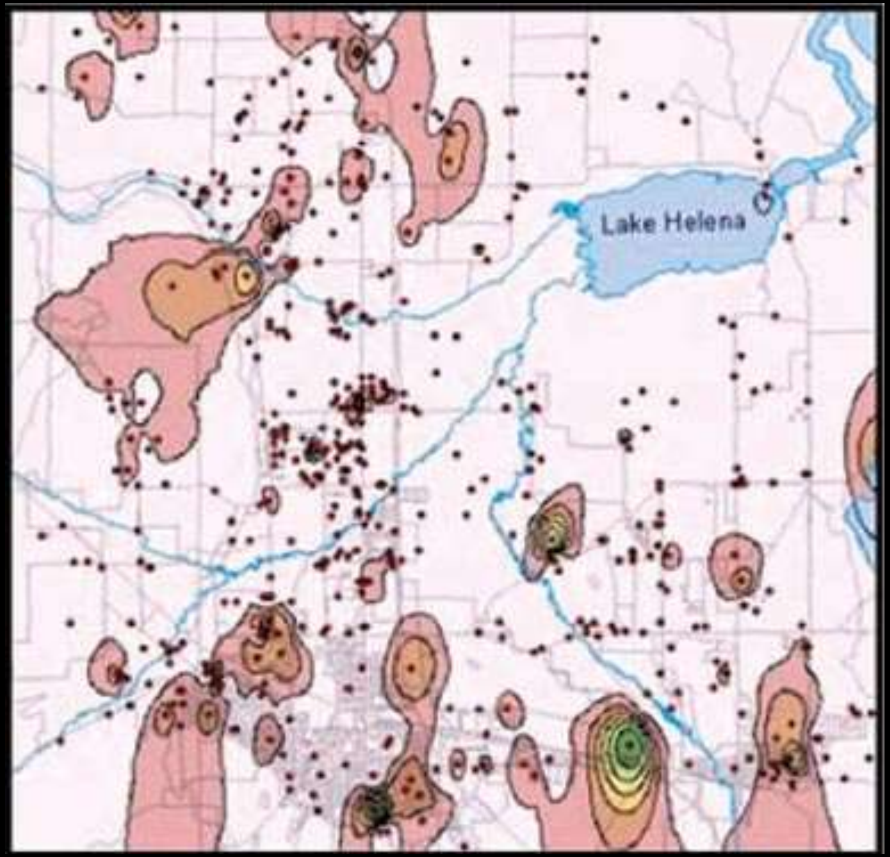




Nitrate – Helena, MT 1970

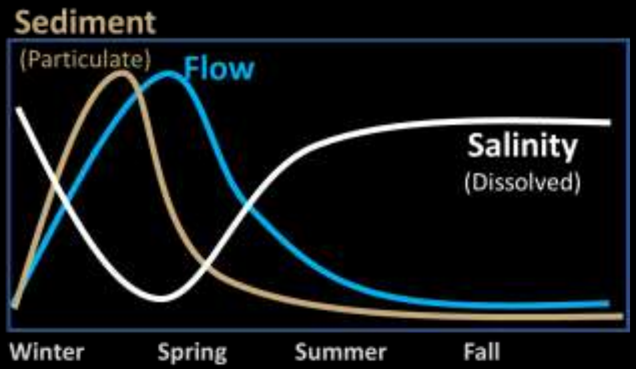


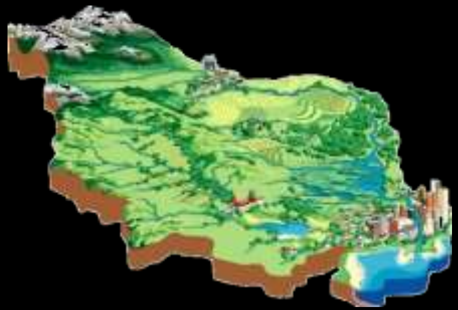
Nitrate – Helena, MT 2000



Drake and Bauder, 2005 Ground Water Monitoring and Remediation

Water Quality Issues in a Landscape Context





1. Primary sources
2. Spatial distribution of sources
3. Pathways of delivery to receiving water
4. Timing of delivery to receiving water
5. Driver of the issue

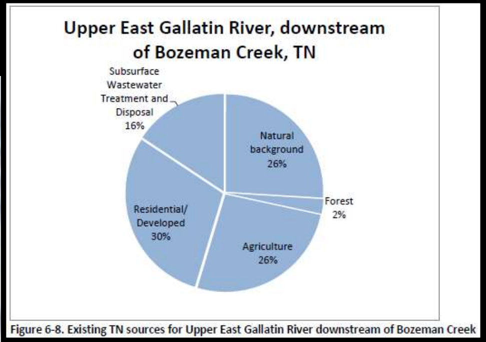
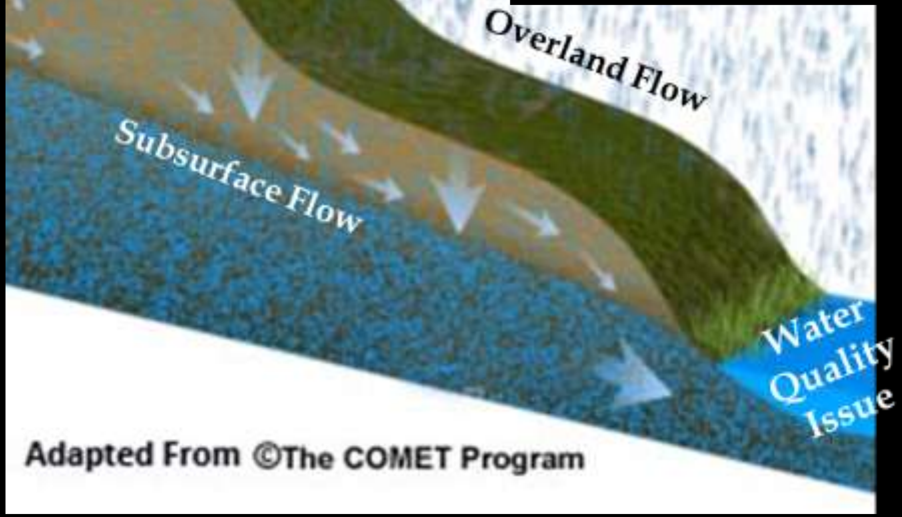
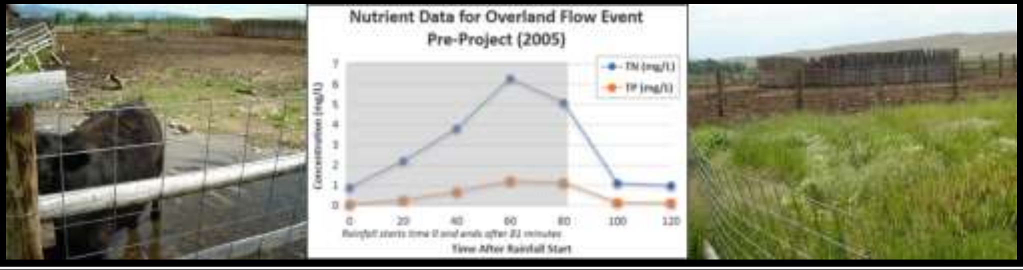


Figure 6-8. Existing TN sources for Upper East Gallatin River downstream of Bozeman Creek

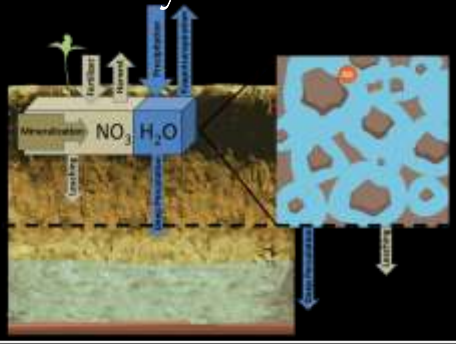


Driver: What is the causal mechanism that links the above elements to explain the root of the issue?

Surface Runoff



Groundwater Pathway



Take Home Points

1. **High quality water**," is a **subjective** term that requires knowledge of an intended **beneficial use** for definition
2. **Nonpoint source pollution** currently impairs more stream miles in the US than point source pollution and requires **public engagement** because compliance is **voluntary**
3. Fish care about **concentrations** vs. managers who care about **loads**
4. **Solving** water quality issues requires understanding:
    1. Primary **sources**
    2. Spatial **distribution** of sources
    3. **Pathways** of delivery to receiving water
    4. **Timing** of delivery to receiving water
    5. **Driver** of the issue –what is the causal mechanism that links the above elements to explain the root of the issue?

Resources

Volunteer Monitoring Planning Catalogue

VOLUNTEER MONITORING PLANNING CATALOGUE

DEQ MONTANA | MONTANA STATE UNIVERSITY EXTENSION

This guide covers key considerations for each step of planning a successful monitoring project and highlights key resources available to help you. Review this guide before you start and refer to it throughout the planning process.

THE SPARK

Why do you want to do monitor water quality?

What questions will data help you answer?

PLAN AHEAD

Start planning at least a year in advance...

- Time is valuable
- Avoid collecting data that already exists, isn't useful, or that you don't know how to interpret.
- Monitoring requires knowledge, skill, equipment, and time – prepare in advance.

GOALS = desired outcomes

Goals can be broad and help you articulate your interests, concerns, motivations, and what you hope to achieve.

Common water quality monitoring goals include:

- Evaluating current conditions
- Establishing a baseline for future comparisons
- Identifying sources of pollution
- Evaluating if projects effectively improved water quality
- Analyzing trends over time
- Education and outreach

For guidance on developing goals and objectives, see

"Water Resource Monitoring Methods Selection Guidance" (MMSG)

(Makarowski and Sigler, 2019)

START WRITING A SAMPLING AND ANALYSIS PLAN (SAP)

What is a SAP?

A document that describes your goals and monitoring objectives and the procedures you will use to collect and analyze data to achieve them.

Why write a SAP?

- Will improve the quality of your data.
- Communicates your objectives and instructions to volunteers, labs, funders, your board, etc.
- Documents which methods were used for people using your data in the future.

Audience

Consider who will use your SAP and what their level of technical expertise is.

Approval

Who must approve your SAP and what are their approval criteria?

Use a SAP template to guide your writing:

- Start by drafting your goals and project background.
- Use placeholders and fill in the details as you proceed through the steps and develop your plan.

Include these sections:

- Introduction (Overview, goals, monitoring objectives)
- Project Team and Responsibilities
- Sampling Design (parameters, site locations, sampling schedule, field and lab methods, forms)
- Quality Assurance and Quality Control
- Data Management and Record Keeping
- Data Analysis & Reporting
- Health & Safety
- Budget

Finalize your SAP before your first monitoring event.

Sampling and Analysis Plans

What is a SAP?

- It's all in the name…

Purpose

- Document WHO, WHAT, WHEN, WHERE and WHY of your monitoring.
- To guide your volunteers
- To communicate your plans

Audience

- You
- Volunteers
- The lab
- Funders
- Data users
- Future monitoring coordinators

Key components

- Background
- Goals, Objectives
- Project team and responsibilities
- Sampling design
- Monitoring procedures and equipment
- QA/QC
- Data management
- Data analysis
- Reporting
- Health & safety
- Budget

Monitoring Method Selection Guide Overview

VOLUNTEER MONITORING PLANNING CATALOGUE

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DEQ MONTANA

MONTANA STATE UNIVERSITY EXTENSION

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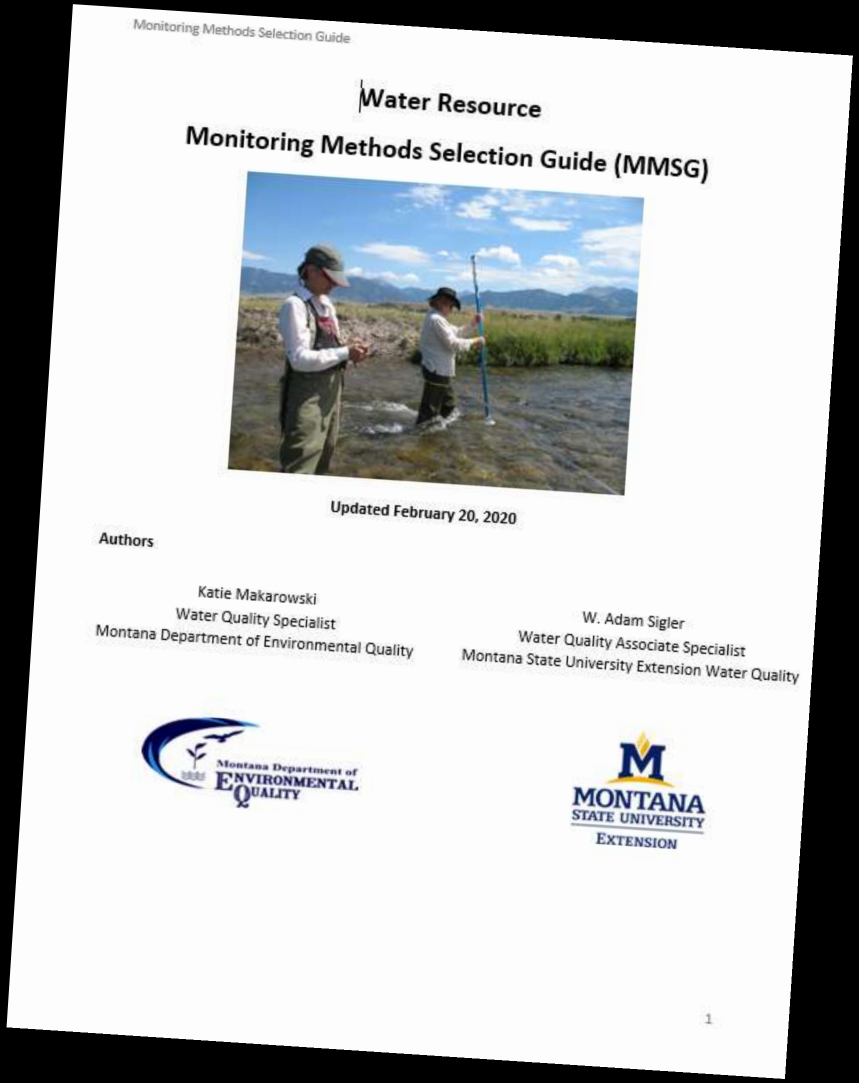
- Budget

Finalize your SAP before your first monitoring event.

- Started as a compilation of field methods
- Developed into a framework for identifying appropriate field methods



Monitoring Methods Selection Guide

Water Resource

Monitoring Methods Selection Guide (MMSG)

Updated February 20, 2020

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Montana Department of Environmental Quality

MONTANA STATE UNIVERSITY EXTENSION

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How to use this guide

This guide is to help people while designing monitoring efforts to articulate monitoring objectives to achieve goals, select appropriate parameters to achieve those objectives, and select appropriate monitoring methods for each parameter.

A **goal** is a desired outcome from an effort and can be relatively broad.

Example Goal 1: Address the algae concern in Spring Creek. (related to Current Conditions; Section 1)

Example Goal 2: Identify pollution source(s) that are contributing to impairments in Dell Creek. (related to Source Assessment; Section 2)

Step 1: State your goals

Prior to using this guide to determine your objectives, parameters of interest, and data collection methods, it is important to clarify your goals. The sections of this document are organized around five categories of goals: Section 1: Current Conditions, Section 2: Pollution Source Assessment, Section 3: Project Effectiveness, Section 4: Trends, and Section 5: Outreach and Education.

An **objective** is more focused than a goal and outlines specific and measurable steps for achieving your goal. Objectives should typically start with the word "To" and include the following details:

- A specific parameter or group of parameters
- A specific location or reach of a waterbody
- A relevant timeframe
- Specific context that is central to the question.

Step 2: Articulate your objectives and select associated parameters of interest

For each of your goals, browse the list of general objectives and associated parameters in Sections 1-5 of this document. These sections contain general objectives to provide ideas, but they are missing the specifics needed to make your objectives complete. Write your own detailed objectives, including specific parameters of interest, using the examples of detailed objectives provided in blue boxes throughout document for guidance.

Example Objective: To determine changes in nitrate concentration between point A and point B during July and August in the town section of Dell Creek where the highest septic system density occurs.

Step 3: Select methods associated with identified parameters

See the Section titled "Index of parameters" to find standard operating procedures (SOPs) for each of the parameters you have selected to monitor. The appendix contains an overview of each method and step-by step instructions for many common data collection methods.

Step 4: Write your SAP and SOP to document your sampling plan

Summarize your goals, objectives, parameters, and methods into a Sampling and Analysis Plan (SAP). The Additional Resources section has guidance for SAP development. Your SAP should be accompanied by a Standard Operating Procedure (SOP) which provides detailed instructions for use in the field; the SOPs in the appendix can be adapted to develop your own.

How this guide is organized

The sections of this guide are organized by categories of goals, and sections are in a logical order which often follows the evolution of monitoring programs over time.

- A group might first be interested in determining the **current condition** of water resources (Section 1).
  - A subsequent objective might be identifying **sources of pollution** (Section 2), used to guide implementation of water quality improvement projects.
    - After projects are implemented it is prudent to follow-up with **project effectiveness monitoring** (Section 3).
      - Finally, **trend analysis** (Section 4) allows your group to determine how conditions change over time.

An additional important and ongoing objective for many watershed groups is to provide outreach and education to increase knowledge, engagement, and stewardship of water resources in their local communities. Methods for education-based monitoring and assessing the success of your outreach efforts are presented in Section 5.

This guide also includes a glossary, a list of additional resources, an index of parameters, and an appendix with standard operating procedures for a variety of monitoring methods.

MMSG Goal Identification

1. Current conditions

Gathering information on current conditions provides a snapshot of a waterbody's health that can be used for a variety of purposes. The method you select for monitoring your parameter(s) of interest should be tailored to the reason you are assessing current conditions.

> Example: Presence of water quality concerns
>
> Locals have observed algae growth in Elm Creek downstream from where the Elm Creek Spring flows into the creek and are curious whether high nutrient concentrations in the spring could be contributing to the issue.
>
> Their **objective** is:
>
> "To characterize nutrient concentrations in the Elm Creek Spring by collecting samples from the spring orifice each month from July – September for nitrogen (TN), phosphorus (TP), nitrate + nitrite (NO_{2+3}), and ammonia (NH_{3+4}) analysis."

One common reason for collecting information on current conditions is to determine whether there are water quality concerns. To accomplish this, you should compare your collected data to the water quality standards or other thresholds that relate to the concern. See the "Additional resources" section for water quality references.

Another reason your group might monitor current conditions is to determine conditions prior to an anticipated change in the watershed (for example, a change in land management or implementation of a restoration project). Monitoring before an anticipated change is called "baseline monitoring." Baseline data can be compared to similar data collected after the change occurs to evaluate subsequent effects on water quality.

> Example: Baseline conditions monitoring
>
> A watershed group is working with a local landowner to provide an alternative water source for her livestock. Prior to this change, the group makes a goal to collect baseline information on the current health of the riparian area so they can quantify the success of their project later on.
>
> Their **objective** is:
>
> "To characterize riparian vegetation along the landowner's 0.5 mile stretch of Rocky Creek by performing a Greenline Assessment in August of the year prior to project implementation."

> Waterbodies that do not meet state water quality standards are considered "impaired waters." While only MDEQ has the jurisdiction to classify a waterbody as impaired, MDEQ may incorporate data collected by volunteers or others during water quality assessments if the data meets data quality and submittal requirements specified in MDEQ's assessment methods and elsewhere.
>
> See the Additional Resources section for links to Montana water quality standards and the MDEQ Clean Water Act Information Center where you can access Montana's list of impaired waters.

A list of objectives and relevant parameters associated with determining current conditions is provided below:

To characterize channel morphology and instream habitat

- Biology – large woody debris
- Physical – extent of undercut banks
- Physical – flood prone width and entrenchment ratio
- Physical – greenline to greenline width
- Physical – pool frequency (e.g., number of pools per 1000 ft)
- Physical – pool tail grid toss – percent fine sediment < 6mm in pool tails
- Physical – residual pool depth
- Physical – riffle pebble count with gravelometer – median particle size (D50)
- Physical – riffle pebble count with gravelometer – percent fine sediment <2mm and or < 6 mm in riffles
- Physical – Rosgen stream type
- Physical – water surface slope
- Physical – width/depth ratio

To characterize riparian vegetation

- Riparian – multiple indicator monitoring – greenline composition
- Riparian – multiple indicator monitoring – stream bank stability and cover

To characterize fine sediment deposition in critical habitats for fish or other aquatic life

- Physical – pool tail grid toss – percent fine sediment < 6mm in pool tails
- Physical – riffle pebble count with gravelometer – percent fine sediment <2mm and or < 6 mm in riffles

To characterize nutrient concentrations

- Chemistry – dissolved oxygen – daily delta
- Chemistry – water samples for chemical constituents (TN, TP, NO2+3, NH3+4)

To characterize metal concentrations

- Chemistry – water samples for chemical constituents (metals)
- Chemistry – water samples for chemical constituents (metals)

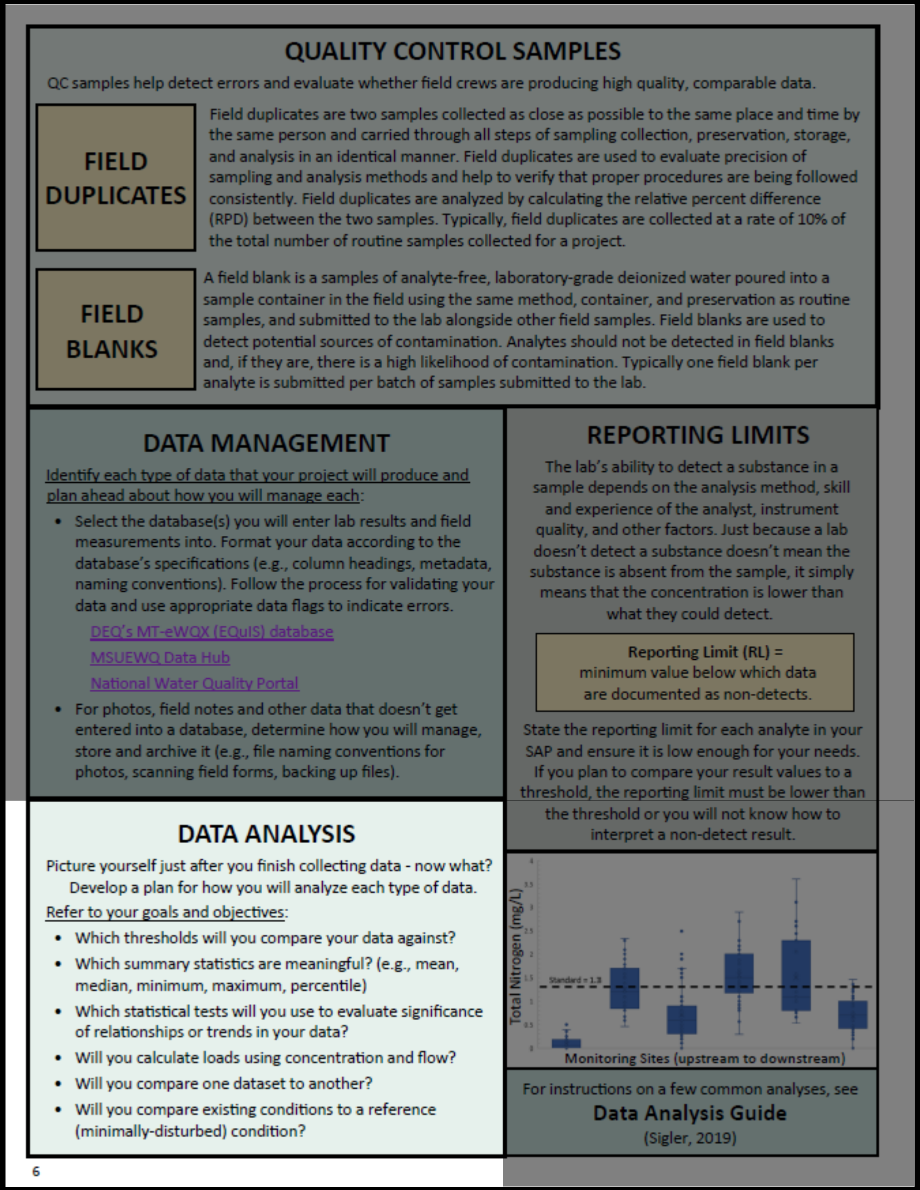
To characterize nuisance algae growth

- Biology – algae – harmful algal blooms
- Biology – benthic algae biomass (chlorophyll-a, ash-free dry mass)

To characterize the aquatic biological community

- Biology – fish community characterization
- Biology – macroinvertebrate assemblage
- Biology – periphyton assemblage: peri- 1 and peri-1 mod

Data Analysis



QUALITY CONTROL SAMPLES

QC samples help detect errors and evaluate whether field crews are producing high quality, comparable data.

FIELD DUPLICATES

Field duplicates are two samples collected as close as possible to the same place and time by the same person and carried through all steps of sampling collection, preservation, storage, and analysis in an identical manner. Field duplicates are used to evaluate precision of sampling and analysis methods and help to verify that proper procedures are being followed consistently. Field duplicates are analyzed by calculating the relative percent difference (RPD) between the two samples. Typically, field duplicates are collected at a rate of 10% of the total number of routine samples collected for a project.

FIELD BLANKS

A field blank is a samples of analyte-free, laboratory-grade deionized water poured into a sample container in the field using the same method, container, and preservation as routine samples, and submitted to the lab alongside other field samples. Field blanks are used to detect potential sources of contamination. Analytes should not be detected in field blanks and, if they are, there is a high likelihood of contamination. Typically one field blank per analyte is submitted per batch of samples submitted to the lab.

DATA MANAGEMENT

Identify each type of data that your project will produce and plan ahead about how you will manage each:

- Select the database(s) you will enter lab results and field measurements into. Format your data according to the database's specifications (e.g., column headings, metadata, naming conventions). Follow the process for validating your data and use appropriate data flags to indicate errors.
  - DEQ's MT-eWQX (EQuIS) database
  - MSUEWQ Data Hub
  - National Water Quality Portal
- For photos, field notes and other data that doesn't get entered into a database, determine how you will manage, store and archive it (e.g., file naming conventions for photos, scanning field forms, backing up files).

REPORTING LIMITS

The lab's ability to detect a substance in a sample depends on the analysis method, skill and experience of the analyst, instrument quality, and other factors. Just because a lab doesn't detect a substance doesn't mean the substance is absent from the sample, it simply means that the concentration is lower than what they could detect.

Reporting Limit (RL) = minimum value below which data are documented as non-detects.

State the reporting limit for each analyte in your SAP and ensure it is low enough for your needs. If you plan to compare your result values to a threshold, the reporting limit must be lower than the threshold or you will not know how to interpret a non-detect result.

DATA ANALYSIS

Picture yourself just after you finish collecting data - now what? Develop a plan for how you will analyze each type of data.

Refer to your goals and objectives:

- Which thresholds will you compare your data against?
- Which summary statistics are meaningful? (e.g., mean, median, minimum, maximum, percentile)
- Which statistical tests will you use to evaluate significance of relationships or trends in your data?
- Will you calculate loads using concentration and flow?
- Will you compare one dataset to another?
- Will you compare existing conditions to a reference (minimally-disturbed) condition?

For instructions on a few common analyses, see **Data Analysis Guide** (Sigler, 2019)

6

Catalogue (page 6)

DATA ANALYSIS

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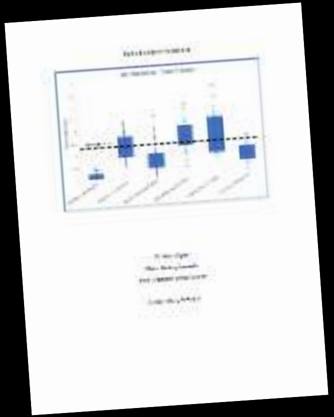
Data Analysis

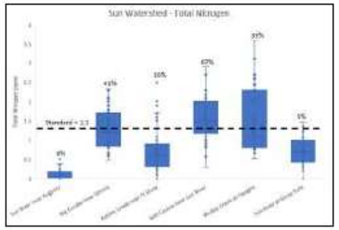


Contents

[Linked here you can find an Excel spreadsheet] used to create this box and whisker plot showing Total Nitrogen concentration by site and the percent of samples exceeding a concentration of interest. There is also a [video linked here] (24:08 minutes) which overviews the process for creating the plots.

1. Comparing data to thresholds

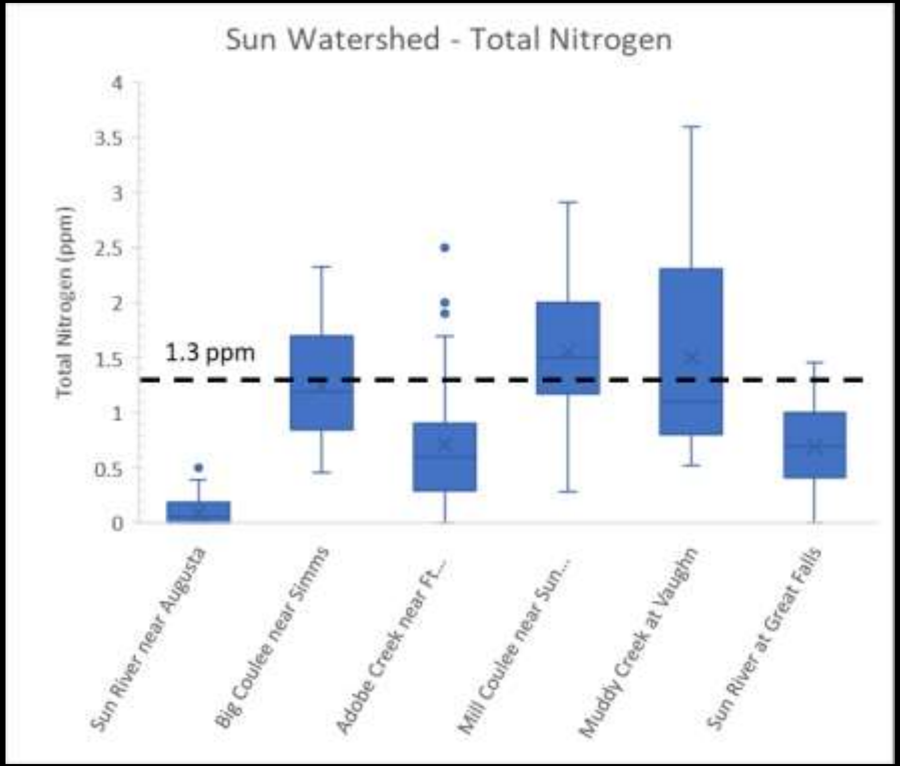
Water quality values are difficult to interpret without knowing what levels are of out of the ordinary or what levels may cause problems for people or organisms using the water. Depending on the water body, water quality standards have often been set to establish concentration targets to protect water for different uses. Different water quality is expected naturally in different parts of the state. High elevation streams and rivers in the western part of the state are naturally expected to have lower temperatures and lower salinity. Lower elevation streams, especially in the eastern portion of the state have naturally higher temperatures and higher salinity in many cases. Water quality standards are often different for different parts of the state and/or might only be applicable for certain parts of the year.



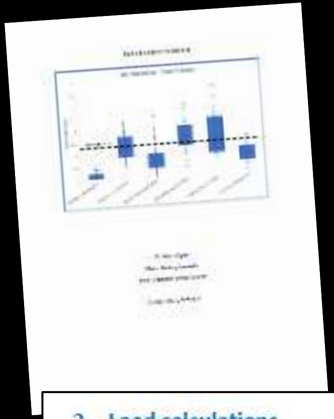
Linked here you can find an Excel spreadsheet used to create this box and whisker plot showing Total Nitrogen concentration by site and the percent of samples exceeding a concentration of interest. There is also a video linked here (24:08 minutes) which overviews the process for creating the plots.

Useful documents:

- Human drinking water – US EPA Maximum Contaminant Levels
  - These are national level standards that regulate maximum concentrations acceptable to provide to users on public water supplies. When surface water is used by public water supplies, it will always need to be treated to remove sediment and pathogens, so sediment and pathogen numbers measured in stream are not appropriate to compare to these standards.
- Montana general water quality – MDEQ circular 7
  - This document includes human drinking water standards from EPA as well as Montana specific standards for human recreation and aquatic life.
- Montana nutrient standards – MDEQ circular 12
  - This document includes standards for nitrogen and phosphorus for wadable streams in Montana. The standards differ based on Ecoregion and are applicable only in the summer months when nuisance algae is commonly an issue in streams.
- Stream classifications for Montana
  - In Montana streams are given a simple water use classification code with a letter and a number (example: B2), which determines what water quality standards apply. Most streams and rivers have letters A-C and numbers 1-3. The letters are related to expected salinity with A and B being low salinity, C being high salinity. The number is related to expected temperature with 1 being cold water, 3 being warm water, 2 being a stream reach transitional between warm and cold. This classification does not provide detailed insights about water quality expected for a stream. Classifications are outlined in Montana administrative rules, but for impaired streams it may be easiest to find classifications in the MDEQ Clean Water Act Information Center.



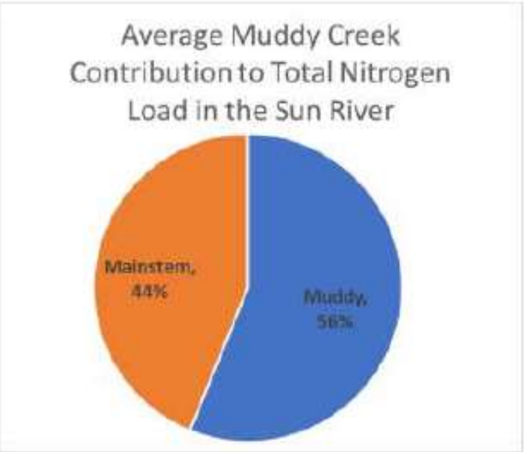
Data Analysi



Contents

2. Load calculations

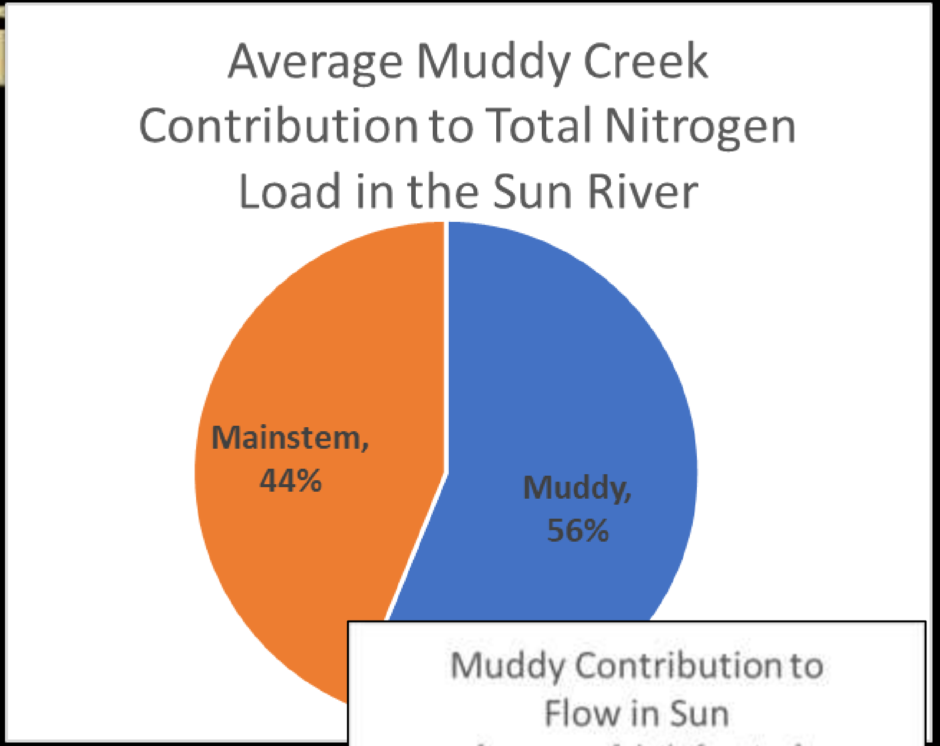
Assessing the fraction of pollutant contribution that different tributaries or stream sections are making to a river requires calculation of load (concentration times stream flow). The fraction of contribution from a tributary can be readily presented as a pie chart.

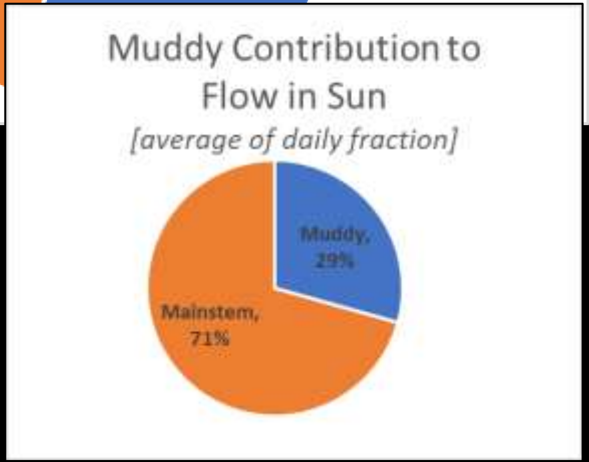


For example, the Sun River Watershed Group collects total nitrogen concentration data for various sites on the Sun River and tributaries. Two of the sampling locations have USGS gages at or near the site which provide daily flow data.

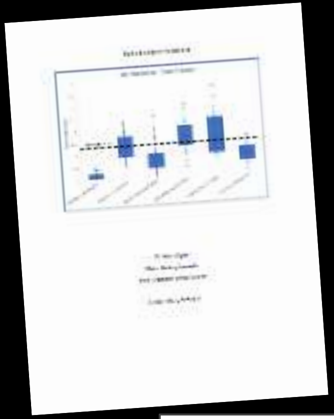
In this case, the total nitrogen load can be calculated for sampling days for the Sun River at Great Falls and for Muddy Creek near the confluence. The total nitrogen load for the mainstem of the Sun is estimated by difference so that the fraction of total nitrogen from Muddy Creek can be calculated.

A spreadsheet is available here, which has the calculations to convert concentration and discharge to load and create the example pie chart. A video is available here (41:31 minutes), which walks through downloading the nutrient data from the MSUEWQ data hub, downloading the flow data from USGS, calculating loads, and creating the pie chart.





Data Analysis

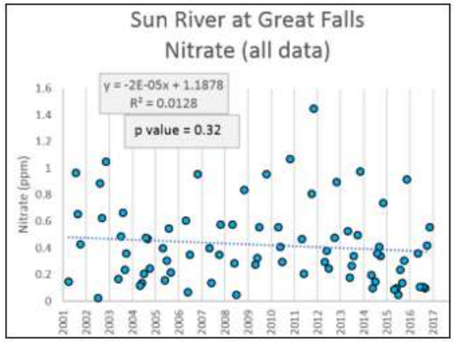


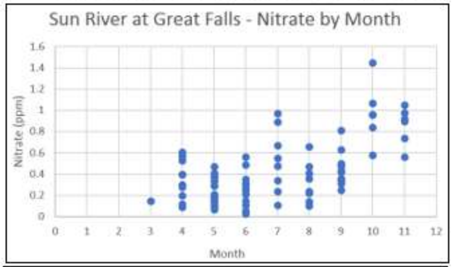
Contents

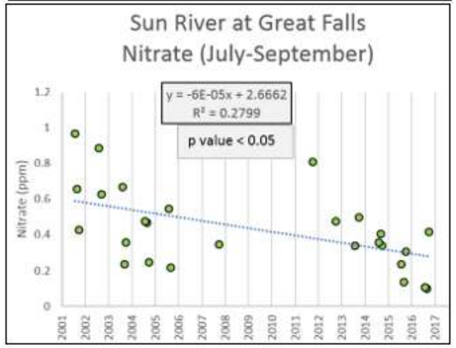
3. Trends over time

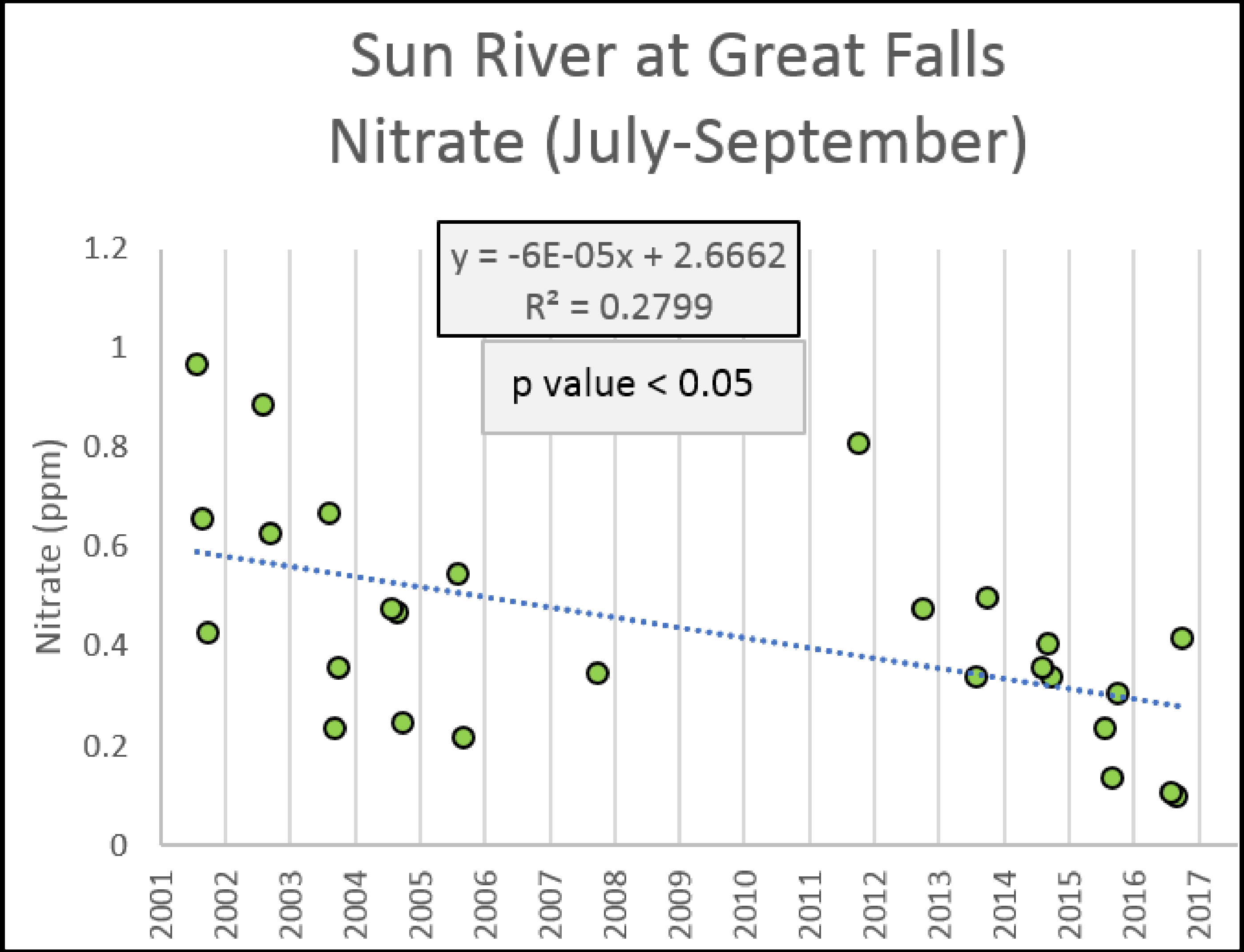
Tracking change over time in water quality can indicate whether management efforts are making a positive impact or whether increasing stressors in a watershed are degrading water quality. Assessment of trends in water quality data over time can be done qualitatively by simply plotting and looking at data. However, there is often a lot of variability in data naturally with seasons or flows, so statistics and/or looking at the data in more refined ways may be necessary.

Here is a link to a spreadsheet where these plots were created as an example and here is a link to a video (22:23 minutes) outlining how to make the plots and calculate the statistics. Looking at all of the nitrate data for the Sun River at Great Falls over a 15 year period (first figure) suggests a decreasing trend, but there is a lot of scatter in the relationship (low R^2) and the statistical significance of the relationship is weak (large p value.) Part of the reason for the scatter in the relationship is the predictable seasonal pattern in nitrate (second figure). If we look at the data for one season together, the relationship becomes clearer (third figure). Looking at the data seasonally may also be of interest because nuisance algae growth related to nutrients typically occurs in warm summer months and that is when numeric nutrient criteria apply in Montana.



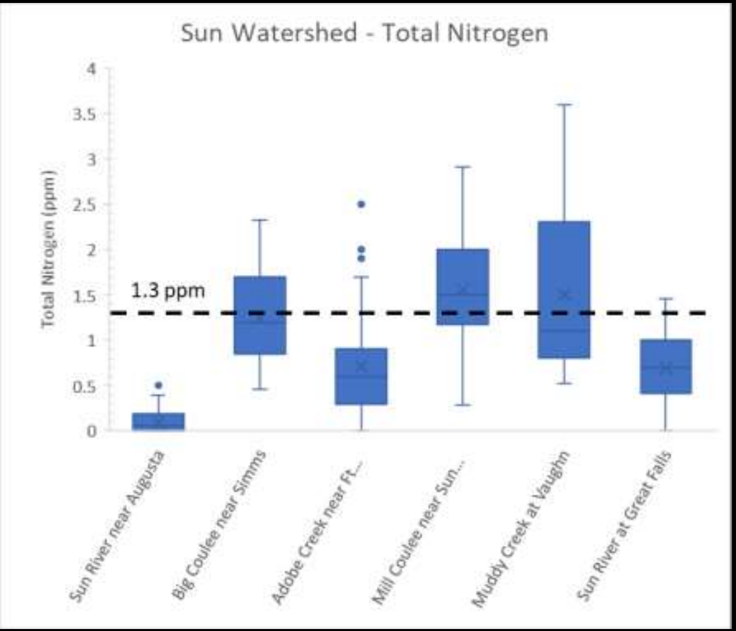




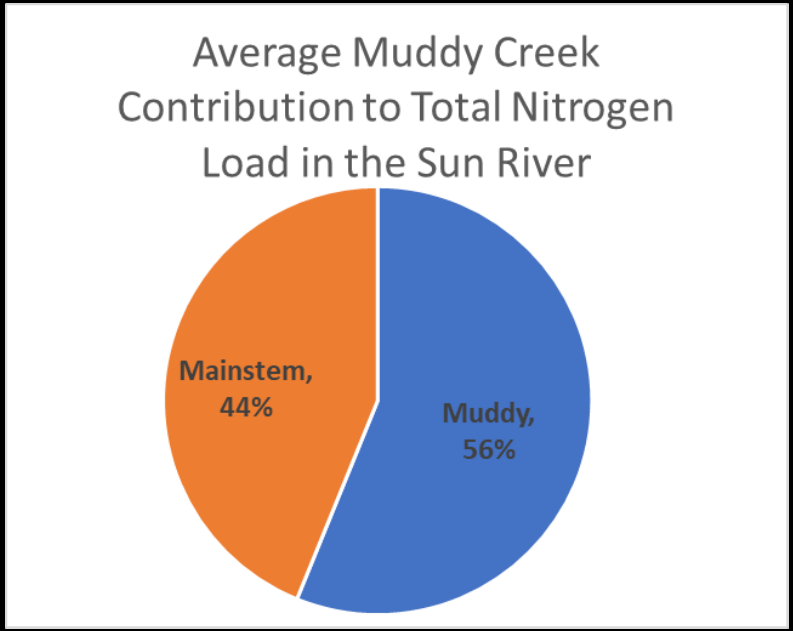


Data Analysis

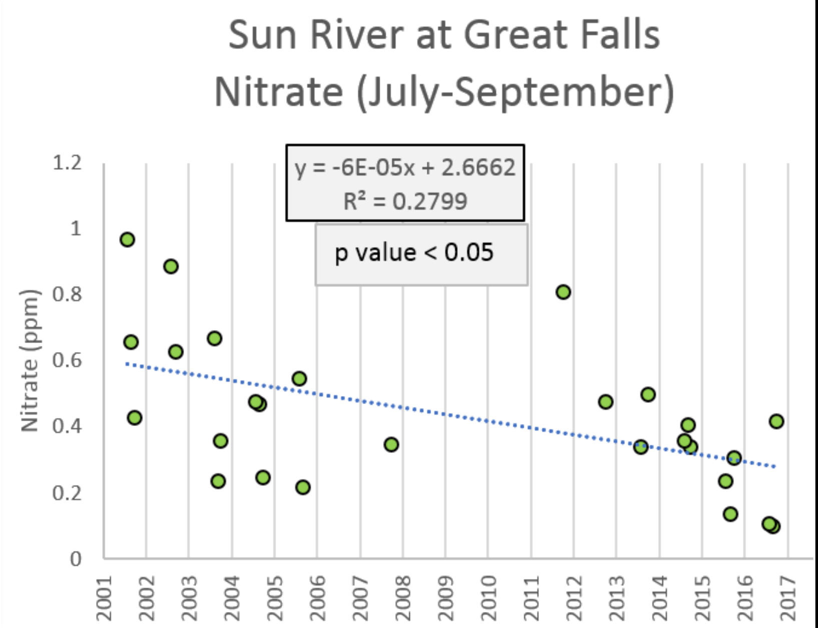
Compare to Threshold



Calculate Tributary Loads



Statistics for Time Trends



What analysis would you do on your data to answer your question?

MWCC Water Monitoring Website

MONTANA WATERSHED COORDINATION COUNCIL

HOME ABOUT US MONTANA'S WATERSHEDS MWCC RESOURCES GIVE

MWCC WATER MONITORING RESOURCES

Welcome to the Montana Watershed Coordination Council's Water Monitoring Resources Page. The MWCC Water Committee led the development of this centralized hub, which includes information about Montana's water monitoring programs as well as other resources relevant to watershed monitoring work.

In the Monitoring Directory, you can search for water monitoring programs statewide based on criteria including type of monitoring and objectives. You can also find contact information for the organizations leading these programs.

The Monitoring Library provides over 200 trusted resources relevant to watershed monitoring work, including tools for starting your own monitoring program.

Volunteer monitoring groups can use these webpages to identify other groups doing similar work or to find technical guidance. Additional support for volunteer monitoring groups in Montana is available through the Montana Department of Environmental Quality, Montana State University Extension Water Quality, and the Flathead Lake Biological Station's Monitoring Montana Waters Program.

Monitoring Directory

Information about water monitoring programs across the state

Monitoring Directory

Monitoring Library

A compilation of go-to resources to support monitoring efforts

Monitoring Library

MONTANA WATERSHED COORDINATION COUNCIL

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Questions and Discussion