EXPLORING NEVADA’S AMAZING WETLANDS

A Middle School Curriculum

Susan Donaldson
Mae Gustin
Melody Hefner

Published by the University of Nevada Cooperative Extension
Curriculum Materials–06–01
A Middle School Curriculum

Susan Donaldson and Melody Hefner
University of Nevada Cooperative Extension

Mae Gustin
University of Nevada
College of Agriculture, Biotechnology and Natural Resources

Curriculum Materials-06-01
Table of Contents

Introduction

Lesson 1:  There’s Water!  Is It a Wetland?
Lesson 2:  Is Dilution the Solution?
Lesson 3:  Man’s Filters: Cleaning Up Wastewater
Lesson 4:  Macroinvertebrate Clues
Lesson 5:  Getting at the Numbers: Measuring Water Quality
Lesson 6:  Wet and Wild: A Wetland Field Study
Lesson 7:  Macroinvertebrate Field Study
Lesson 8:  Natural Processing: Measuring Wetland Water Quality
Lesson 9:  Winning Solutions to Community Pollution

Appendices

Glossary

Resources

Safety Issues

Wetland Sites in the Truckee Meadows

Truckee River 2003 Water Quality Data from NDEP

Additional Web Sites for Local Water Quality Data

Funding courtesy of United States Department of Agriculture, Cooperative State Research, Education, and Extension Service (CSREES), National Integrated Water Quality Program

The University of Nevada, Reno is an equal opportunity affirmative action employer and does not discriminate on the basis of race, color, religion, sex, age, creed, national origin, veteran status, physical or mental disability, or sexual orientation in any program or activity it operates. The University of Nevada employs only United States citizens and aliens lawfully authorized to work in the United States.
Introduction

Wetlands are a precious but dwindling resource in Nevada and the United States. Since the 1700s, the United States has lost more than 50 percent of its wetland resources. Twenty-two states have lost 50 percent or more of their original wetlands. California has lost the largest percentage of original wetlands within the state (91 percent), while Florida has lost the most acreage (9.3 million acres). Estimates suggest that in the 1780s, Nevada was home to 487,350 acres of wetlands. By the 1980s, it was estimated that only 236,350 acres remained, less than half of the acreage present 200 years ago.

Today, according to the Nevada Bureau of Water Quality Planning, there are “approximately 14,988 miles of perennial rivers and streams, 126,257 miles of intermittent/ephemeral streams and channels, 1,782 miles of ditches/canals and 551 border miles of shared rivers. Nevada has 1,070 lakes, reservoirs or ponds with an approximate total acreage of 533,239 (these river and lake sizes are according to EPA’s "Total Waters Report") and approximately 136,650 acres of wetlands.” Only 28 percent of the wetlands present in the 1780s still remain intact today.

Wetlands perform an important role in water resource protection. When wetlands are lost or degraded, the impacts are dramatic, and include reduced water supplies, increased flood danger and damage, decreased ability to retain sediments and nutrients and to filter toxic chemicals from polluted water, impaired wildlife habitat, decreased recreation and tourism opportunities, and loss of unique ecosystems that contribute to our quality of life. Although wetland loss rates are slowing, the United States continues to lose approximately 70,000 to 90,000 acres of wetlands on non-federal, rural lands each year.

Currently, when wetlands are converted to other uses, it is common to require construction of “substitute” wetlands in other areas. However, these wetland mitigation
projects are expensive and often require years to mature. The water quality impacts resulting from the loss of wetlands may result in the need to construct expensive treatment plants at a high cost to communities. Wetland preservation provides a low-tech, low-cost alternative for water quality protection.

Northern Nevada’s Watersheds and Wetlands

The basic unit of water quality protection is the watershed. A watershed is the area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater. Homes, farms, ranches, forests, small towns, big cities and more can make up watersheds. Some watersheds cross county, state, and even international borders.

Watersheds come in all shapes and sizes. Some are millions of square miles; others are just a few acres. Just as creeks drain into rivers, watersheds are nearly always part of a larger watershed. Our area falls within the huge watershed called the Great Basin.

In the Truckee Meadows, our watershed is named after the primary river. The Truckee River is 105 miles long, and encompasses an area of about 3,060 square miles that spans two states: Nevada and California. Flow from Lake Tahoe drains into the Truckee River at Tahoe City, California, and winds its way through the Sierra Nevada past storage reservoirs including Boca, Stampede, Prosser and Donner Lake to the Truckee Meadows and on to Pyramid Lake.

The Great Basin and the Truckee River watershed are unique as compared to most in the United States, in that all water remains within the basin rather than eventually draining to an ocean. We refer to the Truckee Meadows as a closed basin. There are many smaller closed subbasins within the Truckee Meadows, including Lemmon Valley, Spanish Springs, and Cold Springs. The pollution entering a closed basin stays within the closed basin. Our actions affect downstream users as well as our own communities.

In the Truckee Meadows, substantial changes have occurred to the native wetlands since settlement and expansion of Reno, Sparks and other communities. The original path of the Truckee River has been redirected, and the river has widened and deepened, affecting the original riparian habitat. Historically, the bulk of what is now the Sparks industrial area was once a wetland. Settlers traveling through the area in the 1860s encountered a vast marshy area around which they detoured. The wetlands have been drained and filled to allow agriculture and development to occur.

Water that falls within the Great Basin does not drain to the ocean.
These photos, taken in 1868, of what is now the southeast Sparks industrial area reveal a vast, marshy wetland area. Wetlands are areas that:

- Provide for essential filtration of excess nutrients and pollutants, helping avoid water treatment costs.
- Slow the speed of flood waters, and trap and store water for later release.
- Provide flow during the dry season.
- Are home to tremendous biological diversity (plants, insects, animals, etc.)
Truckee River Basin
The absence of the historic wetlands results in negative impacts to Truckee River water quality. Today, the river is listed as impaired for total phosphorus, temperature and turbidity, and is subject to total maximum daily loads (TMDLs) for total nitrogen, total phosphorus, and total dissolved solids.

Other river systems in Northern Nevada that are affected by the loss of wetlands include the Carson River, Walker River, and Humboldt River watersheds. These lessons can be readily adapted to study these watersheds, with the addition of local wastewater treatment methods, any site-specific variations in local wetland vegetation species and macroinvertebrates, and local field sampling or visiting sites.

The Carson River is 184 miles long, and it encompasses 3,966 square miles. It originates in the Sierra Nevada west of Minden and Gardnerville. The river flows in a northeasterly direction to the Lahontan Reservoir and continues on to Fallon and the Carson Sink. Unlike the Truckee River, the Carson River lacks storage reservoirs, and is very susceptible to droughts and flooding. It is also subject to a number of water quality issues, including impairment for a variety of pollutants such as iron, total phosphorus, mercury, temperature and turbidity. The Carson River is subject to TMDLs for biochemical oxygen demand, nitrate, orthophosphates, and total dissolved solids.

The Carson River watershed is home to more than 200 bird species and many other wild animals. The watershed has become a very desirable location, and is one of the fastest growing areas in the state. The rapid development results in a loss of agricultural acreage and threatens riparian areas and wetlands. Efforts to preserve these areas in
the Carson River watershed focus on stream corridor restoration, education, and floodplain protection via conservation easements, county zoning, and public policy.

The Walker River headwaters are in the Sierra Nevada mountain range, west of Topaz Lake and the Bridgeport Reservoir. The watershed area is approximately 4,050 square miles, with about 25 percent of the watershed falling within California and the remainder in Nevada. The river flows northeasterly and then southeasterly, around the Wassuk Range. The river terminates in Walker Lake, which has dropped more than 150 feet between 1882 and 1994. The volume has decreased from 9.1 to 1.9 million acre-ft. due to withdrawals of water for agriculture and other uses. The remaining water is very high in total dissolved solids (TDS, or salts), and habitat for fish and other aquatic organisms has been compromised. The river is subject to TMDLs for total suspended solids.
The Humboldt River watershed is the only major watershed located completely within Nevada. Its headwaters originate in four main mountain ranges: the Ruby, Jarbidge, Independence and East Humboldt Mountain ranges. The river terminates in Humboldt Lake and the Humboldt Sink in Churchill and Pershing Counties. During wet years, the Humboldt Sink may drain into the Carson Sink via the Humboldt Slough. As you might imagine, the basin is very large, covering about 16,840 square miles. The river became a major route for east-west settlers during western migration, and today Highway 80 follows the river across northern Nevada. The Humboldt River is subject to TMDLs for total phosphorus, total suspended solids, and total dissolved solids.
Curriculum Overview

This curriculum is designed for use in teaching Nevada middle school students, and is specifically adapted to conditions in the northern half of the state. It can be used to teach students about the functions and values of wetlands, the technology of wastewater treatment plants, and the relative costs and benefits of each.

There are nine lessons included in the curriculum. Each lesson can be used in part or as a complete exercise. Worksheets, resource lists, tests and answer keys are included in each lesson. Should you find it difficult to make a field trip to a wetland/stream location or water treatment plant, we have provided alternative activities and sample data sets that can be used to give your students the opportunity to complete the exercises. Monthly water quality data from the Truckee River, collected in 2003 from several locations, is included in the appendices. We’ve also suggested alternative exercises from other wetlands curricula that can provide enrichment activities.

Lesson 1: There’s Water! Is It a Wetland?

Purpose:

This activity is designed to define wetlands and introduce students to the benefits they provide.

Summary:

Students will be provided with the definition of wetlands, introduced to various types of wetlands, and learn the importance of wetlands as ecosystems.

Lesson 2: Is Dilution the Solution?

Purpose:

This laboratory or classroom activity introduces students to water pollution concepts and demonstrates that even small amounts of pollution in a water supply can be harmful.

Summary:

Students will learn about point source and nonpoint source pollution, learn to identify some pollution indicators, and attempt to clean up a contaminated sample by diluting the water.
Lesson 3: Man’s Filters: Cleaning Up Wastewater

Purpose:

This laboratory or classroom activity introduces students to wastewater treatment and teaches the steps involved in basic wastewater treatment.

Summary:

Students will learn the components of wastewater, how wastewater is treated by septic systems and at treatment plants, and the basic steps in the treatment process. They will then apply some of the steps to attempt to purify a contaminated water sample.

Lesson 4: Macroinvertebrate Clues

Purpose:

This lesson introduces students to the identification and use of macroinvertebrates as indicators of stream quality.

Summary:

The students will be introduced to the types of macroinvertebrates found in stream systems, will learn how to categorize them using anatomical differences (head, thorax, abdomen), and will learn how macroinvertebrates reflect stream water quality.

Lesson 5: Getting at the Numbers: Measuring Water Quality

Purpose:

In this exercise, the students learn to measure several water quality parameters in the classroom and how to collect and record data.

Summary:

The exercise will introduce the student to methods used to measure water quality parameters, including temperature, pH, nitrate concentration and phosphate concentration. They will learn how to manage and replicate the data. This exercise is also used to prepare students for data collection in the field (see Lesson 8).
Lesson 6: Wet and Wild: A Wetland Field Study

Purpose:
This field activity is designed to reinforce concepts learned in Lesson 1. Students will delineate and define a wetland, based on water, soil and vegetation.

Summary:
In Lesson 1, students were provided with the definition of a wetland, introduced to the variety of types of wetlands, and learned the importance of wetlands as ecosystems. This lesson is a hands-on field activity that puts the information presented in Lesson 1 to practical use.

Lesson 7: Macroinvertebrate Field Study

Purpose:
This field exercise will introduce students to methods for using macroinvertebrates as indicators of stream quality.

Summary:
The students will sort macroinvertebrate samples to determine relative quantities of various organisms and make an assessment of the general stream water quality.

Lesson 8: Natural Processing: Measuring Wetland Water Quality

Purpose:
This activity focuses on collecting data that demonstrates the importance of wetlands for maintaining water quality. The students will develop hypotheses about the difference in water quality they might find if they measure temperature, pH, nitrate and phosphate at the inlet and outlet of a wetland or at different points along a stream.

Summary:
The students will develop hypotheses on how the pH, temperature, nitrate and phosphate concentrations of water will change from the inlet to the outlet of a wetland. They will go and collect data in the field and then determine if their hypotheses were correct.
Lesson 9: Winning Solutions to Community Pollution

Purpose:

Students reach conclusions about the efficiency and values of wastewater treatment by high tech facilities vs. constructed (or natural) wetlands.

Summary:

This exercise combines the data collected during the previous lessons to allow students to draw conclusions about treatment efficiency, relative cost of treatment, and relative benefit to society. This lesson incorporates data synthesis and group presentations, and may require more than one class period.

Learning Goals

By the end of this lesson series, students should:

- Understand what a wetland is
- Understand how a wetland functions
- Understand the importance of wetlands as ecosystems
- Understand point source water pollution
- Understand nonpoint source water pollution
- Know the six major types of water pollutants
- Understand the basics of wastewater treatment
- Be able to identify common macroinvertebrates
- Be able to use macroinvertebrates as indicators of stream quality
- Be able to measure several water quality parameters
- Be able to record data in a logical, unbiased fashion
- Understand the differences and similarities between wastewater treatment plants and constructed or natural wetlands
- Be able to debate the relative values of natural processing by wetlands vs. wastewater treatment technology
Links to Science and Mathematic Education Standards

Each lesson includes a list of the Nevada Education Standards for science and math, to ensure you are meeting your teaching goals. Below is a listing of the Washoe County, State of Nevada and National science and math standards that are addressed by the nine-lesson series. Science standards for Washoe County and the state for individual lessons are shown in the tables on pages 14 and 15.

Links to Washoe County School District Standards, Grades 6-8

Science
- Basic and Integrated Science Process Skills
- Scientific Method
- Internal and External Influences and Organisms
- Ecosystems
- Natural Resources
- Conservation
- Chemical Properties and Composition
- Chemical Reactions

Mathematics
- Numbers, Number Sense and Computation
- Measurement
- Data Analysis
- Problem Solving
- Mathematical Communication
- Mathematical Reasoning
- Mathematical Connections

Links to Nevada Education Standards, Grades 6-8

Science
- Nature of Science Unifying Concept A: Scientific Inquiry
- Nature of Science Unifying Concept B: Science, Technology and Society
- Life Science Unifying Concept A: Heredity
- Life Science Unifying Concept B: Structure of Life
- Life Science Unifying Concept C: Organisms and their Environment
- Life Science Unifying Concept D: Diversity of Life
- Earth and Space Science Unifying Concept A: Atmospheric Processes and the Water Cycle
- Earth and Space Science Unifying Concept C: Earth’s Composition and Structure

Mathematics
- Content Standard 1: Numbers, Number Sense and Computation
- Content Standard 3: Measurement
- Content Standard 5: Data Analysis
- Content Standard 6: Problem Solving
- Content Standard 7: Mathematical Communication
- Content Standard 8: Mathematical Reasoning
- Content Standard 9: Mathematical Connections
Links to National Education Standards, Grades 5-8

Science
- Life Science, Content Standard C:
  - Structure and Function of Living Systems
  - Regulation and Behavior
  - Populations and Ecosystems
- Science in Personal and Social Perspectives, Content Standard F
  - Personal Health
  - Natural Hazards
  - Risks and Benefits
  - Science and Technology in Society

Mathematics
- Numbers and Operations
- Measurement
- Data Analysis and Probability
- Problem Solving
- Mathematic Communication
- Mathematic Connections
- Mathematic Representation
<table>
<thead>
<tr>
<th>Washoe County School District Standards, Grade 6-8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic and Integrated Science Process Skills</strong></td>
</tr>
<tr>
<td>Lesson 1: There’s Water! Is it a Wetland?</td>
</tr>
<tr>
<td>Lesson 2: Is Dilution the Solution?</td>
</tr>
<tr>
<td>Lesson 3: Man’s Filters: Cleaning Up Wastewater</td>
</tr>
<tr>
<td>Lesson 4: Macroinvertebrate Clues</td>
</tr>
<tr>
<td>Lesson 5: Getting at the Numbers</td>
</tr>
<tr>
<td>Lesson 6: Wet and Wild: A Wetland Field Study</td>
</tr>
<tr>
<td>Lesson 7: Macroinvertebrate Field Study</td>
</tr>
<tr>
<td>Lesson 8: Natural Processing: Meas. Wetland Water Quality</td>
</tr>
<tr>
<td>Lesson 9: Winning Solutions to Community Pollution</td>
</tr>
</tbody>
</table>

Introduction -14-
| Lesson 1: There’s Water! Is it a Wetland? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lesson 2: Is Dilution the Solution? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lesson 3: Man’s Filters: Cleaning Up Wastewater | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lesson 4: Macroinvertebrate Clues | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lesson 5: Getting at the Numbers | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lesson 6: Wet and Wild: A Wetland Field Study | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lesson 7: Macroinvertebrate Field Study | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lesson 8: Natural Processing: Meas. Wetland Water Quality | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Lesson 9: Winning Solutions to Community Pollution | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
How to Use this Curriculum

We recognize that it may be difficult to fit the entire curriculum into your science teaching, and have made recommendations for partial use in a variety of circumstances.

<table>
<thead>
<tr>
<th>Lessons to Include</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom Investigation Only (6 to 12+ class periods)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Classroom and Field Investigation (6 to 12+ class periods plus field trip)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Field Investigations Only (field trip plus 2 to 3 class periods)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Basic Introduction to Wetlands (one class period)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Focus on Wetlands and Water Pollution (2 to 4 class periods)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetlands and Wastewater Treatment (2 to 4 class periods, optional tour)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetlands, Water Pollution, and Wastewater Treatment (4 to 6 class periods)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigating Wetland Macroinvertebrates (3 to 5 class periods; can skip field visit if macroinvertebrates are supplied)</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland Plant and Soil Investigation (2 to 4 class periods, includes a field visit)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring Water Quality (4 to 6 class periods, includes a field visit)</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Lesson 1: There’s Water! Is It a Wetland?

**Purpose:**
This activity is designed to define wetlands and introduce students to the benefits they provide.

**Summary:**
Students will be provided with the definition of a wetland, introduced to various types of wetlands, and learn the importance of wetlands as ecosystems.

**Key Learning Points for Students:**

1. Wetlands have many functions. Students should be able to describe at least four different wetland functions.
2. Wetlands are defined by water, soil and plants. Presence of water alone is not sufficient to define a wetland.
3. Wetland soils are hydric and exhibit changes in color (gleying).
4. Hydrophytic plants live in wetlands and have adaptations that allow them to survive in oxygen-poor soils.
5. Halophytic plants are adapted to high salt concentrations.
6. Wetland vegetation can also be defined by its proximity to the water surface.

**Handouts:**

1. Types of Wetlands
2. Why Are Wetlands Important?
3. Vocabulary Activity – Words to Define
4. "Wetland Habitat Identification" Activity
6. Explore Nevada’s Amazing Wetlands Poster Activity
7. Plant Identification Key (found in Lesson 6) Activity/Review

**Grade Level:** 6 to 8

**Nevada Education Standards:**
Science
- Scientific Inquiry
- Science, Technology and Society
- Structure of Life
- Organisms and their Environment
- Diversity of Life
- Atmospheric Processes and the Water Cycle
- Earth’s Composition and Structure

**Activities:**
Video/DVD and Background Information
Words to Define
Wetlands Habitat Identification
Put It On the Map
Explore Nevada’s Amazing Wetlands Poster
Plant Identification Key

**Setting:** Classroom/Lab
Background:

Wetlands are critical components of the ecosystem that provide a number of important benefits, from flood control to water quality protection. Wetlands are generally inundated or under water during wet times of the year. Some wetlands may be dry for prolonged periods at other times of the year. Water is captured, stored, and slowly released to groundwater and back to surface water. These functions help reduce flooding and damage to homes and the river itself. The slow release of water helps maintain stream flow all year round. In areas along the coast, salt marshes, mangroves and estuarine wetlands act as storm buffers, absorbing energy and reducing impacts and erosion.

When water enters a wetland and spreads out, its velocity decreases. This allows sediments to settle out, pollutants to be deposited, and plants to assimilate nutrients. Many times, pollutants are bound to sediments, so they may be deposited and buried in wetlands as the sediment settles.

The plants in wetlands also play an important role in water quality protection. Nitrogen and phosphorus (nutrients) are derived from agricultural wastes, fertilizers and detergents, along with naturally occurring sources. These are necessary elements for plant growth, but excessive amounts can cause problems such as algae blooms and reductions in dissolved oxygen levels. Excessive nutrients in freshwater are considered significant nonpoint source pollutants. Wetlands generally contain a diverse population of plants that can take up the nutrients and remove them from the water. The high rates of primary biological productivity (plant growth) result in consumption of nitrogen and phosphorus, removing them from the water and reducing the potential for pollution to occur in adjacent water bodies.

Wetlands also have high rates of microbial activity. The microbes consume nutrients and polluants and change them to less harmful forms. The conversion of nutrients and pollutants to less harmful forms is called natural processing.

In addition to pollutant processing by sediment detention and plant uptake, wetlands are often areas where rainfall or flood water gently percolates down through the ground to the groundwater table. During this slow percolation, the soil acts as a biological filter, removing pollutants and purifying the water. The water also replenishes, or recharges, groundwater supplies.

While wetlands are valued for their ability to process pollutants, it is important to note that some pollutants, such as mercury, can be converted to more toxic forms in a wetland environment due to anaerobic (oxygen-deprived) soil conditions and bacterial action.

Wetland ecosystems have high rates of primary productivity (plant growth). This provides food for other organisms in the food...
chain. The diversity of food sources provides for high species diversity. For this reason, wetlands are important breeding grounds for many species.

The rich variety of wetland plants and animals provides useful sources of food for both humans and animals. Some wetland food products you may enjoy include wild rice, cranberries, and many commercially-produced fish and shellfish.

What Defines a Wetland?

Despite what its name infers, water is not the only defining characteristic of a wetland. In fact, wetlands are distinguished by the presence of three major characteristics:

1. **Standing water** covering the soil for all or a portion of the time.
2. **Hydric soils** (soils that form under conditions of saturation, ponding, or flooding long enough to develop anaerobic, or oxygen-deprived, conditions).
3. **Hydrophytic** (water-tolerant) **plants**.

A combination of these three factors helps to define and delineate a wetland. In a wetland, the substrate or soil is saturated by or covered with water at some time during the growing season each year. When the upper part of the soil is saturated with water at growing-season temperatures, soil organisms consume the oxygen in the soil. This causes an anaerobic condition to develop in the soil, influencing the texture, color and even the odor of the soil. Most plants cannot tolerate these low oxygen conditions, but some plants have developed adaptations that allow them to thrive in wetland soils. These water-tolerant plants are termed hydrophytic (hydro = water; phytic = loving).

**Characteristic #1: Water**

Wetlands are not always wet. If there is no water present, there are other indicators for which you can look. The ground may be spongy or mushy. Watermarks on woody vegetation or any manmade structures may be used to determine the depth of inundation by water that has occurred in the past. Drift lines on debris can be used establish the minimum area inundated with water. Similarly, the water may leave
sediment deposits during inundation. Plants and other objects or debris may show a thin layer or coating of mineral or organic matter. This coating may remain for a considerable length of time before rain or further flooding removes it. And, of course, the presence of water does not necessarily indicate the area is a wetland! Imagine roadside flooding that occurs after intense rainstorms or periods of snowmelt. The flooded areas are not wetlands, as they lack the specific water, soil and plant characteristics that define a wetland.

Characteristic #2: Soil

Hydric soils are those that have been saturated with water for a sufficiently long period of time that anaerobic or oxygen-deprived conditions have developed in the soils. The lack of available oxygen causes a reducing environment to be present in the soils. This gives the soils a characteristic coloring referred to as gleying (pronounced “glaying”), which includes shades from black to dark gray, blue-gray or green-gray. Gleying occurs when iron is converted from an oxidized state, characterized by a reddish, orange, or yellowish color, to a reduced state, characterized by black and grayish tones. Mottles, or patches of orange, red or yellow, occur when the soils are alternately wet and dry.

A rough measure of soil texture can be made by rubbing the soil through your thumb and fingers or in your palm. In general, mineral or gritty soils have lighter colors. In a reducing environment, organic material does not decompose, as there is a lack of oxygen. Instead, the organic material accumulates, forming a very dark-colored soil. The organic-rich soils consist of black and fine-grained silt or clay. These soils will feel very smooth against your skin.

Sometimes hydric soils have a rotten egg smell. The rotten egg smell is caused by bacteria in the soil that convert the sulfur (S) in the soil from the form sulfate (SO$_4^{2-}$) to the form hydrogen sulfide (H$_2$S). Again, this is a result of the oxygen-poor, reducing environment formed in the soils as a result of water saturation.

Characteristic #3: Plants

Hydrophytic plants are those that can survive when their roots become water-logged. Most plants require some air-filled pore spaces in the soil. Everyone has drowned a houseplant by over-watering the soil at one time or another, filling all the pore spaces with water. Wetland plants, however, have special adaptations that allow them to thrive in saturated soil. Some wetland plants, including cattails, actually take oxygen from the air and move it to their roots, creating an oxygenated environment around the roots. Reeds have long oxygen-transporting tubes. Other adaptations of wetland plants include “knees,” or bulges in the tree’s root system that extend above the high water mark, where they take in oxygen. Cypress tree roots are a good example of this adaptation. Some wetland plants have shallow or exposed roots that allow the plant to obtain oxygen. Roots that dangle in the water, such as those present in water lilies, are another adaptation designed to ensure plant survival under saturated conditions.
Salt-tolerant plants are called halophytic. They may or may not also be hydrophytic. Halophytic plants range from cacti to sea grass. While these plants are more common in coastal ocean areas, we do find several varieties here in the Great Basin. Many of our valleys are actually closed basins. Water entering the closed basin stays within the basin, and does not flow to an ocean. As the water evaporates, the salt content of the remaining water increases. These intermittent lake beds or low points in the closed basins that collect and evaporate water are called playas. During the dry part of the year, playas may appear to be mud or salt flats. Plants that live in these areas must be adapted both to the increased salt content and to variations in water depths.

Vegetation can also be defined by its proximity to the water surface.

**Emergent Vegetation:** These plants emerge above the soil and/or water level. Emergent plants are rooted in the sediment, but have stems, leaves, flowers and fruits above the water surface. Rushes, sedges, grasses, cattails and willows are examples of emergent vegetation. The habitat zone in which emergent plants can be found is characterized by erect, rooted herbaceous hydrophytes, excluding mosses and lichens. This habitat may also contain invasive or exotic species, such as tall whitetop (perennial pepperweed), purple loosestrife, or tamarisk. Generally, areas dominated by emergent vegetation are also dominated by perennial plants. Common names for wetlands
dominated by emergent vegetation include marsh, meadow, fen, prairie pothole, and slough.

**Floating Vegetation:** These plants may be either free-floating or rooted in the soil. They have leaves on the water surface and carry flowers or fruit just above the water surface. Native floating vegetation in our area includes water lily, cow lily, pond lily, water smartweed and several species of duckweed.

**Submergent Vegetation:** These plants grow completely beneath the surface of the water. Native submergent vegetation in our area includes pondweed (many Potamogeton species), Elodea or water weed (many species), American watermilfoil, bladderwort, ditch grass (or wigeon grass), hornwort (or coontail) and nodding water nymph (or slender naiad). Nevada’s water bodies have also been infested by Eurasian watermilfoil and curlyleaf pondweed, two invasive, nonnative, submerged aquatic weeds.

Typical plants found in western Nevada wetlands include woody vegetation such as trees and shrubs, and herbaceous or non-woody vegetation. A tree is generally defined as woody vegetation that has a single trunk and is at least 10 feet tall. A shrub is generally defined as woody vegetation that has several small trunks and is less than 10 feet tall. Herbaceous or non-woody vegetation makes up the bulk of the plants in western Nevada wetlands. This includes grasses, sedges, rushes, cattails, and flowering (broadleaf) plants.

Since we live in the desert, wet areas form an “oasis,” with many types of plants growing near the water source. Some of the more common wetland plants found in western Nevada are shown in the Plant Identification Key that accompanies Lesson 6. In addition, there are several websites listed in the Resource section of this lesson that can help identify wetland plants. You cannot identify a wetland based upon a single plant species. It is important to look at all the plants growing in the area. Remember, it is a combination of water, soil and plant characteristics that defines a wetland.

**Types of Wetlands**

We have all heard terms such as bog, marsh, or swamp, but we may not realize that these are all different types of wetlands. Coastal swamp areas are considered to be wetlands, as are low-lying lands along streams and rivers. The handout “Types of Wetlands” describes bogs, bottomlands, mangrove swamps, marshes, mud flats, playas, pocosins, prairie potholes, salt marshes and swamps.
Vocabulary List

**Anaerobic:** Living in the absence of air or free oxygen.

**Ecosystem:** A community of living organisms and their interrelated physical and chemical environment. An ecosystem can be as small as a rotting log or a puddle of water, but most management efforts focus on larger geographic areas, such as a mountain range, river basin or a watershed.

**Emergent vegetation:** Plants that emerge above the soil and/or water level; upright plants.

**Gleying:** Characteristic soil colors of black, dark gray, green gray and blue-gray found in hydric soils. Low oxygen levels in water-saturated hydric soils create a reducing environment. The iron in the soil becomes reduced, changing the color from the typical red, orange, yellow and/or brown commonly found in oxygenated soils.

**Groundwater:** All subsurface water that fills the pores, voids, fractures and other spaces between soil particles and in rock strata within the saturated zones of geologic formations.

**Halophytic plants:** Plants that are salt-tolerant, ranging from cacti to sea grass. Some of these plants also have the ability to absorb salts and heavy metals, such as cadmium and arsenic.

**Hydric soil:** Soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions that favor the growth of hydrophytic plants.

**Hydrophytic plants:** Plants that grow in water or in saturated soils that are periodically deficient in oxygen as a result of high water content.

**Natural processing:** The natural ability of undisturbed water systems and soils to retain water, adsorb nutrients, absorb other pollutants, slow or reduce surface runoff, and aid in infiltrating storm water.

**Nitrogen:** Nitrogen (N) makes up 78% of the Earth’s atmosphere as N₂ gas. Nitrogen is an essential element required for plant growth. Nitrogen is also a major constituent of nonpoint source pollution.

**Peat:** A mass of semi-carbonized material formed by partial decomposition of various plants in water, especially mosses. Peat varies in consistency from turf to slime. As it decomposes, the color deepens, with old peat being dark brown to black in color.

**Phosphorus:** A chemical element (P) that is one of the three essential elements required for plant growth. Phosphorus tends to adsorb, or stick onto, soil particles. Phosphorus is often a major constituent of nonpoint source pollution.
**Lesson 1: There's Water! Is It a Wetland?** - 8 -

**Water table:** The upper boundary or top surface of the zone of saturation in a soil profile or geologic formation.

**Wetland:** An area that is periodically inundated with water, or an area that is saturated by surface or groundwater on an annual or seasonal basis; displays hydric soils; and typically supports or is capable of supporting hydrophytic vegetation.

**Materials**

- “Fabulous Wetlands” video by Bill Nye, or “Bill Nye the Science Guy, Wetlands” video or DVD.
- Types of Wetlands Handout
- Why Are Wetlands Important? Handout
- Vocabulary Activity – Words to Define
- “Wetland Habitat Identification” Activity
- “Put It On the Map” Activity
- Explore Nevada’s Amazing Wetlands Poster Activity
- Plant Identification Key Review (optional). *Note: The key is located in Lesson 6.*

**The Activities**

1. **Fabulous Wetlands or Bill Nye Wetlands Video or DVD**

   **Procedure:**

   Show students the 6-minute video, “Fabulous Wetlands with Bill Nye,” available from “A World in Our Backyard,” or all or part of the video or DVD titled “Bill Nye the Science Guy, Wetlands” from Disney Educational Productions. The DVD includes a teacher’s guide with ideas on integrating the content into your instructional program, national science education standards, a guide to episodes, and more.

   **Disney Video (Times are approximate. If time is limited, use the first 8 minutes.)**

<table>
<thead>
<tr>
<th>Duration</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 minute</td>
<td>Introduction</td>
</tr>
<tr>
<td>3 minutes</td>
<td>Demonstration of water flow through a wetland model before and after development; three functions of a wetland (flood storage, water filtering, habitat)</td>
</tr>
<tr>
<td>1 minute</td>
<td>Types of wetlands</td>
</tr>
<tr>
<td>1 minute</td>
<td>Kids talk about wetlands</td>
</tr>
<tr>
<td>2 minutes</td>
<td>Demonstrations showing how wetlands soak up floods and slow down water</td>
</tr>
<tr>
<td>1 minute</td>
<td>Kids talk about building a wetland trail.</td>
</tr>
<tr>
<td>2 minutes</td>
<td>Bill Nye gets stuck in muck and talks about wetland soils</td>
</tr>
<tr>
<td>1 minute</td>
<td>Swamp monsters and living organisms in wetlands</td>
</tr>
<tr>
<td>1 minute</td>
<td>Wetland soils, estuaries, wildlife and food sources</td>
</tr>
<tr>
<td>4 minutes</td>
<td>Construction and the loss of wetlands</td>
</tr>
</tbody>
</table>
The Activities, continued

2. Fabulous Wetlands or Bill Nye Wetlands Video or DVD, continued

Disney Video *(Times are approximate. If time is limited, use the first 8 minutes.)*

<table>
<thead>
<tr>
<th>Duration</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 minutes</td>
<td>What a wetland biologist does</td>
</tr>
<tr>
<td>2 minutes</td>
<td>General wetland scenes</td>
</tr>
<tr>
<td>1 minute</td>
<td>The “Maria” song</td>
</tr>
</tbody>
</table>

Disney DVD
From the Main Menu, select “Watch Program Menu” and “Play Program” to play the entire program (about 23 minutes). For a shortened version, select “Big Idea.” Alternatively, select “Try This” to show students demonstrating science concepts; “Big Demo” to show how wetlands soak up water; or “Way Cool Scientist” to meet a real scientist who talks about wetland science. The “Teacher Support” menu includes a quiz.

Provide students with background information on wetlands, including their major defining characteristics (water, soil, plants). Review “Types of Wetlands” and “Why Are Wetlands Important?” with the students.

3. Vocabulary Activity – Words to Define

Procedure:

Have students look up the terms on the vocabulary list and write down their definitions. This information is either contained in the background information or in the handouts. Many of these words will be used in the remaining lessons.

4. Wetland Habitats Identification Activity (from p. 89 in “WOW! The Wonder of Wetlands”)

Procedure:

This activity requires 10 habitat cards that can be copied from WOW. They are also included in this lesson on pages S-8 through S-10. The students read the cards and then use the flow diagram (page S – 7) to determine the type of wetland that is described on the habitat card. Students can split into groups or do the exercise individually.
The Activities, continued

5. Put It On the Map Activity (from p. 43 in “A World in Our Backyard”)

Procedure:

Using a map of the United States, students label the location of some of the better-known wetland types in the United States. Consider using an atlas with maps of the United States vegetation types, land types, etc. to turn this into an interesting geography exercise. You may want to test the student’s knowledge of United States geography by having them name the 50 states. Again, students can split into groups or do the exercise individually. Using the handout, introduce your students to the rich diversity of wetlands found in the United States. Help students decide which types of wetlands would be found in Nevada.

6. Explore Nevada’s Amazing Wetlands Poster Activity

Procedure:

This activity reinforces the concept that wetlands provide important animal habitat and food sources. It is mostly informational, with an 11” x17” poster that students can color. A list of plants and animals found in the poster is included. The numbers on the small black and white diagram correspond to the numbers in the list of plants and animals. Additional activities can be added by the instructor, including:

- Describe the habitat(s) shown in the poster
- Write a report on one of the animals shown in the poster
- Describe the food chain(s) illustrated in the poster

7. Plant Identification Key Activity / Review

Procedure:

If you are doing the wetland field activity described in Lesson 6, it may be helpful to review the Plant Identification Key in the classroom before going to the field. If you collected and pressed plant samples previously, they can be used as a demonstration as you review the Plant Identification Key. The key is found in Lesson 6.
Lesson 1: There’s Water! Is It a Wetland?

Resources


Montana Plant Life. No date. Photo album of wildflowers, separated by color, etc. This may be useful in identifying flowering broadleaf plants. The second site includes a plant identification key. http://montana.plant-life.org/ http://montana.plant-life.org/index2.html


Sea Grant. 2001. Non-Native Invasive Aquatic and Wetland Plants in the United States. If you know the basic family, (i.e. grasses, etc.), you can search the database. http://plants.ifas.ufl.edu/seagrant/aquinv.html


EXPLORE NEVADA’S AMAZING WETLANDS
Test, Lesson 1 – There’s water! Is it a wetland?

Name_________________________________

1) True or False If there is water standing on the ground, the site must be a wetland.

2) List three things that define a wetland.
   1.________________________________________________________________________
   2.________________________________________________________________________
   3.________________________________________________________________________

3) List three useful functions provided by wetlands.
   1.________________________________________________________________________
   2.________________________________________________________________________
   3.________________________________________________________________________

4) Where do hydric soils form?
   a) under saturated conditions
   b) under low-oxygen conditions
   c) in wetland areas
   d) all of the above

5) Under what conditions are halophytic plants adapted to live?
   a) in salty soil conditions
   b) in water-saturated soil conditions
   c) in acidic soil conditions
   d) all of the above

6) Under what conditions are hydrophytic plants adapted to live?
   a) in salty soil conditions
   b) in water-saturated soil conditions
   c) in acidic soil conditions
   d) all of the above
Test, Lesson 1 – There’s water! Is it a wetland? page 2

Name____________________________________

7) Anaerobic means
   a) Living, active or occurring in the absence of oxygen
   b) Living, active or occurring in the presence of oxygen
   c) Living, active or occurring in the presence of water
   d) All of the above

8) True or False Gleying is the term given to the characteristic odor of wetland soils.

9) True or False A playa is a desert lake that contains water year-round.

10) True or False A swamp is a wetland dominated by grasses, sedges and rushes.
Test, Lesson 1 – There’s water! Is it a wetland? Answer Key

1) True or False If there is water standing on the ground, the site must be a wetland.

2) List three things that define a wetland.
   1. Standing water covering the soil for all or a portion of the time.
   2. Hydric soils – soils that form under conditions of saturation, ponding or flooding long enough to develop anaerobic or oxygen-deprived conditions.
   3. Hydrophytic or water tolerant plants

3) List three useful functions provided by wetlands.
   1. Flood control, by impounding storm water and slowly releasing it back to groundwater and surface waters
   2. Storm buffer, by absorbing storm energy and reducing impacts and erosion from the storm
   3. Reduce sediment by filtering water and/or allowing settling
   4. Reduce nutrients and toxic chemicals through natural processing
   5. Purifying and recharging the groundwater supply
   6. Provides food and habitat (nesting, breeding, living) for many animals, including man

4) Where do hydric soils form?
   a) under saturated conditions
   b) under low oxygen conditions
   c) in wetland areas
   d) all of the above

5) Under what conditions are halophytic plants adapted to live?
   a) in salty soil conditions
   b) in water-saturated soil conditions
   c) in acidic soil conditions
   d) all of the above

6) Under what conditions are hydrophytic plants adapted to live?
   a) in salty soil conditions
   b) in water-saturated soil conditions
   c) in acidic soil conditions
   d) All of the above
7) Anaerobic means  
   a) **Living, active or occurring in the absence of oxygen**  
   b) Living, active or occurring in the presence of oxygen  
   c) Living, active or occurring in the presence of water  
   d) All of the above

8) True of **False**  
   Gleying is the term given to the characteristic odor of wetland soils.

9) True or **False**  
   A playa is a desert lake that contains water year-round.

10) True or **False**  
    A swamp is a wetland dominated by grasses, sedges and rushes.
Activity 1: Wetland "Celebrities" of the United States
Lesson 1: There's Water! Is It a Wetland?

**Types Of Wetlands**

**Bog:** A poorly-drained freshwater wetland characterized by an accumulation of peat. Peat is composed of plant tissues that have partially decomposed in water. Sphagnum moss is commonly found in a bog. Bogs generally have no significant inflows or outflows of water. Many large bogs occur in the northeastern United States, near the Great Lakes. A “fen” is a non-acidic bog that receives water primarily from groundwater sources. A “muskeg” is a vast expanse of bog, commonly found in Canada (the Yukon) and Alaska.

**Bottomlands or Forested Bottomlands:** Periodically flooded, low-lying land found along streams and rivers, usually on floodplains. They have rich, fine-textured and poorly-drained soils. They may or may not be forested. They may also occur over a shallow water table. Both forested and non-forested bottomlands generally provide excellent habitat for wildlife. Bottomland Hardwoods occur in Louisiana.

**Mangroves (aka Mangrove Swamp):** A subtropical to tropical tidal swamp found in coastal regions. These areas are dominated by halophytic (salt-tolerant) trees, shrubs and other plants that have stilt-like roots and stems growing in salty tidal waters.

**Marsh:** A marsh is an area periodically covered with water, containing a variety of perennials (mostly grasses), forbs (flowers), and bushes. Marshes do not have trees, as are found in swamps. A marsh generally does not accumulate peat deposits. Marshes are often formed in the transition zone between water and land, such as along streams or rivers. They can form in fresh water or salt water. A couple of notable marshes, Sandhill and Rainwater Basin, occur in Nebraska.

**Mud Flat:** Low-lying muddy land that is covered by water during high tide and exposed to the air during low tide. No plants are visible above the water.

**Playa:** A periodically dry lake bed at the lowest point of an enclosed basin or valley. Wet and dry times vary by season. Salt contents are generally high and vegetation is of the halophytic (salt-tolerant) variety.

**Pocosin:** An upland swamp of shallow water found in the southeastern United States. A pocosin is a peat-accumulating, non-riparian (not adjacent to a river), freshwater wetland, generally dominated by evergreen shrubs and trees. The word means “swamp on a hill.” People in the southeastern United States also refer to these areas as “dismals.” The most famous of these is the Great Dismal Swamp in Virginia and North Carolina.

**Prairie Potholes:** Prairie potholes are shallow, marsh-like ponds. Found primarily in the Dakotas and central Canada, prairie potholes are wetlands formed in a depression in the ground. These ground depressions are the result of the weight of glaciers that used to rest in these areas before they retreated during the last Ice Age. Prairie potholes form a vast region of seasonal wetlands that provide a home for many birds during their migration and breeding seasons.

**Salt Marsh:** A halophytic (salt-tolerant) grassland on alluvial sediments bordering saline water bodies where the water level fluctuates with the tide. These areas stabilize shorelines and prevent erosion from tide and wave actions. A salt marsh can also be a wetland adjacent to a saline spring or lake, with no tidal water fluctuation.

**Swamp:** A wetland dominated by trees or shrubs, with little to no peat deposits. A swamp can be fresh or salt water and tidal or non-tidal. Swamps are periodically covered with standing water. The Great Kankakee Swamp in Illinois and Indiana and the Okefenokee Swamp in Florida and Georgia are two famous swamps in the United States.

**EXPLORE NEVADA'S AMAZING WETLANDS**
Emergent wetlands are dominated by emergent plants. Emergent plants are rooted in the sediment but have stems, leaves, flowers and fruits above the water surface. Rushes and cattails are examples of emergent vegetation. This habitat is characterized by upright, rooted herbaceous hydrophytes, excluding mosses and lichens. For the most part, these areas are dominated by perennial plants. Common names for emergent wetlands include marsh, meadow, fen, prairie pothole, and slough.

Persistent Emergent Wetlands: Wetlands dominated by plant species that remain standing at least until the beginning of the next growing season. These plants include cattails, bulrushes, sedges, grasses, reeds and willows. They may also contain invasive or exotic species, such as tall whitetop, purple loosestrife, or tamarisk (saltcedar).

Nonpersistent Emergent Wetlands: Wetlands dominated by plants that fall to the surface of the ground or below the surface of the water at the end of the growing season. At certain times of the year, there is an absence of non-persistent emergent vegetation. These plants include arrowheads, arrow arum, wild rice, etc.

Riverine refers to fresh water flowing in channels, such as rivers or streams. Riverine habitat includes the wetlands adjacent to the flowing water, called the riparian area. The plants you will see in riverine wetlands will be influenced by the climate of the area.

Lacustrine refers to fresh water lakes or reservoirs greater than 20 acres in size, with less than 30% of the surface covered by emergent vegetation. The plants you will see in lacustrine wetlands will be influenced by the climate of the area.

Palustrine refers to all other fresh water wetlands – ponds, marshes, bogs, playas, etc.

Some famous wetlands include the Dismal Swamp in Virginia and North Carolina, the Great Kankakee Swamp in Indiana and Illinois, and the Mississippi River Delta in Louisiana.

Can you think of examples of each type of wetland in Nevada?

For descriptions and color photos go to www.epa.gov/owow/wetlands/types/
Lesson 1: There’s Water! Is It a Wetland?

Types Of Wetlands

1. Riverine - Desert
   - Forested Wetland
   - Emergent Wetland Nonpersistent
   - High Water
   - Average Water
   - Low Water
   - a - Temporarily Flooded
   - b - Seasonally Flooded
   - c - Semipermanently Flooded
   - d - Intermittently Flooded
   - e - Permanently Flooded

2. Riverine - Montane
   - Forested Wetland
   - Emergent Wetland Nonpersistent
   - High Water
   - Average Water
   - Low Water
   - a - Temporarily Flooded
   - b - Seasonally Flooded
   - c - Semipermanently Flooded
   - d - Intermittently Flooded
   - e - Permanently Flooded

Not To Scale
Type of Wetlands

Lacustrine – Desert

Lacustrine – Montane

Not To Scale
Why Are Wetlands Important?

Wetlands serve many important purposes. After you read this, see if you can think of others.

**Flood control:** Wetlands are flooded during wet times of the year. The water is captured, stored, and slowly released to groundwater and back to surface water. This reduces the amount of water in a river or creek and decreases the potential for flooding and damage to homes.

**Coastal protection:** In areas along the coast, salt marshes, mangroves and estuarine wetlands act as storm buffers, absorbing energy and reducing impacts and erosion.

**Water quality and quantity:** Wetlands are often areas where rainfall or flood water gently soaks down through the ground to the groundwater table. During this slow movement, the water is filtered of pollutants, purifying the water. The water also replenishes, or recharges, groundwater supplies.

**Sediment and pollution traps:** When water enters a wetland, it slows down. This allows sediments to settle out, pollutants to be deposited, and plants to take up nutrients. Many times, pollutants are bound to sediments, and they may be deposited and buried in wetlands as the sediment settles. However, some pollutants, including mercury, can be converted to more toxic forms in a wetland environment. Nitrogen and phosphorus (nutrients) occur naturally, but also are found in agriculture wastes, fertilizers and detergents. These are necessary elements for plant growth, but excessive amounts can cause problems. Excessive nutrients in freshwater are considered pollutants. Wetlands generally contain many different plants, which will take up the nutrients and remove them from the water.

**High rates of biological productivity and important habitat for many organisms:** Wetland ecosystems have high rates of primary productivity (plant growth). This provides food for other organisms in the food chain. The diversity of food sources provides for a wide variety of birds, fish, mammals, and other animals. For this reason, wetlands are important breeding grounds.

**Food production:** Some edible products of wetlands include wild rice, cranberries, and many major commercially-produced fish and shellfish.

Why Are Wetlands Good At Protecting Water Quality?

In wetlands, there are high rates of primary biological productivity, or plant growth. The plants consume the nutrients nitrogen and phosphorus, removing it from the water and reducing the delivery of pollutants to adjacent water bodies. In addition to nutrient removal by plants, sediments are deposited as the water moving through the wetland slows down, allowing storage and burial of wastes and pollutants to occur.

Wetlands have an active microbial community. These microbes consume nutrients and pollutants and change them to less harmful forms. The conversion of nutrients and pollutants to less harmful forms is called natural processing. These processes occur without expensive construction or power costs. This does not mean that wetlands should be the dumping grounds for pollutants! It does mean that wetlands are a vital part of the water cycle, filtering and helping to clean surface water runoff before it harms lakes, streams, or other water bodies.
Words to Define

Name____________________________________

Anaerobic

Ecosystem

Emergent vegetation

Gleying

Groundwater

Halophytic plants

Hydric soil

Hydrophytic plants

Natural processing

Nitrogen

Peat

Phosphorus

Water table

Wetland
Wetland Habitats Flow Chart

Carefully read each of the habitat cards, then use this flow chart to identify each habitat. Start at the left side of the page at the first box. There are two boxes connected to that box—choose the one that matches the description on the card. Then move on to the next set of boxes, following the lines, and make another choice. Continue until you reach the name of the habitat described on the card. Can you identify all ten habitats?

**WOW!: The Wonder Of Wetlands**
**Habitat Cards**

1. During storms, the waves push grains of sand into ever-changing patterns. During low tide the animals that live among the sand grains feel the summer heat or the winter cold. Shore birds search along the water’s edge for these animals and for bits of food that wash in from the water. No plants grow here.

2. Scrubby, low-growing thickets of shrubs grow here, in places that may have started out as wet meadows. You might find these places near the coast, or where lakes, streams, rivers, marshes, and forested swamps overflow. They are not always covered with water. This type of wetland offers good habitat for fish, reptiles, amphibians, and many other animals.

3. In the shallow borders of ponds, lakes, rivers, and streams, where there is good light and the water has little salt, underwater plants and plants with floating leaves grow. Some of these plants are valuable food for many kinds of waterfowl including ducks, geese, and swans. All make places for little fish and other animals to live and feed. These plants slow water movement and protect the soil on shores and banks from erosion.

4. Depressions in the ground may fill with rain and ground water and stay wet for several days or weeks. Landowners often mow or plow around these spots to avoid getting tractor wheels stuck in the soft ground. On spring evenings, these puddles seem alive with the high-pitched calls of spring peepers (tiny frogs) looking for mates among the rushes and sedges that grow here. In the heat of the summer, these places usually dry up.

**WOW!: The Wonder Of Wetlands**
Lesson 1: There's Water! Is It a Wetland?

Habitat Cards

5. Fine particles of dirt make mud when they settle out of the water. Where the water is very shallow, the muddy bottom is uncovered at low tide. While this area may not look like home to many animals, and few or no plants grow here, lots of creatures live down in the mud. Watch for hungry shore birds searching for them in the mud.

6. Tall grasses and other kinds of plants grow up out of the water. The water contains little or no salt, but the push of incoming tides is strong enough to raise the water level in the river. The ground is sometimes flooded and sometimes dry or exposed. The plants provide food and places to hide for many kinds of animals including fish, invertebrates, muskrats, and lots of birds.

7. Where trees grow in low-lying areas, the ground may hold water for part of the year. In the spring, many beautiful wildflowers grow here, and frogs and salamanders find wet places to lay their eggs.

8. In salty bays or at the ocean's edge, two kinds of plants may grow under the shallow water. They can only live where it is shallow because they are rooted on the bottom and need light to make food. The plants are eaten by many animals, and many of them find safe places to live among the plants. These plants protect the shore and reduce the mudiness of the water by slowing the waves.

WOW!: The Wonder Of Wetlands

EXPLORE NEVADA'S AMAZING WETLANDS
**Habitat Cards**

9. Old lakebeds and other low areas that fill with rainwater sometimes accumulate layers of partially decayed plants called peat. At first glance these places might look dry, but their moss-covered floors actually hold a good deal of fresh water just below the surface. The ground here feels very spongy. Some shrubs and evergreen trees also grow above the sphagnum moss. In these unusual conditions, many unique, beautiful, and rare plants and animals can be found.

10. Along the shore where the water is salty, tall grasses grow up out of the water. Tides move in and out, but some places are flooded only during storms and very high tides. When the tough plants here die, they break down in the water to form little particles called detritus. Many animals eat detritus by filtering it out of the water.

**WOW!: The Wonder Of Wetlands**
Objective: Identify the locations of some of the better known wetland areas in the United States on the Wetland “Celebrities” of the United States map provided. A list of names is given below. You may find the “Types of Wetlands” handout useful. It may also be helpful to consult different reference sources, including books and websites.

Question: Do you think there are more inland or coastal wetlands? Why?

Bogs
Bottomland Hardwood Forests
Great Dismal Swamp
Great Kankakee Swamp
Mangroves or Mangrove Swamps
Mississippi River Delta
Okefenokee Swamp
Pocosins
Prairie Potholes
Sandhills and Rainwater Basin Marshes
Tropical Rainforests
Yukon Flats, also known as Muskeg or Wet Tundra
Activity 1: Wetland "Celebrities" of the United States
Explore Nevada’s Amazing Wetlands Poster
Plants and Animals Found on the Northern Nevada Wetland Poster

Species List
1. Great Blue Heron
2. Belted Kingfisher
3. Northern Harrier
4. American Bittern
5. Redwing Blackbird
6. Marsh Wren
7. Bufflehead
8. Northern Pintail
9. Mallard
10. Short-eared Owl
11. Western Tiger Swallowtail Butterfly
12. Common Green Darner
13. Signal Crayfish
14. Northern Leopard Frog
15. Muskrat
16. Beaver
17. Big Brown Bat
18. Brown Trout
19. Channel Catfish
20. Clams and Mussels
21. Gilled and Lunged Snails
22. Caddisfly Larva
23. Common Cattail
24. Rocky Mountain Iris
25. Skunk Cabbage
26. Pond-lily
27. Common Duckweed
28. Pondweed
29. Hardstem Bulrush
1. **Great Blue Heron** – *Ardea herodias*
   This is the largest of the heron family. It can be found motionless along the edge of a pond or marshy pool, seeking out frogs or fish, which are its favorite foods! The great blue heron is a long-legged wading bird that appears almost prehistoric when awkwardly flying through the air.

2. **Belted Kingfisher** – *Ceryle alcyon*
   As the name implies, these birds dine primarily on fish. They expertly plunge headfirst into sheltered waters. Belted Kingfishers are one of few North American bird species whose females are more colorful than males. The females have a chestnut band across the belly that is absent in male’s blue-gray and white coloration.

3. **Northern Harrier** – *Circus cyaneus*
   Formerly known as the marsh hawk, the Northern Harrier is the only North American hawk to have evolved a facial disk similar to an owl. Even a beginning birder can identify this bird as it flies by, exposing its white rump patch. This beauty can be seen “wobbly” flying over grasslands, fields, or marshes with its wings in a V-shape when hunting. Following a sudden and unexpected pounce, it captures small birds and mammals with its long, yellow legs.

4. **American Bittern** – *Botaurus lentiginosus*
   Frequently called a “thunder-pumper” or “stake-driver,” the bittern is known for being heard before it is seen. When approached, it raises its head and points its beak skyward while swaying slowly from side to side, as if imitating waving reeds.

5. **Redwing Blackbird** – *Agelaius phoeniceus*
   You might see this species in just about every environment that is wet or brush-like. They are defensive and territorial in the spring, and are known to attack crows, ravens, magpies and raptors. You may even see them riding on the backs of crows, pecking them with fury. In the winter, they flock together with other blackbirds in farmland or suburban areas.

6. **Marsh Wren** – *Cistothorus palustris*
   This small wren is found in tall reeds, cattails or other similar marsh vegetation. It is very sneaky and often difficult to locate, even though its singing can often be heard. The marsh wren eats mostly insects and sometimes snails. It nests in low groundcover during the breeding season, so watch where you step!

7. **Bufflehead** – *Bucephala albeola*
   The tiny and compact bufflehead is the smallest duck. It has an unusual body shape when hunting. Following a sudden and unexpected pounce, it captures small mollusks, crustaceans, and fish. This “tree nester” picks a long-term mate and builds a nest in cavities excavated by the Northern Flicker, a type of woodpecker.

8. **Northern Pintail** – *Anas acuta*
   This is one of our most common ducks. Its name comes from the appearance of the male’s tail when feeding. Seeds and aquatic plants are its main food, which it retrieves by ducking under the water’s surface and “dabbling,” or straining water through its bill.

9. **Mallard** – *Anas platyrhynchos*
   Mallard ducks are a familiar sight to most of us, being the most widespread and abundant duck in North America. They are found in all kinds of wetlands and are familiar inhabitants of urban park ponds. The males have bright green heads and pale bodies, while the females are dull brown all over. Mallard ducks eat insects, fish eggs, small fish, tadpoles, wild rice, berries, leaves, green plant shoots, and grain, using their bills to filter food from the mud.

10. **Short-eared Owl** – *Asio flammeus*
    If you’re lucky, you’ll spot the short-eared owl cruising low to the ground over grasslands and marshes. These owls are relatively small (about 15” in length) but have the broad wingspan typical of owls. The ears are so short that you probably won’t see them while the owls are in flight, but you will notice that the head is large, and the eyes are a vivid yellow. Short-eared owls feed on small rodents such as voles, and unlike other owls often hunt by day.

11. **Western Tiger Swallowtail Butterfly** – *Papilio rutulus*
    This relatively common butterfly receives its name from a long “tail” on its hind wings that resembles the long, pointed tail of a swallow. The Tiger Swallowtail butterfly is not poisonous, but many females take on a darker coloration to mimic its close relative, the Pipevine butterfly, which is poisonous.

12. **Common Green Darner** – *Anax junius*
    Dragonflies come in just about every color of the rainbow. Common species are black, brown, blue, green, red, orange, yellow, white, or gray, in various shades and combinations. The term “dragonfly” often includes damselflies (spreadwings, pond damsels, jewelwings) and dragonflies proper (petaltails, darners, clubtails, spiketails, cruisers, emeralds, and skimmers). They are all extremely active and fun to watch as they dance around freshwater wetlands.

---

**Explore Nevada’s Amazing Wetlands**
13. **Signal Crayfish** – *Pacifastacus leniusculus*
A native to our western U.S. streams and lakes, this crayfish has been problematic in much of Europe. Accidentally introduced to the British Isles, it competes with their native crayfish, which are much smaller and less aggressive. Despite its invasive tendencies in its non-native ranges, it is an integral part of our western wetlands.

14. **Northern Leopard Frog** – *Rana pipiens*
Northern leopard frogs have slim bodies and leopard-like round, dark spots outlined with pale yellow and white. They are primarily nocturnal (active at night), foraging for insects, worms, and other frogs. When pursued on land, they flee with zigzag leaps until they reach the security of water. Once common, they are becoming scarce in many places.

15. **Muskrat** – *Ondatra zibethicus*
Neither a beaver nor a rat, this large, water-dwelling rodent resembles a large field mouse. Muskrats feed mainly on aquatic plants but will also eat snails, clams, crayfish, and frogs. As its name implies, it produces a yellowish, musky-smelling substance from its anal gland that is used for communication and attraction during the breeding season.

16. **Beaver** – *Castor canadensis*
The beaver is the largest rodent in North America. It is most similar to the muskrat, although it is not related. Shaped for the water, it has a large, chunky body with a waterproof undercoat and layer of fat to help minimize heat loss in freezing conditions. Its specialized tail is broad and flat, with large, blackish scales that are used to slap the water’s surface to alarm others beavers of danger. The beaver is often called "nature’s engineer" because it builds dams that provide habitat for many other animals and plants.

17. **Big Brown Bat** – *Eptesicus fuscus*
A relatively fast flyer, reaching speeds of 40 miles per hour, the Big Brown Bat eats mostly beetles but also takes wasps, ants, plant hoppers, and leafhoppers. They spend the daylight hours sleeping in dark, secluded areas such as hollow trees, beneath loose tree bark, or in the crevices of rocks. The Big Brown Bat is relatively large in size, from about 4 to 5 inches in length, and its fur is moderately long and shiny brown.

18. **Brown Trout** – *Salmo trutta*
Brown trout prefer cool clear rivers and lakes. They are wary and elusive fish that hide in undercut banks, instream debris, surface turbulence, rocks, and deep pools. They also take shelter under overhanging vegetation. Apart from moving upstream to spawn, adult brown trout tend to stay at about the same place in a river. Brown trout are meat-eaters (carnivorous). They eat insects from water and land, and take larger prey such as worms, crustaceans, mollusks, fish, salamanders, and frogs as their size increases.

19. **Channel Catfish** – *Ictalurus punctatus*
Channel catfish hide in cave-like areas formed by undercut banks, rock ledges, or weedy areas. They eat pretty much anything, including aquatic plants and seeds, fish, mollusks, insects and their larva, and crustaceans. They can't see very well, but their whiskers include taste buds that help them find food at night and in muddy waters. Simply touching the whiskers to an object allows a catfish to taste it!

20. **Clams and Mussels** – *Corbiculidae*
This group includes clams and mussels that typically occur in most freshwater habitats. You can recognize members of this group by the two hinged shells that enclose their soft bodies. You may see a soft fleshy "foot" extending from the shell, but won’t find eyes or a distinct head. Clams are generally smaller and more round than mussels.

21. **Gilled and Lunged Snails** - *Gastropoda*
Sometimes referred to a “right-handed” and “left-handed” snails, the two types can be told apart by the side on which their shells open when pointed tip is away from the viewer. Shells that open to the right indicate "good," or gilled snails, while those that open to the left are "poor," or lunged snails. Gilled snails are dependent on good water quality because they must obtain all of their oxygen from the water. Lunged snails get oxygen directly from air trapped in their shell cavity.

22. **Caddisfly Larva** – *Trichoptera*
Caddisfly larvae are the young stage of the Caddisfly, an insect found in streams. Most species live in tubes or cases they construct from sand, pebbles, pieces of leaves and wood. As they move about, they drag the case with them, with only their front ends and legs sticking out. When a larva gets too large for its skin and case, it molts (sheds). Then it builds another, larger, case to grow into. Caddisfly larvae are important food sources for fish and other aquatic vertebrates.

23. **Common Cattail** – *Typha latifolia*
Cattails are commonly found growing in marshes, shallow ponds, and along streambanks and moist ditches. The plant is coarse and stout with broad, flattened leaves. Its flowers form a dense, terminal flower spike (cat-tail) that looks like a large cigar. These wetland plants are found growing along the shore of marshes, ponds, lakes, rivers and ditches in dense clumps. Many species of insects eat and live on them.
24. **Rocky Mountain Iris** – *Iris missouriensis*
   The Rocky Mountain Iris, also called the Western Blue Flag, can be found growing from California east to Colorado. It has beautiful, large blossoms in various shades of blue and broad, flat, sword-like leaves. The Iris can become invasive in pastures and other moist areas, and is poisonous to livestock and humans.

25. **Skunk Cabbage** – *Lysichiton americanus*
   Skunk cabbage is a fresh, succulent and unforgettable addition to a wetland. Its decaying flesh-like smell and alien appearance make the “swamp lantern” a marvelous wetland addition. Skunk cabbage was rarely used as a food for native people, but was used as “Indian wax paper” for lining berry baskets, berry drying racks, and steaming pits.

26. **Pond-lily** – *Nuphar* species
   Aside from acting as a food and habitat source for animals, the Pond-lily’s floating leaves also provide shade and protection for algae and aquatic insects. It has club-like rhizomes (underground root-like stems), heart-shaped leaves and waxy flowers.

27. **Common Duckweed** – *Lemna minor*
   Common Duckweed is one of the smallest flowering plants in the world. It is a free-floating plant that grows in thick green mats covering the surface of the water. Common Duckweed is a food source for many birds and fish, especially ducks, as its name would suggest. It also provides shelter and protection for aquatic animals such as frogs, snakes, fish, insects, and crustaceans.

28. **Pondweed** – *Potamogeton* sp.
   Found in quiet lakes, sluggish streams, ponds, and sloughs, pondweed is the largest and most diverse group of aquatic plants. It may sometimes be submerged. It is highly important food for waterfowl and habitat for aquatic organisms. Some non-native pondweeds are highly invasive weeds in waterways.

29. **Hardstem Bulrush** – *Scirpus acutus*
   This striking wetland plant can reach 10 or more feet tall. It grows best on sites with saturated soil or standing soil for most of the year. Bulrushes (also called tules) are important food and habitat plants for waterfowl and aquatic mammals. Native Americans used roots, pollen, and flowering spikes as food, and stems were used to construct baskets, mats, temporary shelters, and other household items.
Lesson 2: Is Dilution the Solution? An Introduction to Nonpoint Source Pollution

**Purpose:**

This laboratory or classroom activity introduces students to water pollution concepts and demonstrates that even small amounts of pollution in a water supply can be harmful.

**Summary:**

Students will learn about point source and nonpoint source pollution, learn to identify some pollution indicators, and attempt to clean up a contaminated sample by diluting the water.

**Key Learning Points for Students:**

1. Water pollution can be divided into two broad categories, point source (PS) and nonpoint source (NPS) pollution. By the end of the lesson, students should be able to define PS versus NPS pollution.
2. Point source pollution is pollution that can be traced to a single, identifiable source, such as a pipe or culvert.
3. Nonpoint source pollution is polluted runoff that enters a water body from a diffuse source. It results from a variety of land use activities over a widespread area. It is considered the main source of water quality degradation today.
4. There are six main types of NPS pollution. Students should know the six types of nonpoint source pollution and be able to give at least one example of each of the six types (nutrients, pathogens, sediment, toxic chemicals, trash or debris, and thermal stress.)
5. Once contaminated, it is difficult and expensive to clean up water. It is more effective to avoid contamination than to try to improve degraded water quality.
Lesson 2: Is Dilution the Solution?

Handouts:
1. Categories of Nonpoint Source Pollution
2. What You Can Do About Nonpoint Source Pollution
3. Nonpoint Source Pollution Cartoon Activity
4. Vocabulary Activity - Word Search: Is Dilution the Solution?
5. Nonpoint Source Matching Game Activity
6. Dilution Activity Worksheet
7. Remove Oil Pollution from Water Using Different Methods Activity Worksheet

Background:

Water is a vital resource without which life cannot exist. Water has the capacity to cleanse itself when polluted by depositing or diluting the pollutants. Additionally, biological activity by organisms in the water can aid in breaking down pollutants. If too many pollutants enter a water body, its capacity to detoxify itself may be overwhelmed. Problems also arise when small amounts of highly toxic materials enter a stream. Lake, or wetland.

Water pollution can be categorized as point source pollution, in which the source of the pollution is easily determined, and nonpoint source pollution, which results from the cumulative impacts of a variety of land uses.

Point sources include factory discharges and wastewater treatment effluent that is discharged into a river or lake. Because the discharges reach the water from a known single source, such as a factory or wastewater treatment facility, via an easily identified pipe, culvert, or other conveyance, it is possible to measure what is in the discharge and treat or control it before it enters a waterway.

Nonpoint source (NPS) pollution is much more difficult to control due to its diffuse nature. It occurs when water washes over the land surface, whether from rain, car washing, or the watering of crops or lawns, and then picks up an array of contaminants. These contaminants include sediment, fertilizer from lawns and crops, leachate from landfills, and oil from leaky cars that washes off roads. It is not always possible to trace NPS pollution to a single controllable source.

Today, NPS pollution is our biggest water pollution challenge. Everyone’s daily activities can contribute to NPS pollution, so everyone needs to learn how it occurs and how to apply simple measures to decrease it.

There are six major types of water pollutants:

1. Nutrients are materials such as nitrogen and phosphorus that feed plants and stimulate their growth. We use fertilizers, which contain nutrients, to keep our lawns green and our plants and crops healthy and productive. Other sources of nutrients include sewage, septic tank effluent, animal waste, automotive exhaust, industrial wastes, and even car washing.
It’s been estimated that about 80 percent of nitrates and 75 percent of phosphates that are added to lakes and streams in the U.S. are the result of human activities. Plants require nitrogen and phosphorus to grow. When too many nutrients enter waterways, plants such as algae may grow rapidly. These algal blooms can become so overwhelming that water becomes green and slimy. This affects water clarity and blocks sunlight transmission, which harms other aquatic organisms. When the algae dies, the decay process robs the water of oxygen and fish death may occur. The decay process also causes unpleasant odors. Nitrogen occurs in several different forms (nitrates, nitrites, ammonia, etc), and the forms nitrate and ammonia can be toxic to fish. Nitrates in drinking water have also been linked to “blue baby” syndrome in bottle-fed infants. Phosphorus is not directly toxic to humans or other animals.

2. **Pathogens** are disease-causing microorganisms such as bacteria and viruses that come from the fecal waste of humans and animals. These substances may cause serious health problems and can interfere with the use of water for recreation. Special treatment of drinking water may be required when it becomes contaminated with troublesome pathogens such as giardia and cryptosporidium. Pathogens wash off land from wild animal, farm animal and pet wastes, and can also enter our waterways from improperly functioning septic tanks, leaky sewer lines, and boat sanitary disposal systems.

3. **Sediment** includes sand, dirt and gravel eroded by surface runoff or wind. Our sandy Nevada soils are particularly vulnerable to erosion. Any activities that disturb the ground surface and remove plants may accelerate sediment production. Sediment usually ends up in stream beds, retention ponds, or at the shores of lakes and reservoirs. The sediment can alter stream flow and damage aquatic habitat. Sediment affects water clarity, may clog fish gills, and smothers spawning gravels. Additionally, phosphorus tends to adhere to sediment particles. Poorly protected construction sites, bare soil at newly-built sites, overly steep slopes resulting from poor construction methods, areas burned by wildfire, vacant agricultural fields, and suburban gardens can all be sources of sediment pollution.
4. **Toxic Chemicals** are substances that may harm the health of human beings and aquatic life. These include heavy metals, pesticides, and organic compounds such as polychlorinated biphenyls (PCBs). Toxic chemicals result from a variety of human practices and products. Because many of these toxic substances are resistant to breakdown, they tend to be passed up the food chain and concentrated in large predators. Other toxic chemicals, such as mercury, are converted to a more toxic form as a result of ingestion by living organisms. Fish consumption health advisories may result from accumulation of toxic chemicals such as mercury, as has occurred in the Carson River Basin at Lake Lahontan. Oil, grease, and gasoline from roadways (called hydrocarbons), industrial practices, and chemicals used in homes, gardens, yards, and on farm crops are major sources of toxic chemicals. Few people know it, but storm drains dump runoff directly into the nearest river or lake. The storm water is not treated, and thus can be a source of dangerous pollution if people use storm drains as disposal sites for hazardous materials.

5. **Trash (a.k.a. junk or debris)** is a form of water pollution we all can recognize. Plastic bags, fast food wrappers, even shopping carts find their way into local streams and ditches. This type of pollution not only interferes with our enjoyment of our water resources, it also can be a health threat to aquatic organisms and other animals found in wetland habitats. And…it’s just plain ugly. Trash often starts as street litter that is carried by the wind or by runoff into our waterways, or it is directly dumped into streams, ditches and storm drains for disposal.

6. **Thermal Stress** results when streamside vegetation that shades and cools the water is removed. Paved surfaces, particularly asphalt, that transfer their heat to rainfall and runoff also are a source of temperature pollution. Shallow water impoundments and concrete canals will absorb heat and result in elevated temperatures in surface water. Elevated temperatures are harmful to aquatic life, and can even result in changes in fish species from those that require cool temperatures, such as trout, to those that will tolerate warm temperatures, such as carp. Warm temperatures also decrease oxygen concentrations, and create a more favorable environment for pathogen growth. The same lack of streamside vegetation, shallow water and concrete canals can cause lower winter water temperatures. Shallow water may freeze during the winter which would have a detrimental effect of fish and aquatic life also.
While some of these sources of pollution are visible, such as trash, others may be colorless and odorless, making them difficult to detect. Historically, humans have used large bodies of water such as the oceans to dilute and disperse wastes. During the 1860s through the 1890s, the Truckee River in Reno was used as a sewer. Raw wastes were dumped into the river, with the thought that they would move downstream and “go away”. The river was also used to dispose of sawdust waste from paper mills. By the 1890s, it was no longer safe to drink the water due to pathogen contamination. Anecdotes from that time note that there was so much sawdust in the river, it looked like chowder.

Today, of course, we know that no water body is an infinite reservoir that can absorb any amount of pollution without suffering consequences. Medical wastes are washing up on beaches. Sewage dumping has resulted in fish death and health problems. Swimmers become ill from a variety of infections, and beaches must be closed. Dilution is NOT the solution to all pollution!
Lesson 2: Is Dilution the Solution?

Oil Spills at the Water’s Edges

Most disastrous oil spills have occurred when petroleum products are transported across oceans in tankers, which leak due to accidents, etc. However, tanker trucks and trains may also crash and spill products directly into rivers, lakes or wetlands. When oil spills into the ocean or other waters, it's especially likely to harm animals and plants at two interfaces (places where different things come together):

- Near the surface of the water, where water and air meet. As oil slicks move across the water surface, oil can clog the feathers of birds that land on the water or the fur of marine mammals that must surface for air, and oil can kill or damage plankton (the tiny floating plants that support all other marine life) and other small creatures.
- Along the shore, where water and land meet. Here, beached oil can smother creatures such as worms or clams, and toxins in oil can damage other creatures and plants. Where marshes grow near the shoreline, grasses and plants can be oiled and be damaged or killed.

Oil Spills at the Water Surface

Because most kinds of oil are less dense than water, most spilled oil floats on the water surface. It spreads out and is pushed across the water by wind and currents.

How spilled oil affects near-surface creatures depends on just when and where the oil spills--those creatures might or might not even be in the area at the location and time of a spill. That's because things are always changing at the surface: flocks of seabirds come and go; plankton, jellyfish, and other kinds of creatures bloom (reproduce) at certain seasons and then die off to become much less numerous at other times. The distribution of plankton and other small organisms is very patchy in space as well as time: if you were traveling around in the water column below the surface, you would find large spaces with not many animals, and then you might encounter a dense cloud of plankton in one spot.

How oil affects near-surface creatures also depends on how vulnerable those creatures are to the effects of oil.

Birds that float on the water surface and dive to feed can be oiled if they happen to be in the same place as an oil slick. Seabirds keep themselves warm through their feathers, and when these get oiled, the birds become chilled and often die. This is called hypothermia. Since birds preen themselves to clean their feathers, they can also ingest oil, causing illness or death.

Marine mammals such as seals, whales or porpoises must surface to breathe. If they become oiled, this may irritate their eyes or skin, or they may breathe in harmful oil fumes. Seals and sea lions are especially at risk of oiling when their haulout or pupping areas have been oiled. However, most marine mammals will be able to recover from these types of oiling impacts.

Some can be much more seriously harmed, though. There are two types of marine mammals: most seals, whales, and porpoises keep themselves warm by having thick blubber; otters and fur seals keep themselves warm by having thick fur coats. Otters and fur seals are much more
vulnerable to oil than other marine mammals. When the fur of an otter or fur seal gets oiled and matted, it can no longer warm the animal, and the animal soon will die of hypothermia. This is why fur-bearing mammals and seals, along with seabirds, are so vulnerable to oil impacts.

Spilled oil also can affect creatures well below the surface. A small percentage of the spilled oil (how much depends on the type of oil spilled) will disperse naturally down into the water column. The dispersing oil can affect creatures that live there, such as fish and plankton. Some animals may be able to avoid the oil, by swimming away from it (fish, for example). Others, such as plankton, which are tiny plants and animals that drift with the currents or swim very weakly, may be hurt or killed by oil in the water column.

**Oil Spills Along the Shore**

Oil spilled into the water, pushed by winds and currents, often reaches the shore. Oil may strand at the high tide line, leaving black lines or globs of oil on the beach as the tide recedes. Thick layers of oil may coat rocks, beaches or plants. On waterlogged sediments such as on mudflats, oil will remain on the mud surface if left undisturbed, and be lifted again on the next tide. Where animals have burrowed into the mud, oil may penetrate the surface through these openings. Sun, wind, and waves will gradually weather oil that remains on the beach (cause it to change physically and chemically), forming a hard asphalt-like substance, and eventually causing it to break apart and disappear. In sheltered areas, oil may remain for a long time.

Oil harms shore creatures either by injuring or killing them outright. Some creatures that can hide may survive oiling, such as snails or clams that can withdraw into their shells. These animals may take up toxic parts of the oil into their bodies, through eating contaminated food. Birds that feed along the shoreline may get oil on their feathers, causing them to lose their ability to keep themselves warm, and will likely die.

### Common Methods Used for Oil Spill Cleanup

<table>
<thead>
<tr>
<th>Method</th>
<th>Description of Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural recovery</td>
<td>Oil is left in place to degrade naturally.</td>
</tr>
<tr>
<td>Booming</td>
<td>A floating, physical barrier is placed on the water to contain, divert, deflect, or exclude oil.</td>
</tr>
<tr>
<td>Skimming</td>
<td>Mechanized equipment, such as skimmers, draglines, and dredges, are used to recover floating oil from the water surface.</td>
</tr>
<tr>
<td>Barriers and berms</td>
<td>A physical barrier other than a boom is placed across an area to prevent oil from passing. The barrier may consist of earthen berms, trenching, or filter fences.</td>
</tr>
<tr>
<td>Manual oil removal and cleaning</td>
<td>Surface oil is removed using hands, rakes, shovels, buckets, scrapers, pitchforks, etc. The oil is placed in containers. No mechanized equipment is used.</td>
</tr>
<tr>
<td>Mechanical oil removal</td>
<td>Oil and oiled sediments are collected and removed using mechanical equipment not specifically designed for pollution response, such as backhoes, graders, bulldozers, dredges, draglines, etc.</td>
</tr>
<tr>
<td>Sorbents</td>
<td>Sorbents (oil-attracting materials) are placed on the floating oil or water surface to collect the oil. The sorbent material is then recovered.</td>
</tr>
<tr>
<td>Vacuum</td>
<td>A vacuum unit is attached via a flexible hose to a suction head that recovers free oil.</td>
</tr>
</tbody>
</table>
Vocabulary List

**Algal bloom:**  A heavy growth of algae in and on a body of water, usually resulting from high nutrient concentrations in the water. May occur naturally under certain conditions, but usually occurs as the result of pollution.

**Contamination:** The addition of any substance to water that makes it unfit for use.

**Debris:** Trash. Any accumulated material, including floating or submerged trash.

**Dilution:** The reduction of the concentration of a substance in air or water.

**Effluent:** Discharged wastewater, such as the treated wastes from municipal sewage plants, brine wastewater from desalting operations, and coolant waters from a nuclear power plant. Effluent is generally considered point source pollution.

**Fertilizer:** Any organic or inorganic material of natural or synthetic origin that is added to the soil to supply elements essential to plant growth.

**Groundwater:** All subsurface water that fills the pores, voids, fractures and other spaces between soil particles and in rock strata within the saturated zones of geologic formations.

**Hydrocarbons:** Chemical compounds that consist entirely of carbon and hydrogen, such as petroleum, natural gas and coal.

**Leachate:** Liquid that has percolated through the ground, picking up chemicals, metals, pathogens or other hazardous or toxic substances.

**Nonpoint source pollution:** Pollution that enters water from a variety of land use activities over a widespread area. It is also known as polluted runoff. It is considered the main source of water quality degradation today.

**Nutrient:** A substance such as nitrogen or phosphorus that is necessary for plant growth.

**Pathogen:** Disease-causing microorganisms, such as bacteria and viruses, that come from the fecal wastes of humans and other animals.

**Pesticide:** Any chemical agent used to control specific pests. Includes insecticides, herbicides and fungicides.
Vocabulary List, continued

**pH:** The term pH is an abbreviation of the French term “pouvoir hydrogène”, which literally means “hydrogen power.” pH is a measure of the activity or concentration of the hydrogen ion \([H^+]\) in a solution, and is used to determine if a solution is acidic or basic (alkaline). The mathematical expression for pH is:

\[
pH = \text{log} [H^+] \quad \text{(the negative log of the hydrogen ion concentration)}
\]

The pH scale ranges from 0 to 14, with 7 being neutral, less than 7 acidic, and greater than 7 basic or alkaline. The acidity of the solution increases as the pH value decreases. As the pH scale is logarithmic, there is a tenfold increase between each whole number pH value.

**Point source pollution:** Pollution that can be traced to a single, identifiable source, such as a pipe or culvert.

**Pollutant:** Something that causes an undesirable change in the physical, chemical, or biological characteristics of air, water, or land. Something that may harm or affect humans or other living organisms.

**Runoff:** Precipitation or excess irrigation water that flows overland to streams, rivers and lakes.

**Sediment:** Fragmented material from weathered rock and organic matter that is suspended in, transported by, and eventually deposited by air or water.

**Storm drain:** A man-made system of underground pipes that drains water from a paved surface and discharges the storm water into a water body. The storm water is generally not treated to remove pollutants.

**Storm water:** The water produced as a result of a storm.

**Surface water:** All water on the surface of the earth, including lakes, rivers, streams, ponds, oceans, and runoff.

**Thermal stress:** An increase or decrease in the temperature of surface water. The increase or decrease in temperature can be harmful to aquatic life. Removal of streamside vegetation, paved surfaces, shallow water impoundments, and concrete water canals all contribute to thermal stress or temperature pollution.

**Toxic chemical (Toxic contaminant):** A chemical that can harm the health of human beings and/or have a detrimental effect on the propagation, cultivation or conservation of animals or other aquatic life.

**Water quality:** The chemical, physical, biological, and radiological condition of surface water or groundwater.
The Activities

1. Impacts of Nonpoint Source Pollution on Water Resources handout

Procedure:

Review the handout, Impacts of Nonpoint Source Pollution on Water Resources, with the students. Ask students to brainstorm sources of each category of pollutant. Which would result from natural sources? Which are linked to man’s activities?

2. What You Can Do About Nonpoint Source Pollution handout

Procedure:

Review the handout, What You Can Do About Nonpoint Source Pollution, with the students. See how many suggestions for additional actions students can brainstorm.

3. Nonpoint Source Pollution Cartoon Activity

Procedure:

Show students the Nonpoint Source Pollution Cartoon Activity cartoon depicting several different types of homeowner activities that result in nonpoint source pollution. The image can be projected on a large screen. Have the students name as many nonpoint source pollution-producing activities as they can and the types of nonpoint source pollution these activities would produce.

4. Nonpoint Source Pollution Matching Game Activity

Materials:

Start by gathering some props for the students:

- A motor oil can, preferably empty
- A road salt container, or the rock salt itself in a clear container
- A plastic bottle (water or soft drink)
- A container of soil
- Plastic rings from a 6-pack of soda
- A container labeled “pesticide” – empty and cleaned for safety
- A container labeled “fertilizer” – empty and cleaned for safety (or use fake plastic manure)
- A small picture of a tree or a model tree
- A small container of water
- A picture of a playa or small lake
- A picture of a wetland, preferably a local one

This game is designed to help students recognize some of the important problems that contribute to nonpoint source pollution, and ways to control it.
The Activities, continued

4. Nonpoint Source Pollution Matching Game Activity, continued

The exercise is a matching game in which students are given clues describing important nonpoint source pollution sources. They must match the clues with the appropriate prop, which represents a source. Clue cards are printed on pages S – 4 and S – 5. An answer key is provided on page 24. Classroom discussion questions and answers are also included to supplement the game.

There are multiple options for playing the game. You may attach the props to a poster board and the students match the clue cards to the props. Conversely, you may glue the clue cards to a poster board. Students will then match the props to the clues. You may hand out clue cards and props to the students and then instruct each student to find his or her “match.” Use the discussion questions before, during, and after the game to help your students learn more about nonpoint source pollution.

Discussion Questions:

- **Question:** Motor oil and car fluids can be leaked from cars or dumped into storm drains, where they become nonpoint source pollutants. What are some of the actions you can take to prevent these fluids from entering our water and harming aquatic animals and the entire ecosystem?

  **Suggested Answers:**
  - Cars and boats should always be checked for leaks. If found, leaks should be repaired immediately.
  - Oils and other engine fluids should never be dumped down storm drains or sewers. They should be recycled at service stations instead.

- **Question:** Fertilizers and pesticides are applied to places like lawns, gardens and farm fields every day. When it rains, the chemicals are carried into storm drains and from there to our streams, lakes and groundwater. Sometimes these chemicals wash directly into our waterways. What steps can you take around your house to stop these sources from becoming nonpoint source pollutants?

  **Suggested Answers:**
  - Farm, lawn and garden chemicals should be used wisely and, most importantly, only when needed.
  - Apply fertilizers and pesticides only when there is no chance of wind and/or rain.
  - Use non-toxic products whenever possible.
  - Only buy and mix up the amount of chemicals needed to do the job. Always follow instructions!
  - Pick up after your pet. Animal manure is a source of nitrogen and phosphorus, and also contains pathogens.
  - Test your soil to see if it needs fertilizer and if so, how much to apply.
The Activities, continued

4. Nonpoint Source Pollution Matching Game, continued

- Some bugs live by eating other bugs. Instead of using a pesticide to kill bugs, research whether you can safely introduce a predator bug to kill your pest bug. For example, ladybugs can be introduced to eat aphids.

- **Question:** Plastics are one type of nonpoint pollution. What are some of the ways that plastics are introduced into our waters? What can you do to keep them out of our waterways?

  **Suggested Answers:**
  - Most plastics get into our waters due to littering.
  - The easiest way to keep plastic and other trash out of our waterways is to dispose of trash properly.
  - Recycling plastics and other trash whenever possible will not only reduce litter but also the bulk of trash put into our landfills.

- **Question:** What are some reasons why we would want to eliminate runoff and nonpoint source pollution?

  **Suggested Answers:**
  - It is very expensive to clean up water, and no one wants to pay more for their drinking water.
  - Cleaning up nonpoint source pollution might be difficult, since this kind of pollution is caused by the things we do every day. Since everyone is part of the problem, everyone needs to do their share to become part of the solution.
  - People depend on clean water for living, recreation and in some cases for their jobs (like farming, ranching). It is important to keep our water resources clean so we can continue to use them.

5. Word Search - Is Dilution the Solution (a vocabulary exercise)

**Procedure:**

Have students find the hidden words in the word search. You may want to assign them to look up the definitions for some or all of the words. This can be an in-class or take-home exercise.

An answer key for this puzzle is provided on page 25.
The Activities, continued

6. Dilution Experiment Activity

Materials:

- 6 plastic cups per group
- Permanent markers, one per group
- 100-mL graduated cylinders, one per group
- Measuring spoons (tablespoon)
- Water
- Dropper
- Plastic spoons for tasting and mixing
- Colored powdered drink mix (such as Kool-Aid, etc.), without sugar
- Colored powdered drink mix, with sugar (darker colors work well)
- Sugar
- Student worksheet for dilution exercise

Preliminary discussion:

- Discuss nonpoint source pollution with the students. Have them generate a list of all the types of pollutants they can think of. This can be done in conjunction with Activity 3.

- Ask the students to name some local water bodies that might be experiencing problems with nonpoint source pollution. Where is it coming from, and what kinds of pollution might be occurring?

- Ask students to think of some ways to decrease the amount of pollution affecting our waterways. How might they prevent a repeat accident or situation?

- To lead into the exercise, ask students how easy they think it might be to clean up the different types of pollutants. Which might be the easiest? Which might be the most difficult?

Procedure: *(Adapted from The Water Sourcebook, Grades 6-8).*

1. Mix up the unsweetened drink mix according to the package directions, but do not add any sweetener. Have students taste the unsweetened mixture. Add sugar one tablespoon at a time and have students continue to taste spoonfuls of the mixture until it seems sweet. Have them keep track of the number of spoonfuls added (note: 16 tablespoons is one cup, 8 tablespoons is 1/2 cup, 4 tablespoons is 1/4 cup). How many tablespoons did it you add until the mixture seemed sweet? Can the students see the sugar? Point out to the students that pollutants may have neither color NOR taste, but may still be in the water threatening our health. An example is nitrate contamination, which has neither color, odor, nor taste.
The Activities, continued

6. Dilution Experiment Activity, continued

2. Divide the students into small groups. Give each group six plastic cups and a graduated cylinder. Direct the students to number the cups from one through six using a permanent marker.

3. Have the students measure 50 mL of water in cups 2 through 6 for each group. This represents the “pure” water that will be “polluted” by the drink mix.

4. Mix the powdered sweetened drink mix according to the directions.

5. Use the graduated cylinder to place 100 mL of the prepared sweetened drink mix into cup number 1 for each group. Explain to students that cup number 1 represents a source of pollution to local water, such as fertilizer running off a lawn. The students should use a clean plastic spoon to taste the drink. Be careful – if they taste too much, you’ll run out! Have students record the color and taste on the handout.

6. Place 50 mL of the “polluted” mix from cup 1 into cup 2 using the graduated cylinder and have students stir the mixture. Ask a single student to taste the mixture and describe the difference in sweetness. Have them record their observations on the chart.

7. Ask the students to predict how dark the solutions will be in cups 3 through 6 after they are diluted, and how sweet they will be. Enter the predictions on the chart.

8. Continue to add 50 mL from the polluted water source into the clean water in cup 3, and continue until you have diluted all the solutions. Have the students mix the solutions and record their observations on the chart.

9. Have students compare the color of cup 1 to cup 3 and cup 6. Place white paper under the cups if needed for contrast. Compare tastes again, using clean spoons each time.

10. Have the students answer the questions on the chart. Ask them where they think pollution goes. Does it stay in the water forever? What happens to it? (It may wash downstream, be biodegraded, evaporate, stick onto sediments, etc.).
The Activities, continued

7. Remove Oil Pollution from Water Using Different Methods Activity

(Also adapted from the Water Sourcebook. Alternatively, do the activity “Cleaning Oil Spills” on p. 5-5 of the Sourcebook.)

Materials: Provide the following materials to each group:

- Clear plastic cups
- Large ladle, such as a gravy ladle or large serving spoon
- Plastic teaspoon
- Medicine dropper
- Visibly colored cooking oil (used to simulate motor oil)
- Water
- Graduated cylinder for measuring oil (100 mL)
- Paper towels
- Student worksheet

Procedure:

Students will compare three different physical procedures for removing oil from water.

1. Begin by asking students to brainstorm ways to remove oil pollution from water. As an additional assignment, you could also ask the students to research historic methods and compare the historic methods to methods used today. The following links maybe useful:


2. Divide the students into groups.

3. Each group of students will need three samples consisting of approximately ½ cup of water contaminated by 50 mL of vegetable oil. The oil should be dark enough in color that it can be differentiated from the water. Students should carefully and accurately measure the oil into each container. Use a plastic cup for each contaminated sample. Each group will also need a large ladle, such as a gravy ladle or a large serving spoon, a plastic spoon, a medicine dropper, paper towels, graduated cylinder, three cups for waste oil, and one worksheet per student.
The Activities, continued

7. Remove Oil Pollution from Water Using Different Methods Activity

4. Describe the three methods to be used (ladle, spoon, or dropper). Have the students enter their hypothesis on the worksheet. The hypothesis should answer the question, “Which method will work best? Why?”

5. Have each group attempt to remove as much oil as possible from one cup using the ladle. Have them dump the oil into an empty plastic cup. When no more can be removed, measure the amount of oil removed using the graduated cylinder. Pour the oil from the plastic cup into the cylinder. Measure the oil in milliliters. Be careful not to measure the water! Enter the amount removed on the worksheet. Dump the oil into the used plastic cup for disposal.

6. Next, have groups repeat the procedure using the plastic teaspoon and the second contaminated sample, and enter the amount removed on the worksheet.

7. Finally, have the groups repeat the procedure using the medicine dropper and the third contaminated sample. Enter the amount removed on the worksheet.

8. Calculate the percent removed in each sample to determine which method worked best.

9. Have students complete the worksheet.

10. Discuss adsorption techniques, such as booms used during oil spills.

11. Discuss prevention techniques versus clean up techniques. The Web sites listed under item 1 may be helpful.
Resources

Minnesota IDEALS and Educational Web Adventures. 1998. The Watershed Game. [Website]

National Oceanic and Atmospheric Administration. No date. The Nonpoint Source Pollution Matching Game. [Website]


North American Association for Environmental Education. No date. [Website]

United States Environmental Protection Agency. No date. Kids Website. [Website] Games, activities, links and more.

United States Environmental Protection Agency. No date. Nonpoint Source Educational Resources. [Website]

United States Environmental Protection Agency. No date. Polluted Runoff (Nonpoint Source Pollution) website. [Website] Articles and Activities for Middle School Students.


Also see fact sheets at [Website]
Test - Lesson 2: Is Dilution the Solution? – An Introduction to Nonpoint Source Pollution

Name______________________________

1) What is the best definition of point source pollution?
   a) Pollution that comes from an industrial facility only
   b) Pollution that comes from a specific and identifiable point of discharge
   c) Pollution that comes from diffuse sources, such as homes and parking lots
   d) Polluted runoff
   e) None of the above

2) What is the best definition of nonpoint source pollution?
   a) Pollution that enters a water body from a diffuse source
   b) Polluted runoff from residences and businesses
   c) The number one threat to our nation’s waters
   d) All of the above
   e) None of the above

3) Where does water entering the storm drain system flow?
   a) To the wastewater treatment plant for treatment
   b) To the nearest water body with no treatment
   c) To a separate water treatment plant
   d) To infiltration ponds to replenish groundwater

4) Which type of pollution does runoff from paved surfaces and removal of streamside vegetation contribute to?
   a) Thermal stress
   b) Debris
   c) Pathogens
   d) Nutrients

5) Which of the following is a pathogen?
   a) A disease-causing microorganism, such as bacteria or viruses
   b) A toxic chemical such as paint, hydrocarbons, or pesticides
   c) A compound that stimulates plant growth
   d) None of the above
Test - Lesson 2: Is Dilution the Solution? – An Introduction to Nonpoint Source Pollution, page 2

Name______________________________

6) To which types of pollution do failing septic systems, leaking sewer lines and animals wastes contribute?
   a) Nutrients and pathogens
   b) Pathogens and debris
   c) Pathogens and toxic chemicals
   d) Nutrients and toxic chemicals

7) To which type of pollution do pesticides, paint, used oil and antifreeze contribute?
   a) Nutrients
   b) Toxic chemicals
   c) Debris
   d) Pathogens

8) Sediment is a pollutant that can result from:
   a) Poorly protected construction sites
   b) Agricultural fields
   c) Erosion of disturbed areas
   d) All of the above
   e) None of the above

9) True or False Pathogen pollution always causes a brown color in water.

10) List three things you can do to reduce nonpoint source pollution.

   1. _______________________________________________________________________

   2. _______________________________________________________________________

   3. _______________________________________________________________________
Lesson 2: Is Dilution the Solution?  - 21 -
Answer Key

Test - Lesson 2: Is Dilution the Solution? – An Introduction to Nonpoint Source Pollution – Answer Key

1) What is the best definition of point source pollution?
   a) Pollution that comes from an industrial facility only
   b) **Pollution that comes from a specific and identifiable point of discharge**
   c) Pollution that comes from diffuse sources, such as homes and parking lots
   d) Polluted runoff
   e) None of the above

2) What is the best definition of nonpoint source pollution?
   a) Pollution that enters a water body from a diffuse source
   b) Polluted runoff from residences and businesses
   c) The number one threat to our nation’s waters
   d) **All of the above**
   e) None of the above

3) Where does water entering the storm drain system flow?
   a) To the wastewater treatment plant for treatment
   b) **To the nearest water body with no treatment**
   c) To a separate water treatment plant
   d) To infiltration ponds to replenish groundwater

4) Which type of pollution does runoff from paved surfaces and removal of streamside vegetation contribute to?
   a) **Thermal stress**
   b) Debris
   c) Pathogens
   d) Nutrients

5) Which of the following is a pathogen?
   a) **A disease-causing microorganism, such as bacteria or viruses**
   b) A toxic chemical, such as paint, hydrocarbons, or pesticides
   c) A compound that stimulates plant growth
   d) None of the above
Test - Lesson 2: Is Dilution the Solution? – An Introduction to Nonpoint Source Pollution – Answer Key

6) To which types of pollution do failing septic systems, leaking sewer lines and animals wastes contribute?
   a) **Nutrients and pathogens**
   b) Pathogens and debris
   c) Pathogens and toxic chemicals
   d) Nutrients and toxic chemicals

7) To which types of pollution do pesticides, paint, used oil and antifreeze contribute?
   a) Nutrients
   b) **Toxic chemicals**
   c) Debris
   d) Pathogens

8) Sediment is a pollutant that can result from:
   a) Poorly protected construction sites
   b) Agricultural fields
   c) Erosion of disturbed areas
   d) **All of the above**
   e) None of the above

9) True or **False** Pathogen pollution always causes a brown color in water.

10) List three things you can do to reduce nonpoint source pollution.

   **Partial List:**
   1. Use fertilizers sparingly.
   2. Sweep, don’t wash, driveways, sidewalks and roads.
   3. Never dump anything down storm drains.
   4. Vegetate or mulch the bare spots in your yard.
   5. Compost your yard waste.
   6. Limit pesticide use and always match the product to the pest.
   7. Direct gutter downspouts away from paved surfaces and towards vegetated surfaces to increase storm water infiltration and reduce storm water runoff.
   8. Take your car to the car wash or wash it on a non-paved permeable surface. Do not wash it in the driveway.
   9. Check your car for leaks and fix the leaks promptly.
   10. Recycle used motor oil.
   11. Pick up pet wastes.
Look at the nonpoint source pollution cartoon. Try to determine all the visible sources of pollution in the cartoon. Match the sources of pollution to the category of pollutant (nutrient, pathogen, sediment, toxic chemicals, trash, or thermal stress)

1. The streambank is eroding because the bank is not stabilized by vegetation. Use plants and trees, preferably native varieties, to provide a buffer zone adjacent to the stream. Lack of vegetation will result in sediment pollution when the bank erodes. The lack of a vegetated buffer zone will prevent natural processing from occurring. Natural processing will remove some nutrients and toxic contaminants and filter some sediment. Additionally, the lack of a buffer zone will reduce stream shading, contributing to thermal stress.

2. The man is bagging up his lawn clippings. Leave the lawn clippings as a source of nutrients for the lawn, or compost the clippings and return them to the garden beds. Lawn clippings should not go to our already overcrowded landfills. The waste is a source of nutrients and perhaps toxic chemicals, depending on the time since the last fertilizer application.

3. The woman is spilling fertilizer and/or pesticides on the lawn. This is a source of nutrients and/or toxic chemicals. If the fertilizer is uncomposted manure, it could even be a source of pathogens. Apply only what is needed, be careful about spillage and never apply either a fertilizer or a pesticide immediately before rain has been forecasted. In addition to polluting our waterways, it is a waste of money to have either fertilizers or pesticides washed off the landscape before they have a chance to do their job.

4. The sprinkler is watering the sidewalk. The runoff washes anything in its path into the storm drain – trash, toxic chemicals, fertilizers, or pathogens. The water temperature rises before it enters the storm drain due to heat transfer from the hot pavement, causing thermal stress. Place sprinklers so that the water goes only on the lawn. Do not water the sidewalk, driveway or street. Water during the coolest part of the day, so less water evaporates and more water infiltrates. Do not water on windy days, as the water will be blown away and wasted.

5. DON’T LITTER! This is the most obvious source of debris or trash. Litter is often swept away with storm water into the storm drain system. Remember, storm drains lead to the nearest water body, with no treatment during the trip.

6. The car is leaking oil or radiator fluid. The oil and antifreeze are washed into the storm drain and then to the nearest water body with no treatment. This is a source of toxic chemicals.

7. NEVER DUMP ANYTHING IN THE STORM DRAIN! Remember: the drain is for rain! Storm drains lead to the nearest water body, with no water treatment during the trip. This is a source of nutrients, toxic chemicals, debris, pathogens, and whatever else is dumped.
<table>
<thead>
<tr>
<th>Nonpoint Source Pollution Matching Game</th>
<th>text for the clues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pesticide</strong></td>
<td>I am used on farms and gardens to keep insects away, but I am toxic to most aquatic life. I tend to build up in the food chain.</td>
</tr>
<tr>
<td><strong>Plastic bottle</strong></td>
<td>I am a common item of trash. I can be recycled, reducing the volume of trash taken to our landfills. I do not biodegrade over time.</td>
</tr>
<tr>
<td><strong>Picture or model of a tree</strong></td>
<td>I prevent soil on land from eroding and keep fertilizer from washing away into streams and lakes when it rains. I also provide you and your family with clean air.</td>
</tr>
<tr>
<td><strong>Motor oil can</strong></td>
<td>I can leak from cars and boats. Once I am in the water, I can poison animals and coat the feathers and fur of animals, keeping them from staying warm.</td>
</tr>
<tr>
<td><strong>Road salt</strong></td>
<td>People put me on roads and sidewalks to help melt snow and ice. When the snow and ice melt, I wash off the roads and sidewalks, polluting our streams and lakes.</td>
</tr>
<tr>
<td><strong>Container of soil</strong></td>
<td>Once I erode from land, I muddy up the water. I can ruin spawning grounds for fish. I also make it harder and more expensive to treat drinking water.</td>
</tr>
<tr>
<td><strong>6-pack ring</strong></td>
<td>Fish and birds can get tangled in me. As the animals spend energy trying to get free, they can get sick, weak and even die.</td>
</tr>
<tr>
<td><strong>Container of water</strong></td>
<td>I fall to the ground in the form of rain or snow. Then I wash pollution, such as soil, oil and plastics, into rivers and lakes. I may even get into the groundwater.</td>
</tr>
<tr>
<td><strong>Bottle of fertilizer or plastic poop</strong></td>
<td>I am used to help gardens and crops grow. Once I get in the water, I can make aquatic plants grow like crazy. These plants blocks out sunlight. When they die, it reduces oxygen levels in the water which can kill fish.</td>
</tr>
<tr>
<td><strong>Picture of a playa or lake</strong></td>
<td>I am a small lake that forms at the low point of an enclosed basin. Water from the basin collects in me and either evaporates or infiltrates to the groundwater. I am usually dry for part of the year. The soil within and around me is generally very salty. I can concentrate pollutants through evaporation and may contaminate the groundwater.</td>
</tr>
<tr>
<td><strong>Picture of a wetland</strong></td>
<td>I am an area that is periodically inundated with water or an area that is saturated by surface or groundwater on an annual or seasonal basis. I generally support abundant plant and animal life. I also benefit the planet by slowing stormwater and other runoff, filtering out sediment, absorbing fertilizers and processing some pollutants into less harmful forms.</td>
</tr>
</tbody>
</table>
Is Dilution the Solution? Answer Key

(Over, Down, Direction):
ALGAL BLOOM (12,11,NW)  PATHOGEN (19,27,NE)
CONTAMINATION (26,16,N)  PESTICIDE (1,3,SE)
DEBRIS (19,14,SE)  POINT SOURCE POLLUTION (22,20,NW)
DILUTION (8,16,SW)  POLLUTANT (29,1,S)
EFFLUENT (9,11,W)  RUNOFF (25,22,S)
FERTILIZER (30,10,N)  SEDIMENT (17,4,E)
GROUNDWATER (15,12,W)  STORM DRAIN (14,16,NE)
HYDROCARBONS (1,2,SE)  STORM WATER (10,26,E)
LEACHATE (9,26,NW)  SURFACE WATER (14,1,S)
NONPOINT SOURCE POLLUTION  THERMAL STRESS (2,13,NE)
(25,3,W)  TOXIC CHEMICAL (1,14,E)
NUTRIENT (12,8,N)  WATER QUALITY (28,1,SW)
## Impacts of Nonpoint Source Pollutants on Water Resources

<table>
<thead>
<tr>
<th>Nutrients (nitrogen &amp; phosphorus)</th>
<th>Fisheries</th>
<th>Water Supply</th>
<th>Wetlands</th>
<th>Recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Promotes algae and inhibits aquatic plant growth</td>
<td>• Promotes algae blooms, resulting in odors and poor taste</td>
<td>• Promotes eutrophication of lakes and rivers</td>
<td>• Promotes eutrophication of lakes and rivers</td>
<td></td>
</tr>
<tr>
<td>• Favors survival of less desirable species</td>
<td>• Increases treatment costs</td>
<td>• Increases algae growth, which may create public health risks</td>
<td>• Increases algae growth, which may create public health risks</td>
<td></td>
</tr>
<tr>
<td>• Reduces dissolved oxygen levels through increased productivity and decay of organic matter</td>
<td>• Increases nitrate concentration (drinking water limit is 10 mg/L)</td>
<td>• Decreases aesthetic value</td>
<td>• Decreases aesthetic value</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Results in loss of wetland recreation areas</td>
<td>• Intervenes with fishing and boating activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Introduces harmful organisms to aquatic life and food chain</td>
<td>• Reduces tourism and property values</td>
<td></td>
</tr>
<tr>
<td>Pathogens (bacteria &amp; viruses)</td>
<td>• Introduces disease-bearing organisms to aquatic life</td>
<td>• Increases public health risks</td>
<td>• Closes swimming areas</td>
<td></td>
</tr>
<tr>
<td>Sediment</td>
<td>• Decreases light transmission</td>
<td>• Increases treatment costs for drinking water supplies</td>
<td>• Decreases water clarity, affecting public health and safety</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Increases surface water temperature</td>
<td></td>
<td>• Decreases aesthetic and recreational value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Decreases spawning habitat</td>
<td></td>
<td>• Reduces sport fishing populations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Transports contaminants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic Contaminants (metals, pesticides)</td>
<td>• Accumulates in sediments, affecting bottom feeders</td>
<td>• Damages water treatment plants, equipment</td>
<td>• Bioaccumulates in food web</td>
<td>• Reduces waterfront property values</td>
</tr>
<tr>
<td></td>
<td>• Bioaccumulates in fish tissue</td>
<td>• Increases treatment cost</td>
<td>• Hinders photosynthesis in aquatic plants</td>
<td>• May restrict sport fishing</td>
</tr>
<tr>
<td></td>
<td>• May kill fish and other aquatic organisms</td>
<td>• Reduces reservoir volume</td>
<td>• Affects reproductive rates and life spans of wetland organisms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Hinders photosynthesis in aquatic plants</td>
<td>• Nutrients increase, stimulating algae growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Decreases river bottom infiltration, reducing well yields</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salts</td>
<td>• Favors salt-tolerant species</td>
<td>• Increases treatment costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Creates stressful environment</td>
<td>• Forms deposits in pipes (metals)</td>
<td>• Bioaccumulates in food web</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Destroys habitat and food source plants for some species</td>
<td>• Causes odors in water supplies (pesticides)</td>
<td>• Hinders photosynthesis in aquatic plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Alters species composition</td>
<td>• Colors water and stains clothing and fixtures</td>
<td>• Affects reproductive rates and life spans of wetland organisms</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Poses public health risks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>• Reduces growth and health of fish</td>
<td>• Reduces drinking water quality</td>
<td>• Alters wetland vegetation and species composition</td>
<td>• May cause skin or eye irritations</td>
</tr>
<tr>
<td></td>
<td>• Reduces resistance to disease</td>
<td></td>
<td>• Destroys habitat and food sources for wetland animals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dissolved oxygen concentration decreases as temperature increases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Alters fishery from cold water species to warm water species</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Nonpoint Source Pollution: A Handbook for Local Governments, 1997
What You Can Do About Nonpoint Source Pollution

- Never pour, dump, or place trash or yard wastes in a storm drain, ditch, or stream.
- Make sure your parents recycle their used motor oil. It is never appropriate to dump it on the ground or down the storm drain.
- Pick up after your pets, and dispose of their wastes in the trash or down the toilet.
- Never dump anything down a storm drain. Ask if you can join in a storm drain stenciling program, to paint the words “No Dumping: Drains to River” on storm drains in your neighborhood.
- If you’re going to use chemicals or fertilizers, always read the label first and follow the directions carefully. Don’t use chemicals or fertilizers if they are not needed.
- If you have a horse, or other livestock, make sure to clean up the manure on a regular basis. Compost the manure and add it to your garden, or give it to gardeners, or take it to a recycling facility.
- Use nontoxic products whenever possible.
- Dispose of hazardous household chemicals at approved disposal sites.
- Educate your parents! Encourage them to have the septic tank pumped on a regular basis, and to make sure to minimize any bare erodible ground on your property. Don’t let them be a source of nonpoint pollution!
Lesson 2: Is Dilution the Solution?

Student Pages

On a separate sheet of paper:

1. Make a list of as many different types of pollutants as you can.

2. Look at the nonpoint source pollution cartoon above. Try to determine all the visible sources of pollution in the cartoon. Write down the category(ies) of pollutant(s) that goes with each source of pollution you found in your drawing (nutrient, pathogen, sediment, toxic chemicals, trash, thermal stress). What are some things the people in the picture could do to prevent nonpoint source pollution?

3. What are some local water bodies that might be experiencing problems with nonpoint source pollution? Where is the pollution coming from and what types of pollution might be occurring?

What’s wrong with this picture?
Lesson 2: Is Dilution the Solution?

I am used on farms and gardens to keep insects away, but I am toxic to most aquatic life. I tend to build up in the food chain.

People put me on roads and sidewalks to help melt snow and ice. When the snow and ice melt, I wash off the roads and sidewalks, polluting our streams and lakes.

I am a common item of trash. I can be recycled, reducing the volume of trash taken to our landfills. I do not biodegrade over time.

I can leak from cars and boats. Once I am in the water, I can poison animals and coat the feathers and fur of animals, keeping them from staying warm.

Once I erode from land, I muddy up the water. I can ruin spawning grounds for fish. I also make it harder and more expensive to treat drinking water.

Fish and birds can get tangled in me. As the animals spend energy trying to get free, they can get sick, weak and even die.

I am a small lake that forms at the low point of an enclosed basin. Water from the basin collects in me and either evaporates or infiltrates to the groundwater. I am usually dry for part of the year. The soil within and around me is generally very salty. I can concentrate pollutants through evaporation and may contaminate the groundwater.

I am an area that is periodically inundated with water or an area that is saturated by surface or groundwater on an annual or seasonal basis. I generally support abundant plant and animal life. I also benefit the planet by slowing stormwater and other runoff, filtering out sediment, absorbing fertilizers and processing some pollutants into less harmful forms.

Nonpoint Source Pollution Matching Game
### Nonpoint Source Pollution Matching Game

<table>
<thead>
<tr>
<th>I fall to the ground in the form of rain or snow. Then I wash pollution, such as soil, oil and plastics, into rivers and lakes. I may even get into the groundwater.</th>
<th>I am used to help gardens and crops grow. Once I get in the water, I can make aquatic plants grow like crazy. These plants blocks out sunlight. When they die, it reduces oxygen levels in the water which can kill fish.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I prevent soil on land from eroding and keep fertilizer from washing away into streams and lakes when it rains. I also provide you and your family with clean air.</td>
<td></td>
</tr>
</tbody>
</table>

---

EXPLORE NEVADA’S AMAZING WETLANDS
Lesson 2: Is Dilution the Solution?  
Student Pages

Word Search: Is Dilution the Solution?

Name______________________________

Find the following words in the puzzle above

ALGAL BLOOM
CONTAMINATION
DEBRIS
DILUTION
EFFLUENT
FERTILIZER
GROUNDWATER
HYDROCARBONS
LEACHATE
NONPOINT SOURCE POLLUTION
NUTRIENT
PATHOGEN

PESTICIDE
POINT SOURCE POLLUTION
POLLUTANT
RUNOFF
SEDIMENT
STORM DRAIN
STORM WATER
SURFACE WATER
THERMAL STRESS
TOXIC CHEMICAL
WATER QUALITY

EXPLORE NEVADA’S AMAZING WETLANDS
Materials: Each group will need:

- 6 plastic cups
- 100-mL graduated cylinder
- Water
- Plastic spoons for tasting and mixing
- Colored powdered drink mix, with sugar
- Worksheet

Procedure:

1. Divide into small groups. Each group needs six plastic cups and a graduated cylinder. Number the cups from one through six using a permanent marker.

2. Measure 50 mL of water in cups 2 through 6. This represents the “pure” water that will be polluted by the drink mix.

3. Mix the powdered sweetened drink mix according to the directions.

4. Use the graduated cylinder to place 100 mL of the prepared sweetened drink mix into cup number 1. Cup number 1 represents a source of pollution to local water, such as fertilizer running off a lawn. Use a clean plastic spoon to taste the drink. Be careful – if you taste too much, you’ll run out! Record the color and taste on the worksheet.

5. Place 50 mL of the “polluted” mix from cup 1 into cup 2 using the graduated cylinder and stir the mixture. Have one group member taste the mixture and describe the difference in sweetness. Record your observations on the worksheet.

6. Predict how dark the solutions will be in cups 3 through 6 after they are diluted in a similar manner, and how sweet they will be. Enter the predictions on the worksheet.

7. Continue to add 50 mL from the polluted water source into the clean water in cup 3, and continue until you have diluted all the solutions. Mix the solutions and record your observations on the worksheet.

8. Compare the color of cup 1 to cup 3 and cup 6. Place white paper under the cups if needed for contrast. Compare tastes again, using clean spoons each time.

9. Answer the questions on the worksheet. Where do you think pollution goes? Does it stay in the water forever? What happens to it?

(adapted from The Water Sourcebook, Grades 6-8)
Lesson 2: Is Dilution the Solution?

Student Pages

Dilution Experiment Worksheet

Name: _________________________

Directions: Dilute each water sample and record your color and taste observations.

<table>
<thead>
<tr>
<th>Starting liquid</th>
<th>100 mL drink mix</th>
<th>50 mL drink + 50 mL water</th>
<th>50 mL solution 2 + 50 mL water</th>
<th>50 mL solution 3 + 50 mL water</th>
<th>50 mL solution 4 + 50 mL water</th>
<th>50 mL solution 5 + 50 mL water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Predicted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Observed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste (how sweet is it?)</td>
<td>Predicted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste (how sweet is it?)</td>
<td>Observed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. How could you tell that pollution still remained even when the solution was diluted?

2. How many more times do you think that the polluted water would need to be diluted in order not to cause color or taste changes? Why?

3. Do you think dilution is a good solution for pollution? Why or why not?
Lesson 2: Is Dilution the Solution?

Remove Oil Pollution from Water Using Different Methods Activity

Materials: Each group will need:

- Clear plastic cups
- Large ladle
- Plastic teaspoon
- Medicine dropper
- Visibly colored cooking oil (used to simulate motor oil)
- Water
- Graduated cylinder for measuring oil (100 mL)
- Paper towels
- Worksheet

Procedure: Experiment with three different physical procedures to try to remove oil from water.

1. Brainstorm ways to remove oil pollution from water. You can research historic methods and compare them to the methods used today.

2. Divide into groups.

3. Each group will need three samples consisting of approximately ½ cup of water contaminated by exactly 50 mL of oil. Carefully measure the cooking oil into each container. Use a plastic cup for the contaminated sample.

4. Three methods will be used (ladle, spoon, or dropper) to remove oil from the contaminated water. Enter your hypothesis as to which method will work best on the worksheet and why.

5. Attempt to remove as much oil as possible using the ladle. Dump the oil into a clean plastic cup. When no more can be removed, measure the amount of oil removed using the graduated cylinder. Pour the oil you collected from the plastic cup into the cylinder. Measure the oil in milliliters. Be careful not to measure the water! Enter the amount removed on the worksheet. Dump the oil into the used plastic cup for disposal.

6. Next, repeat the procedure using the second contaminated sample and the plastic teaspoon, and enter the amount removed on the worksheet.

7. Finally, repeat the procedure using the medicine dropper and the third contaminated sample. Enter the amount removed on the worksheet.

8. Calculate the percent removed in each sample to determine which method worked best.

9. Complete the worksheet.

(adapted from The Water Sourcebook, Grades 6-8)
Remove Oil Pollution from Water Using Different Methods Activity Worksheet

Name______________________

I think this method will work best: ______________________________________________

Because:_________________________________________________________________

<table>
<thead>
<tr>
<th></th>
<th>Method 1 (large ladle)</th>
<th>Method 2 (spoon)</th>
<th>Method 3 (medicine dropper)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of oil contaminating water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount removed after treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of oil removed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To calculate the percentage of oil removed, divide the amount of oil removed by the amount of oil originally contaminating the water, and multiply by 100.

1. Which method worked best? Which method was least effective? Why?

2. Which method resulted in the most spills during cleanup?

3. Which method removed the least water?

4. Were all three methods equally effective in helping you remove 50 percent (one half of the 50 mL) of the pollution?

5. How might you improve your method to clean up even more oil?
Lesson 3: Man’s Filters: Cleaning Up Wastewater

Purpose:
This laboratory or classroom activity introduces students to wastewater treatment and teaches the steps involved in basic wastewater treatment.

Summary:
Students will learn the definition of wastewater, how household wastewater is treated by septic systems and at treatment plants, and the basic steps in the treatment process. They will then apply some of the steps to attempt to purify a contaminated water sample.

Key Learning Points For Students:
1. All water that goes down the drain is considered wastewater.
2. Wastewater can contain a variety of substances that must be treated or removed before it can be discharged to surface water or groundwater.
3. There are two methods of wastewater treatment: septic tanks (primarily used in rural and suburban areas) and municipal wastewater treatment plants (used by industry, businesses and urban households).
4. Septic systems must be pumped on a regular basis. Students should be able to describe how a septic system functions.
5. There are four basic steps to municipal wastewater treatment. Students should be able to describe the four steps:
   a. Pretreatment
   b. Primary treatment
   c. Secondary treatment
   d. Tertiary treatment

Grade Level: 6 to 8

Nevada Education Standards:
Science
- Scientific Inquiry
- Science, Technology and Society
- Organisms and their Environment
- Atmospheric Processes and the Water Cycle
Mathematical
- Numbers, Number Sense and Computation
- Measurement
- Data Analysis / Problem Solving
- Mathematical Connections

Activities:
Vocabulary Matching Game

Wastewater Treatment Experiment

Setting:
Classroom/Lab
Optional tour at Truckee Meadows Water Reclamation Facility (or local facility)
Lesson 3: Man's Filters: Cleaning Up Wastewater

Handouts:

1. Vocabulary Activity - Matching Game
2. Wastewater Treatment Process at Truckee Meadows Water Reclamation Facility Handout
3. Truckee Meadows Water Reclamation Facility Schematic
4. Truckee Meadows Wastewater Reclamation Facility Tour Activity Worksheet
5. Wastewater Treatment Activity

Background:

All the water that goes down the drain, whether in homes or businesses, is considered wastewater. This includes water from sinks, baths and showers, dish washing, washing machines, and toilets, as well as water used in manufacturing and industry. Some businesses may collect and treat their own wastewater. Others will discharge the wastewater into the municipal sewer system.

Wastewater from domestic and industrial uses contains a variety of substances, including human wastes, kitchen debris, toxic chemicals, and inorganic materials such as plastics. This water can be high in nutrients, pathogens, and toxic chemicals, and poses a risk to both drinking water and aquatic habitats. For this reason, wastewater must be treated before it can be discharged to rivers, lakes, or oceans.

In nature, water filtration occurs when rainfall and snowmelt seep into the ground, where the soil acts as a filter, and microorganisms in the soil help degrade pollutants. This is called natural processing. Man’s wastewater treatment systems incorporate some of the same elements.

There are two main methods of wastewater treatment in use today. On-site septic systems, in which wastes enter a tank where settling and biological breakdown occur before effluent is discharged to a leach field in the soil, are primarily used for single homes or small clusters of homes. Municipal wastewater treatment facilities are used in urban areas and for wastes from industrial and manufacturing facilities. The wastewater is piped underground to a treatment facility.

How a Septic System Works

All septic systems function in the same general manner, piping household wastewater to a holding tank where solids are removed. Through bacterial action, some of the solids are digested and converted to liquid for discharge into a “soil absorption area” or leach field. The remaining solids are stored for future disposal.

The septic tank was patented in London, England around 1900 and is described in Webster’s Dictionary as “a tank in which waste matter is decomposed through bacterial action.” The modern septic tank is a watertight box usually made of precast concrete, concrete blocks, or reinforced fiberglass.
When household waste material enters the box, several things occur:

1. Organic solid material floats to the surface and forms a layer that is commonly called scum. Bacteria present in the septic tank begin to biologically convert some or all of this material into liquid.

2. Inorganic or inert solid materials that cannot be biologically converted, and the by-products of bacterial digestion, sink to the bottom of the tank and form a layer commonly called “sludge.”

3. A cloudy liquid, called effluent, lies between the sludge and scum. This is the only thing in the septic tank that should move out of the tank and into the leach field.

Septic systems require two things: proper bacterial action and periodic pumping. Bacteria must be present in the septic tank to digest the organic solids. Normal household waste provides enough bacteria to digest the solids UNLESS the bacteria is killed off. Bacteria are very sensitive to environmental changes and may be destroyed by such common home-care products as:

- detergents
- cleaning compounds
- disinfectants
- polishes
- toilet cleaners
- sink and tub cleaners
- bleach
- caustic drain openers
- acids
Check the labels on these and other products used in the home. Labels carrying any of the following warnings indicate the presence of ingredients that may kill bacteria.

“Harmful if swallowed”
“Avoid contact with the skin”
“Do not get in open cuts or sores”
“If product comes in contact with eyes, call a physician immediately”

Look for products labeled “safe for use in septic systems.” When bacteria are not present to digest and liquefy the scum at the top of the septic tank, the scum will accumulate until it overflows, clogging the soil absorption area.

The sludge at the bottom of the septic tank is inorganic and inert material that is not biodegradable and will not decompose. If not removed on a periodic basis, it will accumulate and overflow, clogging the absorption area.

The frequency of pumping for a given septic tank will depend on the size of the tank, the number of people occupying the home, the frequency of garbage disposal use, and the condition of the system. Since there is no tank additive that will dissolve or eliminate the accumulation of sludge, IT MUST BE PUMPED OUT. Failure to pump periodically can cause solids to overflow into the absorption area or leach field. This can clog the system and may force replacement of the absorption area at considerable expense and inconvenience. Typical leach field replacement costs are likely to exceed $5,000 and may be as much as $15,000 to $20,000 for engineered systems. Typical pumping costs are $200 to $400. Obviously, it is more cost effective to pump! Pumping occurs from the manhole access.

Generally, a properly-designed tank of 1,000 gallons capacity that is used by a family of four people should be pumped about every three years. More frequent pumping may be necessary in larger families or if a garbage disposal is used or excessive amounts of household grease enter the system. The table below provides recommendations for pumping intervals based on tank size and household size. Pumping of septic tanks should be performed by professionals who have the necessary equipment to do the job properly. They can be found in the Yellow Pages of your telephone directory under “Septic.”

<table>
<thead>
<tr>
<th>Household Size (number of people)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Size (gallons)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>12.4</td>
<td>5.9</td>
<td>3.7</td>
<td>2.6</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>1250</td>
<td>15.6</td>
<td>7.5</td>
<td>4.8</td>
<td>3.4</td>
<td>2.6</td>
<td>2.0</td>
</tr>
<tr>
<td>1500</td>
<td>18.9</td>
<td>9.1</td>
<td>5.9</td>
<td>4.2</td>
<td>3.3</td>
<td>2.6</td>
</tr>
</tbody>
</table>
Municipal Wastewater Treatment Facilities

Most cities and counties rely upon municipal wastewater treatment plants. In this complex system, wastewater from homes, manufacturing and industrial facilities is piped underground to a wastewater treatment plant. The effluent from these plants is considered a point source discharge, and levels of pollutants are carefully monitored.

The Truckee Meadows Water Reclamation Facility (TMWRF) is the main wastewater treatment plant for the Reno/Sparks area. Another treatment plant has been built in the South Meadows area. TMWRF has the capacity to treat 40 million gallons per day (MGD), and, in 2004, treated an average of 30 MGD.

There are four basic phases to most municipal wastewater treatment: pretreatment, primary treatment, secondary treatment and tertiary treatment. During pretreatment, which is basically a physical process, the wastewater is screened to remove large objects such as stones or sticks that could plug lines or block tank inlets. A grit chamber is used to allow sand, grit, and small stones to settle to the bottom.

During primary treatment, the sewage then moves to a sedimentation tank, where most of the solids settle to the bottom as raw sludge, and oils and grease float to the top and are skimmed off. Substances such as alum may be used to help flocculate, or stick together, particles so they can be removed from the water. The raw sludge is removed from the tank for further processing when necessary.

The wastewater resulting after primary treatment still contains suspended and dissolved pollutants in the form of organic matter, nutrients and pathogens. During secondary treatment, an activated sludge containing microorganisms is used to break down organic material with aeration and agitation. Solids are then able to settle out. As much as 95 percent of wastewater pollutants can be removed during secondary treatment. The resulting sludge mixture, which is full of millions of bacteria that feed on organic wastewater pollutants, can be combined with new sewage in the presence of lots of fresh air to continue the process. Secondary settling tanks are used to separate the water from the organisms. After these steps are complete, municipal wastewater is usually disinfected using chlorine or other disinfecting compounds.

Tertiary treatment is used to bring the effluent or discharge water to local water quality standards. Tertiary treatment may be used to remove nutrients such as nitrogen and phosphorus, and carbon adsorption can be used to remove chemicals. In plants using tertiary treatment, disinfection occurs after this step. The sludge byproduct can be treated and landfilled or applied to land to improve soil properties, and the treated, clean effluent is discharged to a local water body or used for irrigation.

TMWRF discharges its effluent into Steamboat Creek, which then flows into the Truckee River. By law, since TMWRF is a point source of pollution, it must have a permit with limits on the amount of pollutants that can enter the river. For example, TMWRF is permitted to discharge up to 500 pounds per day of nitrogen. The plant uses tertiary treatment to reduce the nitrogen level of its effluent in order to meet this requirement. A Truckee Meadows Water Reclamation Facility Schematic and description of the treatment process are included as handouts in this lesson.
Vocabulary List:

**Activated sludge:** Sludge particles produced by the growth of microorganisms in aerated tanks as a part of the activated sludge process to treat wastewater.

**Aeration:** Process of stirring or bubbling air through a liquid. This adds oxygen to the wastewater and allows other trapped gasses to escape.

**Chlorine:** Chemical element Cl. Various forms of chlorine are used as a disinfectant in drinking and wastewater treatment processes.

**Contamination:** The addition of any substance to water that makes it unfit for use.

**Disinfection:** Process by which most microorganisms in or on a substance are killed.

**Effluent:** Discharged wastewater, such as the treated wastes from municipal sewage plants, brine wastewater from desalting operations, and coolant waters from a nuclear power plant. Effluent is generally considered point source pollution.

**Filtration:** A mechanical process that involves moving water through a material, usually sand, designed to catch and remove particles.

**Flocculation:** Process by which clay and other suspended solid particles are chemically stuck together so they can be removed from water by sedimentation or settling.

**Natural processing:** The natural ability of undisturbed water systems and soils to retain water, adsorb nutrients, absorb other pollutants, slow or reduce surface runoff, and aid in infiltrating storm water.

**Nonpoint source pollution:** Pollution that enters water from a variety of land use activities over a widespread area. It is also known as polluted runoff. It is considered the main source of water quality degradation today.

**Organic material:** Material derived from living things that contains carbon compounds.

**Point source pollution:** Pollution that can be traced to a single, identifiable source, such as a pipe or culvert.

**Pollutant:** Something that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land. Something that may harm or affect humans or other living organisms.

**Pretreatment:** The stage of wastewater treatment in which wastewater is screened to remove large objects and a grit chamber is used to allow sand, grit and small stones to settle out.

**Primary treatment:** The stage of wastewater treatment, in which settleable or floating solids are removed.
Secondary treatment: A stage of wastewater treatment in which biological treatment processes such as activated sludge are used to convert dissolved and suspended pollutants into a form that can be removed.

Settling: The process during which a substance, such as heavy organic solids or sediment, sinks to the bottom.

Sludge: Any solid or semisolid waste that settles to the bottom of sedimentation tanks or septic tanks.

Surface water: All water on the surface of the earth, including lakes, rivers, streams, ponds, oceans, and runoff.

Tertiary treatment: Any stage of wastewater treatment beyond secondary treatment, including filtration, nutrient removal, and removal of toxic chemicals and metals.

Wastewater: All water and associated waste materials that go down a drain.

The Activities

1. Wastewater Treatment Process at Truckee Meadows Water Reclamation Facility

Procedure:

Describe the wastewater treatment process at TMWRF for the students. Use Wastewater Treatment Process at Truckee Meadows Water Reclamation Facility Handout and the Truckee Meadows Water Reclamation Facility Schematic Handout. The schematic can be displayed on an overhead. Review the wastewater treatment process at TMWRF with the students.

2. Matching Game Vocabulary Exercise

Procedure:

Have the students match the definitions to the vocabulary words on the left side of the page.
The Activities, continued

3. Wastewater Treatment Experiment Activity

Materials: (You will need one set per group of students.)

- Muddy water with added soil and leaves (material from a stream bed works well), green food color, and a few drops of detergent
- 16 or 20 ounce clear plastic bottle with the bottom cut off (ask students to collect water bottles)
- Alum (potassium aluminum sulfate; available at a pharmacy and sometimes in grocery stores in the spice department)
- Flexible nylon screen (pantyhose work well) or a coffee filter
- Cotton batting
- 20 ounce large-mouth bottle or jar with a lid
- 2 to 3 plastic cups
- Washed fine sand
- Washed coarse sand
- Washed small pebbles or aquarium gravel
- Large beaker, jar, or clear plastic cup
- Plastic basin
- Teaspoon
- Rubber band
- Goggles
- Wastewater Treatment Experiment Activity Worksheet – procedure included on student worksheet

Procedure:

Students will build a filter and use it to clean “swampy” or muddy water. The procedure is incorporated in the student worksheet.

1. Pour about 1 cup of the muddy water into the 20 oz. large-mouth bottle. Keep a sample of water to use for comparison at the end of the exercise.

2. Direct the students to describe the appearance and smell of the water on their worksheet.

3. Have the students place the lid on the bottle and shake the water vigorously for 30 seconds. This will aerate the water. Pour the water into a plastic cup, and pour it back and forth at least 10 times to continue aeration. Ask the students to describe any changes they note on the worksheet.

4. Next, have students add one heaping teaspoon of alum crystals to the aerated muddy water. Explain that the alum will help flocculate or “glom” the particles together so they will settle out during sedimentation. Slowly stir the mixture for 5 minutes.
The Activities, continued

3. Wastewater Treatment Experiment Activity, continued

5. Allow the mixture to sit for 20 minutes so sedimentation can occur. Have students check the solution every 5 minutes and write their observations of the changes in appearance on the worksheet. While they are waiting, have them construct a filter as described in the next step.

Note: If time is short, you can skip steps 4 and 5. You can also stop here and begin with step 6 during your next class period.

6. Have students build one filter per group.
   a. Remove the cap from the water bottle. Attach a nylon screen or coffee filter to the neck of the bottle using a rubber band. The other end of the bottle should be removed to allow the filter to be filled.
   b. Turn the bottle upside down and place it in the beaker or jar to support it. You may also use a ring stand and clamp to support the filter.
   c. Place about ½ inch of cotton batting on top of the nylon screen or coffee filter.
   d. Pour a layer of fine sand on top of the cotton batting in the inverted bottle.
   e. Pour a layer of coarse sand on top of the fine sand.
   f. Pour a layer of pebbles on top of the coarse sand. The filter is complete. There should be enough room above the pebble layer to pour in the 1-cup water sample.
   g. Place a basin or beaker under the filter and pour clean tap water through the filter until it drains clean from the bottom. Be careful not to disturb the pebble layer too much. This step prepares the filter for use with the sample.

Note: As an alternative, allow the students to design their own filters, using the materials provided. They should attempt to build a filter that will efficiently remove pollutants.

7. After the 20-minute settling period, carefully pour the top two-thirds of the water sample through the filter. Explain that at the wastewater treatment facility, the solids (sludge) are left behind. Be careful not to disturb or pour out the sediment. It should stay in the jar. Let the sample filter into a clean jar, cup, or beaker.

8. Compare the treated and untreated water, and have the students complete their worksheet. Do not allow them to drink the water!

Note: Please reiterate to students that this exercise uses only physical removal methods. In all wastewater treatment, biological processes are an essential component.
4. Truckee Meadows Wastewater Reclamation Facility Tour Activity

Procedure:

Using the Truckee Meadows Water Reclamation Facility Schematic Handout and Wastewater Treatment Process at Truckee Meadows Water Reclamation Facility Handout, follow the directions on the Truckee Meadows Wastewater Reclamation Facility Tour Activity Worksheet.

5. Optional Exercise: Visit Truckee Meadows Water Reclamation Facility (or local facility)

Resources


Truckee Meadows Water Reclamation Facility. No date. www.tmwrf.com


Water Environment Federation. No date. www.wef.org
Test – Lesson 3:  Man’s Filters: Cleaning Up Wastewater

Name________________________

1) What is the best definition of wastewater?
   a) All water that goes down a drain
   b) Water that comes only from industrial uses
   c) Water that comes only from toilets
   d) Water that comes from storm drains

2) What is the best definition of primary wastewater treatment?
   a) The first step in wastewater treatment
   b) Basically a physical process in which wastewater is screened
   c) Leaves suspended and dissolved pollutants in the wastewater
   d) All of the above
   e) None of the above

3) True  or  False  As much as 95 percent wastewater pollutants can be removed during secondary wastewater treatment.

4) True  or  False  Tertiary treatment is used to remove chemicals and nutrients.

5) Explain the difference between filtration and flocculation.

6) Explain the difference between sludge and effluent.

7) What do you think would happen if wastewater was dumped into the Truckee River after only the primary treatment phase?

8) Is wastewater that has been through primary and secondary phases of municipal wastewater treatment drinkable? Would you drink it? Explain your answer.
Lesson 3: Man's Filters: Cleaning Up Wastewater
Answer Key

Test – Lesson 3: Man’s Filters: Cleaning Up Wastewater, Answer Key

1) What is the best definition of wastewater?
   a) All water that goes down a drain
   b) Water that comes only from industrial uses
   c) Water that comes only from toilets
   d) Water that comes from storm drains

2) What is the best definition of primary wastewater treatment?
   a) The first step in wastewater treatment
   b) Basically a physical process in which wastewater is screened
   c) Leaves suspended and dissolved pollutants in the wastewater
   d) All of the above
   e) None of the above

3) True or False As much as 95 percent of wastewater pollutants can be removed during secondary wastewater treatment.

4) True or False Tertiary treatment is used to remove chemicals and nutrients.

5) Explain the difference between filtration and flocculation.

   Filtration is a mechanical process that removes particles from water. Flocculation is a chemical process designed to cause suspended particle to stick together so they can settle out of solution or be filtered out of solution.

6) Explain the difference between sludge and effluent.

   Sludge is any solid or semisolid waste that settles to the bottom of sedimentation tanks or septic tanks. Effluent is discharged wastewater, such as the treated wastes from a municipal sewage plant.

7) What do you think would happen if wastewater was dumped into the Truckee River after only the primary treatment phase?

   Wastewater after primary treatment still contains suspended and dissolved pollutants in the form of organic matter, nutrients and pathogens. Dumping this water could cause fish or other aquatic animal kills, algal blooms (and the subsequent decomposition, oxygen deprivation and smells), and/or beach closures.

8) Is wastewater that has been through primary and secondary phases of municipal wastewater treatment drinkable? Would you drink it? Explain your answer.

   NO. This water may still be high in nitrogen, which can be dangerous for children and pregnant or nursing women. The water has not yet been disinfected and may harbor bacteria and viruses.
<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L</strong></td>
<td>Activated sludge</td>
<td>A. The addition of any substance to water that makes it unfit for use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E</strong></td>
<td>Aeration</td>
<td>B. A mechanical process that involves moving water through a material, usually sand, designed to catch and remove particles.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>Filtration</td>
<td>C. Process by which most microorganisms in or on a substance are killed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F</strong></td>
<td>Organic material</td>
<td>D. The stage of wastewater treatment in which settleable or floating solids are removed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>K</strong></td>
<td>Tertiary treatment</td>
<td>E. Process of stirring or bubbling air through a liquid. This adds oxygen to the wastewater and allows other trapped gasses to escape.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>Disinfection</td>
<td>F. Material derived from living things that contains carbon compounds.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>Secondary treatment</td>
<td>G. Chemical element, abbreviated Cl. Various forms of this chemical are used as a disinfectant in drinking and wastewater treatment processes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>H</strong></td>
<td>Effluent</td>
<td>H. Discharged wastewater, such as the treated wastes from municipal sewage plants, brine wastewater from desalting operations, and coolant waters from a nuclear power plant.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td>Flocculation</td>
<td>I. Process by which clay and other suspended solid particles are chemically stuck together so they can be removed by settling.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>Primary treatment</td>
<td>J. Any solid or semisolid waste that settles to the bottom of sedimentation tanks or septic tanks.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O</strong></td>
<td>Settling</td>
<td>K. Any stage of treatment beyond secondary treatment, including filtration, nutrient removal, and removal of toxic chemicals and metals.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>Chlorine</td>
<td>L. Sludge particles produced by the growth of microorganisms in aerated tanks as a part of the process to treat wastewater.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>J</strong></td>
<td>Sludge</td>
<td>M. A stage of wastewater treatment in which biological treatment processes such as activated sludge are used to convert dissolved and suspended pollutants into a form that can be removed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>Wastewater</td>
<td>N. All water that goes down a drain and associated waste materials.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A</strong></td>
<td>Contamination</td>
<td>O. The process during which a substance, such as heavy organic solids or sediment, sinks to the bottom.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 3: Man’s Filters: Cleaning Up Wastewater

Truckee Meadows Water Reclamation Facility Schematic

Legend of New Facilities

1. Primary Influent Structure
2. Primary Sedimentation Tank 2D
3. Primary Sludge/Scum Pump Room
4. Primary Sludge Screening Facility
5. Aeration Tank 2C
6. Secondary Sedimentation Tank 2D
7. RAS Pump Room
8. Chemical Building No. 2
9. Ferric Chloride Building
10. Acid-Phase Digester 1
11. Digester Control Building 4
12. Sludge Receiving Facility Biofilter

Existing facility to be modified
- Pretreatment
- Primary
- Secondary
- Primary & Secondary
- Tertiary

TMWRF Expansion Layout
March 2002

Go to www.tmwrf.com/plant_facilities/schematic/schematic_detail.html for interactive schematic.
Lesson 3: Man’s Filters: Cleaning Up Wastewater

1) What happens during pretreatment? Put the letters “PT” on the map next to the parts of the system used for pretreatment.

   *Removes large solid materials and grit*

2) What happens during primary treatment? Put the letters “1o” on the map next to the parts of the system used for primary treatment.

   a) **Solids drop out and go to anaerobic digesters.**
   b) **Soluble material goes to the activated sludge**

3) What happens during secondary treatment? Put the letters “2o” on the map next to the parts of the system used for primary treatment.

   a) **Activated sludge, anaerobic digesters, secondary clarifiers.**
   b) **Organic nitrogen is converted to ammonia, phosphorus is removed, suspended solids decrease to less than 10 mg/l**

4) What happens during tertiary treatment? Put the letters “3o” on the map next to the parts of the system used for primary treatment.

   a) **Nitrification and denitrification.**
   b) **Ammonia is converted to nitrate and then to nitrogen gas.**
   c) **Final polishing and chlorination occurs here also.**

5) How much waste (in million gallons per day) does the plant process? (data current as of 2004)

   **30 MGD**

6) About how much nitrogen is present in the waste when it arrives at the plant?

   **32 mg/l**

7) About how much nitrogen is present in the waste when it leaves the plant?

   **1.7 mg/l**

8) What percent of nitrogen is removed? (total removed/initial total)

   **95%**

9) About how much phosphorus is present in the waste when it arrives at the plant?

   **6 mg/l**

10) About how much phosphorus is present in the waste when it leaves the plant?

    **0.3 mg/l**

11) What percent of phosphorus is removed? (total removed/initial total)

    **95%**
The Wastewater Treatment Process at
Truckee Meadows Water Reclamation Facility

1. Pretreatment
   - **Rotating mechanical bar screens** with half-inch spaces remove rags and other large materials, which are taken to the landfill.
   - Grit removal – The liquid flow slows down, allowing grit to drop out. The grit is taken to the landfill.

2. Primary Treatment
   - **Primary clarifiers** allow solids to drop out in large settling tanks.
     1. Solids are sent to the anaerobic digesters.
     2. Remaining suspended solids and soluble material are sent to the activated sludge step.

3. Secondary Treatment
   - **Activated sludge**: During this step, in the soluble materials, most organic nitrogen is converted to ammonia; most all biological oxygen demand (BOD) and phosphorus is removed biologically; and suspended solids are decreased to below 10 mg/L. The process selects for certain bacteria that will grab onto and separate out the phosphorus, by manipulating the environmental conditions (aerobic/anaerobic), the age of the microbes, and their concentration. The process begins as an anaerobic process, and then later oxygen is added.

   - **Secondary clarifiers**: The secondary clarifiers receive effluent from the activated sludge. At this point, all the BOD and suspended solids are essentially gone; organic nitrogen (about 32 mg/L) has been converted to ammonia; and phosphorus is almost gone (from about 6 mg/L to 0.3 mg/L, or more than 95 percent removal). In the secondary clarifiers, the microbes settle to the bottom and are collected, and most are returned to the beginning of the activated sludge step. The rest are wasted and sent to the dissolved air floatation step, during which air under pressure at 60 psi is released, allowing the microbes that are now high in phosphorus to be returned to the anaerobic digesters. The high-phosphorus concentrate is precipitated with lime to form phosphate “rocks.” The liquid returns to the primary clarifiers, where the phosphate “rocks” settle out and are removed with the solids in the centrifuge step. The high-ammonia concentrate is returned to the beginning of the process, and used in the nitrification towers.

   - **Anaerobic digesters** for sludge treatment: Anaerobic bacteria break down or "digest" organic material in the absence of oxygen and produce biogas (methane) as a waste product. Methane molecules consist of one atom of carbon and four atoms of hydrogen (CH₄). It is the major component of the natural gas that is used in many homes for cooking and heating. The biogas is used to keep the anaerobic digesters at body temperature, or 98°F (36.7°C). Some of the gas is used to make electricity and to run a blower that provides air during the activated sludge process. The rest is burned. The digested sludge is dewatered in centrifuges, and used as a soil amendment on garlic crops.
4. **Tertiary Treatment** (removal of nitrogen)

- **Nitrification towers**: These structures are used to convert ammonia to nitrite and then nitrate. The towers are filled with a honeycomb plastic media on which bacteria grow. Air enters at the bottom, and water enters at the top. The bacteria convert ammonia (about 32 mg/L) to nitrate (about 32 mg/L). Centrate from the anaerobic digesters, which is very high in ammonia (about 1500 mg/L), is used about once a week to kill the snails growing in the towers. The snails eat the nitrifying bacteria and must be killed in order to keep the process working properly.

- **Denitrification using fluidized bed anoxic reactors**: The reactors consist of a sand bed with high-speed water that fluidizes the bed. Bacteria are attached to the sand particles. The bacteria convert nitrate to nitrogen gas, which is released to the atmosphere. As the amount of bacteria attached to the sand particles grows, the volume of the particle grows, and eventually they float. The floating particles are removed and the microbes are harvested and returned to the sand bed. About 95 percent of the nitrogen has now been removed (from 32 mg/L to 1.7 mg/L). About 80 percent of the remaining nitrogen is in the form of dissolved organic nitrogen. The water leaving denitrification is anaerobic, so it is aerated prior to the sand filtration step, and also chlorinated.

- **Final polishing**: Polishing involves passing the liquid through dual media (sand and anthracite) gravity filtration, with the solids sent to the plant drain system. Alum is used on the spent backwash from the sand filters. The effluent is then returned to the sand filter, and the solids to the anaerobic digesters.

- **Final chlorination**: During the final step, chlorine is added to effluent. After about a one-hour retention time, the effluent is dechlorinated with sodium bisulfite and discharged into Steamboat Creek, or used to irrigate Sparks Recreation facilities, Wild Creek Golf Course and University Farms. The effluent reuse program provides a nitrogen credit for the plant equivalent to about 3 MGD during the irrigation season.

---

### Data from a Sample Tertiary Plant

<table>
<thead>
<tr>
<th></th>
<th>Influent mg/l</th>
<th>Effluent mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suspended Solids</strong></td>
<td>175</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Nitrogen</strong></td>
<td>32</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Total Phosphorus</strong></td>
<td>6</td>
<td>0.3</td>
</tr>
</tbody>
</table>

---

**EXPLORE NEVADA’S AMAZING WETLANDS**
Truckee Meadows Water Reclamation Facility Schematic

Name ______________________

Go to www.tmwrf.com/plan_facilities/schematic/detail.html for interactive schematic.
Write the letter of the definition in the lines next to the vocabulary word.

<table>
<thead>
<tr>
<th>Vocabulary Match Game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated sludge</td>
</tr>
<tr>
<td>Aeration</td>
</tr>
<tr>
<td>Filtration</td>
</tr>
<tr>
<td>Organic material</td>
</tr>
<tr>
<td>Tertiary treatment</td>
</tr>
<tr>
<td>Disinfection</td>
</tr>
<tr>
<td>Secondary treatment</td>
</tr>
<tr>
<td>Effluent</td>
</tr>
<tr>
<td>Flocculation</td>
</tr>
<tr>
<td>Primary treatment</td>
</tr>
<tr>
<td>Settling</td>
</tr>
<tr>
<td>Chlorine</td>
</tr>
<tr>
<td>Sludge</td>
</tr>
<tr>
<td>Wastewater</td>
</tr>
<tr>
<td>Contamination</td>
</tr>
</tbody>
</table>

Name: ___________________________
Wastewater Treatment Experiment

Materials: (one set per group of students)

- Muddy water with added soil and leaves
- 16 or 20 ounce clear plastic bottle with the bottom cut off
- Alum (potassium aluminum sulfate)
- Flexible nylon screen (pantyhose work well) or a coffee filter
- Cotton batting
- 20 ounce large-mouth bottle or jar with a lid
- 2 to 3 plastic cups
- Washed fine sand
- Washed coarse sand
- Washed small pebbles or aquarium gravel
- Large beaker, jar, or clear plastic cup
- Plastic basin
- Teaspoon
- Rubber band
- Goggles

Procedure:

Follow instructions on the student worksheet.
This exercise simulates the steps taken at a water treatment facility. The underlined portions of this worksheet will prompt you for required answers. Record your observations during each step of the process. Your observations should include the color, odor and clarity of the water sample you are observing.

Describe the appearance and smell of the untreated water sample:

Pour about 1 cup of the untreated water into the 20 ounce large-mouth bottle with a lid. Keep a sample of water to use for comparison at the end of the exercise.

**STEP 1 Aeration:** Place the lid on the 20 oz large-mouth bottle and shake vigorously for 30 seconds. This will aerate the water. Pour the water into a plastic cup. Pour the water back and forth between the water and the bottle at least 10 times; this should continue the aeration.

What changes in the liquid did you observe after aeration?

Did aeration remove any of the odors? What does it smell like now?

**STEP 2 Sedimentation:** Add one heaping tablespoon of alum crystals to the aerated water sample. Slowly stir the sample for 5 minutes. The alum will act as a flocculating agent – it will cause the particles in the water to “glom” together. The larger particles will then settle out. Allow the mixture to sit for 20 minutes. Check the solution every 5 minutes and record your observations.

Sedimentation - 5 minutes:

Sedimentation – 10 minutes:
Lessons 3: Man’s Filters: Cleaning Up Wastewater  
Student Pages

Wastewater Treatment Experiment Worksheet, page 2

Sedimentation – 15 minutes:

Sedimentation – 20 minutes:

What was removed by sedimentation?

STEP 3 FILTRATION: While you are recording your observations of the sedimentation process, you can start constructing a filter for the next step of the wastewater treatment process.

1. Cut the bottom off a water bottle. Discard the bottom. Use the rest of the bottle to construct your filter.

2. Remove the cap. Attach a nylon screen to the neck of the bottle using a rubber band. You can substitute a coffee filter.

3. Turn the bottle upside down and place it in a beaker or jar to support it.

4. Put about ½ inch of cotton batting on top of the nylon or coffee filter screen.

5. Pour a layer of fine sand on top of the cotton batting in the inverted bottle.

6. Pour a layer of coarse sand on top of the fine sand.

7. Pour a layer of pebbles on top of the coarse sand. The filter is complete. There should be enough room above the pebble layer to pour in the 1-cup water sample.

8. Pour clean tap water through the filter until it drains clean from the bottom. Be careful not to disturb the pebble layer too much. This step prepares the filter for use with the sample. Empty and clean the beaker or jar in preparation for the filtration step.

After the 20 minute settling period for the sedimentation step (don’t forget to record your observations of the sedimentation process), and after construction of your filter, you are ready to begin the filtration step of wastewater treatment. Carefully pour the top two-thirds of the water sample through the filter. Be careful not to disturb or pour out the sediment; the sediment should stay in the jar! Let the sample filter into a clean jar or beaker.
How does the filtered water look different?

What was removed by the filter?

STEP 4 - WRAP IT UP: Compare the untreated and treated water samples. Write down your observations:

Do you think your purified water is safe to drink? Why or why not?

What else would you need to do to make the water clean enough to drink?
1. What happens during pretreatment? Put the letters “PT” on the map next to the parts of the system used for pretreatment.

2. What happens during primary treatment? Put the letters “1o” on the map next to the parts of the system used for primary treatment.

3. What happens during secondary treatment? Put the letters “2o” on the map next to the parts of the system used for primary treatment.

4. What happens during tertiary treatment? Put the letters “3o” on the map next to the parts of the system used for primary treatment.

5. How much waste (in million gallons per day) does the plant process? ________________

6. About how much nitrogen is present in the waste when it arrives at the plant? __________

7. About how much nitrogen is present in the waste when it leaves the plant? __________

8. What percent of nitrogen is removed? (total removed/initial total) ________________

9. About how much phosphorus is present in the waste when it arrives at the plant? ________

10. About how much phosphorus is present in the waste when it leaves the plant? __________

11. What percent of phosphorus is removed? (total removed/initial total) ________________
Lesson 4: Macroinvertebrate Clues

Purpose:
This lesson introduces students to the identification and use of macroinvertebrates as indicators of stream quality.

Summary:
The students will be introduced to the types of macroinvertebrates found in stream systems, will learn how to categorize them using anatomical differences (head, thorax, abdomen) and eating habits, and will learn how macroinvertebrates reflect stream water quality.

Key Learning Points for Students:

1. Many organisms inhabit stream systems.
2. Scientists use many methods to assess stream water quality and health. One method assesses the macroinvertebrates present in the stream or wetland.
3. Assessing stream health by surveying the numbers and diversity of macroinvertebrates present is useful for several different reasons:
   a. It is inexpensive.
   b. It is relatively easy.
   c. You can do it for several different sites along a stream to identify trouble spots.
4. Most macroinvertebrates have a four- to six-month life cycle. They do not move great distances during this time. Unlike water chemistry samples, which tell you about the water quality at the exact moment the sample was taken, macroinvertebrate surveys provide information about the average water quality during the four- to six-month period.
5. Macroinvertebrates can be identified by their body parts and life cycles.
   a. Head, thorax and abdomen
   b. Complete versus incomplete metamorphosis
Key Learning Points for Students, continued:

6. Macroinvertebrates can also be categorized by eating habits:
   a. Shredders
   b. Collectors
   c. Scrapers
   d. Predators

7. There are at least two methods to assess water quality using macroinvertebrates.
   a. Survey for the variety of organisms.
   b. Survey for indicator species (presence or absence).

Handouts:

1. Beginner’s Key to Macroinvertebrate Groups
2. Macroinvertebrate Eaters
3. Freshwater Invertebrates
4. Macroinvertebrate M&Ms Worksheet

Background:

Many organisms inhabit stream systems. Healthy streams have highly diversified populations ranging from microscopic diatoms and algae to large fish, birds, and mammals. This diversity provides for various food chains and also can act as an indication of water quality in the stream.

Using Surveys to Decode Stream Condition

It’s not always easy to tell if a stream or wetland is in trouble. If you see strange colors or dead fish or other wildlife, you might assume the water quality is poor. However, we need to know if water quality is degrading long before such extreme consequences are seen. Scientists generally rely upon a variety of methods for assessing water quality, including water chemistry and stream functioning condition assessments. One easy and relatively inexpensive method of assessing a stream’s health is to assess the macroinvertebrates or “bugs” present in the stream. Organisms that are found on the bottom (benthic), lack a backbone (invertebrates) and are large enough to be seen with the naked eye (macro), called benthic macroinvertebrates, can be used as indicators of stream quality. While we tend to think of these things as “bugs”, in reality, there are a number of groupings of macroinvertebrates that can be found in fresh water systems.
Taxonomists organize members of the animal kingdom into categories and assign them unique Latin names:

Kingdom: Animalia
SubKingdom: Metazoa (many-celled animals)

The organisms below are all considered to be macroinvertebrates:

**Insect Orders**
- Mayflies (Ephemeroptera)
- Stoneflies (Plecoptera)
- Caddisflies (Trichoptera)
- True flies (Diptera)
- Aquatic beetles (Coleoptera)
- Dobsonflies and alderflies (Megaloptera)
- Dragonflies and damselflies (Odonata)
- Aquatic true bugs (Hemiptera)
- Springtails (Collembola)

**Non-Insect Orders or Groups**
- Water mites, Hydracarina (Acarina)
- Scuds, sowbugs, and crayfish (Crustacea)
- Snails, limpets, clams, and mussels (Mollusca)
- Aquatic worms (Oligochaeta, Polychaeta)
- Leeches (Hirudinea)
- Flatworms (Turbellaria)
- Ribbon worms (Nemertea)
- Roundworms (Nematoda)
- Horsehair worms (Nematomorpha)

Other organisms, such as plankton, may float or swim freely throughout a stream. More plankton is found in water bodies with slow-moving water.

Macroinvertebrate surveys have an additional benefit. A water chemistry sample is a “snapshot” of the stream’s health at the very second the sample was taken. Macroinvertebrates live in the stream. In most streams and rivers, the larval or nymph stages of insect development will tend to dominate the macroinvertebrate community. These organisms cannot move far from their immediate habitat, and thus must adjust to changes in water quality, including the food that is available to them, the kind of stream bottom, predators, the temperature, and the speed of the water. This makes them very good indicators of the stream’s health for the bulk of their life cycle, about 4 to 6 months. For this reason, biologists often choose to use macroinvertebrate analyses to monitor water quality. In the Truckee River, regular macroinvertebrate surveys are used to assess conditions in the river.

**Macroinvertebrate Anatomy**

To categorize aquatic insect macroinvertebrates, it is useful to examine the three main body segments: head, thorax, and abdomen. The head segment includes both head and antennae. The middle part of the body is called the thorax, and includes the jointed legs and the wings. Wings are only present in adult insects. The final section of the body is the abdomen. The segments contain clues to the identity of the organism.
Macroinvertebrate Life Cycles

All aquatic macroinvertebrates begin their lives as eggs. Insects hatch from eggs and begin eating and growing (if, of course, they are not eaten themselves). Insects develop one of two ways. Insects that undergo complete metamorphosis go through egg, larva, pupa and adult stages. The larval stage of these types of insects often eat different foods and live in much different habitats than the adult stage of these insects. An example that we are all familiar with is a butterfly. Riffle beetles are common aquatic insect macroinvertebrates that exhibit complete metamorphosis.

Some insects will not change much as they grow, but just continue to get larger. This is called incomplete metamorphosis. These insects hatch from egg to nymph and grow from nymph to adult. The adults have undergone one major change: they have wings. Incomplete metamorphosis has no pupal stage. A common land insect that exhibits incomplete metamorphosis is the grasshopper. Stoneflies and some mayflies are common aquatic macroinvertebrates that exhibit incomplete metamorphosis.

Changes in form complicate surveys, as you must learn to identify the different stages of each of the insects. Larvae tend to look worm-like, while nymphs are more like adults in appearance.
Organizing Macroinvertebrates by Eating Habits

Every animal on earth eats something. The complex pattern of living organisms eating and being eaten is called the food chain. Living organisms that are eaten are referred to as “producers,” while those doing the eating are referred to as “consumers.” Since consumers can also be consumed, it is a very complex system! When producers are plentiful, consumers also flourish. For example, diatoms coating a rock feed primary consumers such as mayflies. They, in turn, feed higher-order consumers such as stoneflies and fish. The streamside vegetation found in riparian areas and wetlands also supplies terrestrial insects to the food chain, and many aquatic insects depend on this vegetation during emergence and adult stages of their life cycle.

Bottom dwellers can be categorized by how they eat. Some insects, called shredders, chew up pieces of dead plants (leaves, grasses, algae, etc.) and reduce the dead material to very fine pieces that are then excreted. Most caddisfly and stonefly larvae are shredders. Collectors gather and eat very fine pieces of decaying material and also eat the bacteria that live on the decaying material. This includes the materials excreted by the shredders. Some act as filters, straining small particles out of the water, such as net-building caddisfly larvae. Other collectors, such as certain mayfly nymphs, gather and eat material that has dropped to the bottom of the stream. Scrapers remove and eat green plants and algae from the rocks they are growing on, and graze on surface plants. Their bodies may be flat, allowing water to flow over them when attached to rocks. Some mayfly nymphs are scrapers. The final category of eaters includes predators. Predators feed on smaller, live, aquatic organisms. Some will sit still and stay hidden, waiting for their prey to approach. Dragonfly and damselfly larvae are predators.

Organizing Macroinvertebrates by Habitat

Benthic organisms can also be categorized by their habitat. Some will live in the spaces between rocks and rubble on stream bottoms. These macroinvertebrates are adapted to the fast-moving water and high oxygen levels, as might occur in riffles or rapids. Others burrow into or cling to silt, sand, and sediments where the water is warmer and quieter. These organisms are adapted to lower oxygen levels and warmer water temperatures. Other types may cling to leaves, attached algae, or rooted aquatic plants, and can be gathered using nets.

Methods to Assess Water Quality Using Macroinvertebrates

To determine relative health of a stream or wetland, biologists look at the types of macroinvertebrates that live in different reaches. Different species have different tolerance levels to pollution. If many pollution-intolerant species, such as stonefly or caddisfly nymphs, are present, then the water quality is probably quite good.

Although the presence of certain species indicates good water quality, the absence of these species does not necessarily indicate bad water quality. Other factors besides pollution may have accounted for their absence. Since macroinvertebrates are easy to collect, and relatively easy to identify, they can provide a relatively low-cost method for
assessing trends in water quality once a well-trained volunteer network has been developed.

There are two ways to judge water quality using benthic macroinvertebrates. The first is by surveying the variety of organisms. When the water quality degrades, certain creatures will disappear. For example, if the level of sediment in the water increases, it may settle into the spaces between the rocks and ruin homes for caddisflies and other organisms that live in these spaces.

The second method is to look for certain “indicator” species. Caddisflies need good habitat, and will be found in areas where the stream water quality is good. Red midges will survive in areas with low dissolved oxygen, and sowbugs like warm water. If you find lots of red midges and/or sowbugs and few other macroinvertebrates, stream water quality is degraded. These presence or absence surveys give a clue to the overall health of the stream.
**Vocabulary List**

**Abdomen:** The rear body section of some invertebrates.

**Antennae:** Flexible sensory appendages, generally occurring in pairs, on the heads of some invertebrates.

**Benthic:** At or near the bottom of a water body.

**Collectors:** Animals that feed on fine organic matter, such as plant fragments, bacteria, stream bed deposits and waste products from other organisms.

**Complete metamorphosis:** Insect development consisting of egg, larva, pupa and adult stages. During the pupa stage, the insect is immobile. The larva stages appear much different from the adult stages.

**Head:** The front body section of invertebrates.

**Incomplete metamorphosis:** Insect development consisting of egg, nymph and adult stages. Nymphs resemble adults. The adult stage is reached when wings develop.

**Larvae:** Immature insect stage of life, generally occurring in insects that undergo complete metamorphosis. Commonly referred to as grub, caterpillar or maggot.

**Macroinvertebrates:** Animals that lack a backbone and are visible with the naked eye.

**Metamorphosis:** Insect development, involving a change of form. All insects start as an egg and end as an adult. There are two types of metamorphosis: complete metamorphosis and incomplete metamorphosis.

**Nymph:** An immature insect with undeveloped wings. Generally occurs in insects that undergo incomplete metamorphosis.

**Predators:** Animals that feed on other animals. In this instance, aquatic macroinvertebrates that feed on smaller, live, aquatic organisms.

**Pupa:** The stage between the larva and the adult stages in insects that undergo complete metamorphosis. This is a non-feeding, inactive stage where adult features develop and grow.

**Scrapers:** Aquatic macroinvertebrates that remove and eat green plants and algae off the rocks they are growing on and graze on surface plants.

**Shredders:** Insects that chew up pieces of dead plants.

**Thorax:** The middle body segment or section of an insect, between the head and the abdomen. This is generally the body segment or section where legs and wings are located.

**Water quality:** The chemical, physical, biological, and radiological condition of surface water or groundwater.
The Activities

1. **Vocabulary – Invent a Bug**

Procedure:

On a separate sheet of paper, draw and name an imaginary aquatic invertebrate. Describe what it eats, and where it lives. What special features or adaptations does your bug have that helps it survive? Where in a stream would you find your bug? Make sure to label head, thorax, abdomen, legs (correct number!), antennae and wings. **Extra Credit:** Show the life cycle of your bug.

2. **Macroinvertebrate Clues**

Materials:

- Beginner’s Key to Macroinvertebrate Groups Handout
- Macroinvertebrate Eaters Handout
- Freshwater Invertebrates Handout
- Index cards
- Photocopies of “Key to Macroinvertebrate Life in the River”
- Unlabeled pictures. Cut apart and give each group 10 to 20 pictures. Use pictures from the handouts mentioned above or from your own collection of pictures or drawings.

Procedure:

1. Provide an introduction to macroinvertebrates. First, ask if students know what the word “macroinvertebrate” means. Then, explain where benthic aquatic macroinvertebrates are found (habitats) and what they eat (shredders, collectors, scrapers, predators). Give examples of each.

2. Ask students if they can name the three segments of a macroinvertebrate (head, thorax, and abdomen), and show approximately where they would occur on one of their classmates.

3. Using the labeled pictures, show and name the different segments. What differences exist between larval, nymph, and adult forms?

4. Divide students into groups. Give each group 20 to 40 index cards and one set of 10 to 20 unlabeled pictures. Have students cut apart the pictures and glue or tape each picture to a separate index card.

5. Have students write the name of the macroinvertebrate on the back of each card.

6. On a blank set of cards, have students write a description of each of the 10 to 20 macroinvertebrates. Include information on appearance, habitat, and sensitivity to water pollution. Write the name of the macroinvertebrate on the back.
The Activities, continued

2. Macroinvertebrate Clues, continued

7. Tell students to shuffle the description cards and lay them in a rectangle. Next, shuffle the picture cards and make a pile, picture side up. Taking turns, students will draw the top picture card and attempt to match it to the appropriate description card. If the student correctly matches the description to the picture, ask them to name the organism. If they can correctly match name, picture, and description, they may pick up the cards.

8. Continue to take turns until all the cards have been picked up.

3. Macroinvertebrate M&Ms (adapted from Utah State University Water Quality Extension)

Materials:

- M&Ms, jelly beans or Skittles (allow for consumption!) If you prefer to avoid foods, use colored beads, marbles, etc. The mixture should have about six different colors.
- Small plastic bags, one bag per group of students
- Graph paper
- Colored pencils
- Macroinvertebrate M&Ms Worksheet

Procedure:

1. Divide the candy or objects randomly into the bags. You may have either one bag per student, or one bag per group of students. There should be about 30 pieces of candy or objects per bag. Each bag represents all the macroinvertebrates collected at a sample site.

2. Have the class assign a macroinvertebrate to each color of candy or object. For example, red might represent a stonefly nymph, yellow a cranefly larva, green a leech, etc. See example below.

Example:

<table>
<thead>
<tr>
<th>Color (M&amp;Ms)</th>
<th>Macroinvertebrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Stonefly (intolerant)</td>
</tr>
<tr>
<td>Orange</td>
<td>Caddisfly larva (intolerant)</td>
</tr>
<tr>
<td>Yellow</td>
<td>Beetles (somewhat tolerant)</td>
</tr>
<tr>
<td>Green</td>
<td>Cranefly larva (somewhat tolerant)</td>
</tr>
<tr>
<td>Blue</td>
<td>Midge larva (tolerant)</td>
</tr>
<tr>
<td>Dark brown</td>
<td>Leeches (tolerant)</td>
</tr>
</tbody>
</table>

EXPLORE NEVADA’S AMAZING WETLANDS
The Activities, continued

3. Macroinvertebrate M&Ms, continued

3. Distribute a student worksheet and graph paper to each student or group. Have the students create a bar graph for the macroinvertebrates in the sample. Label the x-axis with the names of the macroinvertebrates represented by that color of the candy or objects, and the y-axis with the number of individuals in the sample.

4. Give each student or each group a bag of candy. Tell the students to separate and count the number of pieces in each color group, enter the results on the data sheet, and graph the results using the colored pencils.

5. Using the Beginner’s Key to Macroinvertebrate Groups, have students try to determine the water quality based on their sample.

Note: Please stress that this is not a true test of diversity. This test only considers macroinvertebrate families, not the different types or species of macroinvertebrates within the families.
Resources

http://www.seanet.com/~leska/Online/Guide.html

www.iwla.org

League of America. www.iwla.org This version is sold out. A new version is  
scheduled for printing in 2006.

#88-16. PO Box 47600, Olympia, WA 98504-7600. (360) 407-7472. Publication is  
available as a pdf in four parts (88-16a, b, c, d) for download at  
www.ecy.wa.gov/pubs/8816a.pdf or the publication can be ordered online for $18.00 at  
www.ecy.wa.gov/biblio/8816a.html

Adopt-a-Stream Foundation, Everett, WA 98208. (360) 316-8592.  
www.streamkeeper.org/catalog/books.htm

for identification of stream insects, mollusks, and crustaceans.  
www.rayswords.com/bugs/pages/intro.htm

University of Virginia, Department of Environmental Sciences. 1999. Stream Study –  
Aquatic Macroinvertebrate Identification Key. www.people.virginia.edu/~sos-  
iwla/Stream-Study/Key/MacroKeyIntro.HTML

University of Wisconsin – Extension, in cooperation with the Wisconsin Department of  
Natural Resources. No Date. Key to Macroinvertebrate Life in the River.  
http://clean-water.uwex.edu/wav/otherwav/riverkey.pdf

Utah State University Water Quality Extension. 2005. Macroinvertebrate Graphing  
Activity. http://extension.usu.edu/_sites/wq/Education.htm

section on macroinvertebrates under “Biological Surveys”).  

Test, Lesson 4 – Macroinvertebrate Clues

Name_______________________

1) What are benthic macroinvertebrates?

2) Draw a picture of a typical insect, labeling the body parts

3) Name two methods by which macroinvertebrates can be categorized.

4) Why are benthic macroinvertebrate samples a better indicator of stream health than a simple water chemistry sample?
5) Match the name to the description (draw a line).

**Shredder**
Gather and eat very fine pieces of decaying material and the bacteria that live on them.

**Collector**
Remove and eat green plants and algae off the rocks they are growing on and graze on surface plants.

**Scraper**
Feed on smaller, live, aquatic organisms.

**Predator**
Chew up pieces of dead plants (leaves, grasses, algae)

6) List two types of macroinvertebrates found in good quality water.

7) List two types of macroinvertebrates adapted to poor quality water.
Test, Lesson 4 – Macroinvertebrate Clues – Answer Key

1) What are benthic macroinvertebrates?

*Benthic – Bottom dwelling
Macro – Visible with the naked eye
Invertebrates – Lack a backbone*

2) Draw a picture of a typical insect, labeling the body parts

*Should have head, thorax, abdomen, wings, legs and antennae, at a minimum.*

3) Name two methods by which macroinvertebrates can be categorized.

*By their eating habits – shredders, collectors, scrapers, predators

By their habitat – some live in the spaces between rocks and rubble, where the water is fast-moving and cool with high oxygen levels. Some live in slow water, where the water is warmer, lower in oxygen content and less clear because the bottom is silty or sandy. Others live attached to aquatic plants.*

4) Why are benthic macroinvertebrate samples a better indicator of stream health than a simple water chemistry sample?

*The life cycle of macroinvertebrates is usually four to six months. During this time, they cannot or do not move very far. They must adjust to the changes in their environment, including presence of pollutants, available food, changes in stream bottom condition, predators, temperature, and water velocity (this affects dissolved oxygen levels).*
5) Match the name to the description (draw a line).

- **Shredder**: Gather and eat very fine pieces of decaying material and the bacteria that live on them.
- **Collector**: Remove and eat green plants and algae off the rocks they are growing on and graze on surface plants.
- **Scraper**: Feed on smaller, live, aquatic organisms.
- **Predator**: Chew up pieces of dead plants (leaves, grasses, algae)

6) List two types of macroinvertebrates found in good quality water.

- *Stonefly nymph*
- *Dobsonfly nymph*
- *Mayfly nymph*
- *Caddisfly larva*
- *Water penny*
- *Riffle beetle*
- *Gilled Snail*

7) List two types of macroinvertebrates adapted to poor quality water.

- *Midge fly larva*
- *Black fly larva*
- *Lunged snail*
- *Pouch snail and pond snails*
- *Aquatic worms*
- *Leeches*
**Beginner’s Key to Macroinvertebrate Groups Handout**

Pictures of each of the macroinvertebrates mentioned are shown on the Freshwater Invertebrates handout or the Key to Macroinvertebrate Life in the River flowchart.

**GROUP 1:** These organisms are generally not tolerant of pollution. If your sample consists mostly of these organisms, the water quality is generally good to excellent. These sensitive or intolerant species are easily killed, impaired, or driven off by bad water quality.

- Stonefly nymph
- Mayfly nymph
- Caddisfly larva
- Water penny
- Riffle beetle
- Gilled Snail

**GROUP 2:** These organisms will usually be tolerant of a wide variety of water quality conditions. They are tolerant of some level of pollution. These somewhat tolerant species will survive under a variety of conditions, and may be found in both good and bad quality water.

- Sowbugs (isopods)
- Scuds
- Cranefly larva
- Crayfish
- Clam
- Filtering caddisfly larva
- Beetles

**GROUP 3:** These organisms are more tolerant of pollution, and when found to be the largest segment of the population, generally indicate fair to poor water quality. These tolerant species are capable of surviving in poor water quality.

- Midge fly larva
- Black fly larva
- Lunged snail
- Pouch snails and pond snails
- Aquatic worms
- Leeches
Lesson 4: Macroinvertebrate Clues

Shredders: Chew up pieces of dead plants (leaves, grasses, algae, etc.) and reduce the dead material to very fine pieces that are then excreted. Most caddisfly larvae are shredders.

Collectors: Gather and eat very fine pieces of decaying material and the bacteria that live on them. This includes the materials excreted by the shredders. Some act as filters, straining small particles out of the water, such as net-building caddisfly larvae. Other collectors, such as certain mayfly nymphs, gather and eat material that has dropped to the bottom of the stream.

Scrapers: Remove and eat green plants and algae off the rocks on which they are growing and graze on surface plants. Their bodies may be flat, allowing water to flow over them when attached to rocks. Some mayfly nymphs are scrapers.

Predators: Feed on smaller, live, aquatic organisms. Some will sit still and stay hidden, waiting for their prey to approach. Dragonfly and damselfly larvae are predators.

[Images of various macroinvertebrates are shown, including shredders, collectors, scrapers, and predators.]

Explore Nevada's Amazing Wetlands
Mayfly nymphs (*Order Ephemeroptera*)

Mayflies are insects that spend most of their lives in streams, emerging briefly as adults (“ephemerally”) to mate and lay eggs. Gills are often visible along the abdomen. If an animal has three tails, it’s a mayfly. However, some mayflies have two tails. Mayfly nymphs are strong swimmers and move like dolphins. As immature nymphs, many mayflies feed on algae. As adults, they do not eat. Mayfly diversity declines as streams are degraded. They are particularly sensitive to mine waste.

Stonefly nymphs (*Order Plecoptera*)

Stonefly nymphs are typically found on or near stones in the stream. They are rather primitive and may have been among the first insects to develop flight. Adult males and females emerge from the water to mate and locate each other by drumming with their abdomens. Stoneflies move like turtles. Many are predators that hide and stalk their prey between stones and cobble. They look much like mayflies, but are stockier. Diversity of these animals declines rapidly at the first signs of human disturbance.
Caddisfly larvae (*Order Trichoptera*)

Similar to butterflies, caddisflies use silk to build cases from gravel, twigs, needles, or sand. Different species build distinct cases, but they often lose them when removed from a stream. Caddisflies are insects that emerge to mate as winged adults. Caddisfly larvae make a living in a variety of ways: some capture food in nets, and others scrape algae or shred leaf litter. Free-living caddisfly larvae do not build cases. Many are predators and need to move quickly to capture other animals for food. Some caddisflies are very sensitive to human disturbance, and others are tolerant.

**Adult mayfly, stonefly, caddisfly**

All three of these groups leave the water to mate as winged adults. Large swarms of mating mayflies and caddisflies often occur when all the individuals of a single species emerge at the same time. Stoneflies crawl out of the water and mate on the ground. The females of all three groups fly upstream and drop their eggs onto the water or dive into the stream to attach them to rocks or leaves.
Riffle beetles (*Order Coleoptera*)

Riffle beetle larvae are specially adapted to cling to smooth rocks in fast-flowing water, called riffles. After emergence, adults fly for a short time but return to the water to feed in the same habitat as the larvae. Both the larvae and adults are rather small, dark-colored, and tend to drift to the bottom of a sample, so they may be hard to see. Riffle beetles collect and gather a variety of different foods.

**Fly larvae (*Order Diptera*)**

There are many species of true flies, but you are likely to recognize three main groups or families. Midge larvae (or chironomids) are very small, often C-shaped, and have a spastic, squirming movement. They are often attached to debris by their tiny legs. Black fly larvae (or simuliids) are dumbbell-shaped and soft. They attach themselves to the substrate and prefer soft sediment. Cranefly larvae (or tipulids) are large and fleshy with very short “tentacles” at one end.
Aquatic worms

Flatworms (planaria), roundworms (nematodes), and freshwater earthworms (oligochaetes) are properly called worms, but don’t confuse them with the soft-bodied larvae of flies, for example, which are not. Nematodes and oligochaetes are long and thin and writhe like snakes. Note that these animals do not have legs.

Crustaceans

Amphipods, also called scuds, are very fast swimmers that look like shrimp. They have many appendages and look fuzzy. High proportions of these animals are present in very degraded sites. Isopods, or sowbugs, are usually found creeping through leaf litter.
Mollusks *(Classes Gastropoda & Pelecypoda)*

Most snails and limpets eat algae they scrape from rocks. Check to see if the animal is still in the shell. As larvae, freshwater mussels (or clams) may hitch a ride by attaching themselves to migrating fish. Mussels are very sensitive to sediment because they feed by filtering stream water through their shells. Mature mussels indicate an undisturbed site and may be up to 40 years old.

Lesson 4: Macroinvertebrate Clues
Student Pages

Vocabulary List

- Abdomen
- Antennae
- Benthic
- Collectors
- Complete metamorphosis
- Head
- Incomplete metamorphosis
- Larvae
- Macroinvertebrate
- Nymph
- Pupa
- Predators
- Scrapers
- Shredders
- Thorax
- Water Quality

The Activities

1. Vocabulary – Invent a Bug

Procedure:

On a separate sheet of paper, draw and name an imaginary aquatic invertebrate. Describe what it eats, and where it lives. What special features or adaptations does your bug have that helps it survive? Where in a stream would you find your bug? Make sure to label head, thorax, abdomen, legs (correct number!), antennae and wings.

Extra Credit: Show the life cycle of your bug.

2. Macroinvertebrate Clues

Materials:

- Beginner’s Key to Macroinvertebrate Groups Handout
- Macroinvertebrate Eaters Handout
- Freshwater Invertebrates Handout
- Index cards
- Copies of the “Key to Macroinvertebrate Life in the River” flowchart
- Unlabeled pictures of macroinvertebrates

Procedure:

1. Divide into groups. Each group should have 20 to 40 index cards and one set of 10 to 20 unlabeled pictures. Cut apart the pictures and glue or tape each picture to a separate index card.
The Activities, continued

2. Macroinvertebrate Clues, continued

2. Write the name of the macroinvertebrate on the back of each card.

3. On a blank set of cards, write a description of each of the 10 to 20 macroinvertebrates. Include information on appearance, habitat, and sensitivity to water pollution. Write the name of the macroinvertebrate on the back.

4. Shuffle the description cards and lay them in a rectangle. Next, shuffle the picture cards and make a pile, picture side up. Taking turns, draw the top picture card and attempt to match it to the appropriate description card. If you correctly match the description to the picture, name the organism. If you can correctly match name, picture, and description, you may pick up the cards.

5. Continue to take turns until all the cards have been picked up.

3. Macroinvertebrate M&Ms (adapted from Utah State University Water Quality Extension)

Materials:

- Small plastic bags containing M&M, Skittles or other colored objects, one bag per student or group of students
- Macroinvertebrate M&Ms student worksheet
- Graph paper
- Colored pencils

Procedure:

1. Get a bag of “macroinvertebrates” from your teacher. You may have either one bag for yourself or one bag for your group. Each bag represents all the macroinvertebrates collected at a sample site.

2. As a class, you need to assign a macroinvertebrate name to each color of candy. For example, red might represent a stonefly nymph, green a cranefly larva, dark brown a leech, etc. See the example below.

Example:

<table>
<thead>
<tr>
<th>Color (M&amp;Ms)</th>
<th>Macroinvertebrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Stonefly nymph (intolerant)</td>
</tr>
<tr>
<td>Orange</td>
<td>Caddisfly larva (intolerant)</td>
</tr>
<tr>
<td>Yellow</td>
<td>Beetles (somewhat tolerant)</td>
</tr>
<tr>
<td>Green</td>
<td>Cranefly larva (somewhat tolerant)</td>
</tr>
<tr>
<td>Blue</td>
<td>Midge larva (tolerant)</td>
</tr>
<tr>
<td>Dark brown</td>
<td>Leeches (tolerant)</td>
</tr>
</tbody>
</table>

Explore Nevada’s Amazing Wetlands
The Activities, continued

3. Macroinvertebrate M&Ms, continued

3. Count the number of different “macroinvertebrates” present in your sample. Enter the results on the Macroinvertebrate M&M Student Worksheet.

4. Using a piece of graph paper, create a bar graph for the macroinvertebrates in the sample. Label the x-axis with the names of the macroinvertebrates represented by candy, and the y-axis with the number of individuals in the sample. Color in the bars on the bar graph. A sample graph is shown below.

5. Using the Beginners Key to Macroinvertebrate Groups (page S-1), try to determine the water quality based on your sample.
Lesson 4: Macroinvertebrate Clues
Student Pages

Key to Macroinvertebrate Life in the River

- **Stalks**
  - Single Shell
    - Limpet
  - Double Shell
    - Freshwater Mussel
    - Mallard Snail
    - Pill or Finger shell

- **No Stalks**
  - **With Tentacles, Brushes or "Feet"**
    - Tubifex Worm
    - Flatworm or Planarian
  - **With Appendages**
    - Leech
  - **No Appendages**
    - Midge Larva
  - **Microscopic**
    - Nematodes or Threadworm

- **Wings**
  - Bee-like: Wings Hard
  - Beetle-like: Wings Hard
  - Whirligig Beetle
  - Crawling Water Beetle
  - March Treader
  - Water Strider
  - Giant Water Bug
  - Backswimmer
  - Water Boatman

- **No Wings**
  - No Obvious "Feet" 
  - One or Two "Feet" 
  - Three "Feet"

- **Legs**
  - Single pair
    - 1st Pair: Legs
      - Lobster-like
      - Shrimp-like
    - 2nd Pair: Legs
      - Walks on bottom
      - Stays, arms or legs
  - Four Pairs of Legs
    - Lobster-like
    - Shrimp-like
    - Walks on bottom
    - Stays, arms or legs
  - Three Pairs of Legs
    - Stays, arms or legs
    - Walks on bottom
    - Stays, arms or legs

- **No Legs**
  - Round shape with a feeler or antenna
  - Seed and Copepod
  - Water Flea or Daphnia

- **Other**
  - Water Scorpion "Nepa" 
  - Water Scorpion "Barenda"
Lesson 4: Macroinvertebrate Clues

Student Pages

### Macroinvertebrate M&Ms Worksheet

<table>
<thead>
<tr>
<th>Color</th>
<th>Macroinvertebrate</th>
<th>Number counted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark Brown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Do you think the water quality at your sample location is excellent, good, fair or poor? Why?

2. Share your results with other groups. List each group’s water quality data.

3. What might the variation in water quality assessment data suggest about the stream water quality and the sampling locations?

4. What pollutants might be responsible for the types of macroinvertebrates at your site?
Lesson 5: Getting at the Numbers: Measuring Water Quality

Grade Level: 6 to 8

Nevada Education Standards:
Science
- Scientific Inquiry
- Science, Technology and Society
- Organisms and their Environment

Mathematical
- Numbers, Number Sense and Computation
- Measurement
- Data Analysis / Problem Solving
- Mathematical Communication
- Mathematical Reasoning
- Mathematical Connections

Activities:
- Vocabulary – Crossword Puzzle
- Water Testing Experiment

Setting:
- Sample gathering occurs in the field
- Experiment is performed in the classroom or lab

Purpose:
In this exercise, students learn how to measure several water quality parameters in the classroom, and how to collect and record data.

Summary:
The exercise will introduce students to methods used to measure water quality parameters, including temperature, pH, nitrate concentration and phosphate concentration. Students will learn how to manage and replicate the data. This exercise also prepares students for data collection in the field (see Lesson 8).

Key Learning Points for Students:
1. Typical water quality parameters that are good indicators of ecosystem health include pH, temperature, nitrate and phosphate content and dissolved oxygen content.
2. pH is a measure of the acidic or basic (alkaline) nature of a solution. It is determined by the concentration of the hydrogen ion \([H^+]\) in a solution. Students should know that the optimal range of pH for most life falls between pH 6.5 and pH 8.2. Students should be able to name at least two environmental factors that can affect pH.
3. Temperature has a major effect on aquatic habitat, and temperatures above 25 degrees C (77 degrees F) are lethal for trout (salmonids) and some aquatic insects. Students should be able to name at least three things that can cause changes in water temperature.
4. Nitrogen and phosphorus are nutrients required by all organisms. Excess amounts of these nutrients can negatively affect aquatic systems. Students should be able to name at least three sources of nutrients and three problems nutrients can cause in aquatic environments.
Key Learning Points for Students, continued:

5. Dissolved oxygen is another important factor in water body health. Oxygen is more easily dissolved in clear, cold, higher-velocity water than in warm, slow-moving or stagnant water with high concentrations of dissolved or suspended solids.

6. It is essential to repeat, or replicate, all measurements to ensure data is accurate and of good quality.

Handouts:

1. The pH of Common Substances and Lethal pH Limits for Aquatic Organisms
2. Optimal Temperature Ranges for Aquatic Life
3. Vocabulary Activity – Crossword Puzzle
4. Water Quality Testing Worksheet

Background:

When scientists are interested in determining or maintaining aquatic ecosystem health, they investigate many different environmental parameters to assess the water quality. Common water quality parameters that are good indicators of ecosystem health include pH, temperature, nitrogen and phosphorus content, and dissolved oxygen content. Nitrogen and phosphorus are nutrients that are important components of proteins and essential for life. Too much or too little of any or all of these parameters in an aquatic system can significantly affect ecosystem health.

Environmental Parameters

1. pH: The pH of a water body can influence the types of organisms that inhabit a stream. pH is a measure of the activity of the hydrogen ions [H⁺] in a solution, and is used to determine if a solution is acidic or basic (alkaline). The mathematical expression for pH is:

   \[ \text{pH} = -\log [\text{H}^+] \] (the negative log of the hydrogen ion concentration)

   The pH scale ranges from 0 to 14 with 7 being neutral, less than 7 acidic, and greater than 7 basic or alkaline. Acidic solutions have higher concentrations of hydrogen ions than hydroxyl ions (OH⁻). Basic or alkaline solutions have higher concentrations of hydroxyl ions than hydrogen ions. When the concentrations of both ions are equal, the pH is 7, or neutral.

   The acidity of the solution increases as the pH value decreases. As the pH scale is logarithmic, there is a tenfold increase between each pH value. Thus, a pH difference of 2 (for example, from pH 5 to pH 7) reflects a 10 times 10 or 100 times difference in the concentration of hydrogen ions. A solution at pH 5 has 100 times as many hydrogen ions as a solution at pH 7. The optimal range for most life falls between pH 6.5 and pH 8.2.

   The pH in a water body can be influenced by the geology of an area, the pH of rainfall, the presence of lakes and wetlands in the watershed, and human activity. Rainwater pH can become more acidic by interacting with air pollutants such as nitrogen and sulfur gases,
creating nitric and sulfuric acid, respectively. Dry deposition (deposition directly from the air) of these gases from the atmosphere can also increase the acidity of water in a watershed. The diagram on page S - 1 shows the pH of common substances and the lethal limits for organisms.

2. Temperature: Temperature controls the metabolic rate, reproductive activity and life cycles (development of eggs and young) of aquatic organisms. Most aquatic organisms are cold-blooded, which means that their environment regulates their body temperature, and their body temperatures are the same as the water temperature. Most organisms are adapted to a specific temperature range, and temperatures outside that range or rapid fluctuations in temperature can negatively affect them. Both warmer and colder temperatures can affect the metabolism, development and growth rates of aquatic organisms. Temperature also affects the amount of oxygen that can be dissolved in water and the activity of parasites and diseases, and it can affect the sensitivity of organisms to pollution.

Temperatures fluctuate seasonally and daily. Water quantity and velocity can also influence the temperature of a water body. Shading from trees, stream bed color, and orientation to the sun also affect the amount of sunlight absorbed by water, and thus its temperature. Human activity influences temperature in a number of ways, for example, through releases of water from power plants and industrial uses. Rainfall runoff events from hot asphalt surfaces result in water heating. Irrigation water withdrawals leave less water in rivers and creeks, and the remaining water is subject to sharp fluctuations in temperature. Agricultural return flows, which are usually warmer than a stream’s water, can also increase temperatures. Water releases from dams, which usually involves cold water withdrawn from deep below the water surface, will also influence temperature, in this case moderating temperature increases. The chart on page S - 2 shows the optimum temperature range for aquatic organisms.

3. Nutrients: Nitrogen and phosphorus are commonly-measured water quality parameters. These nutrients are required by organisms for growth, reproduction and survival. Various chemical forms of nitrogen and phosphorus occur naturally in stream water.

If there are excess nutrients in the water, they over-stimulate growth of aquatic plants and algae. The vegetation can clog waterways and is unsightly, interfering with recreational uses. When the vegetation dies, it is decomposed by bacteria. The bacterial decomposition process consumes the oxygen in the water, resulting in decreases in dissolved oxygen concentrations. This can adversely affect fish and aquatic invertebrate survival, leading to a decrease in community diversity via fish and macroinvertebrate kills. The decomposition process also produces unpleasant odors. Sources of nutrients include fertilizers, sewage from septic systems and treatment plants, animal wastes and detergents. Sources of nitrogen can also include car exhaust and atmospheric deposition.

Nitrate (NO$_3^-$), nitrite (NO$_2^-$), and ammonia (NH$_4^+$) are forms of nitrogen found in water. Nitrate is the most common form analyzed when measuring water quality. It is helpful to understand the transformations of nitrogen in the environment by studying the nitrogen cycle. Both nitrate and ammonia can be taken up by plants and converted into proteins. However, ammonia is toxic to plants in high concentrations. Animals get the nitrogen they need by
eating plants. Some of the nitrogen is then excreted as waste products. Both plant and animal wastes contain organic nitrogen, which can be converted to inorganic nitrogen (ammonia) by bacteria. Not all is converted, and some remains as non-digestible matter. Plants can take up the resulting ammonia, but if there is excess ammonia, it is converted to nitrite in a process called nitrification. Bacteria oxidize nitrite to nitrate. Under anaerobic (oxygen-depleted) conditions, nitrate and nitrite can both be converted to nitrogen gas, N₂, which escapes to the atmosphere. Nitrogen gas can not be readily used by animals and most plants. It is “fixed” by bacteria in the soil and lightning in the atmosphere. Organic nitrogen is not available to plants and is not really of concern. Nitrite is usually present in such low concentrations that it requires sophisticated methods of measurement. Thus, nitrate is often the most appropriate form to analyze for water quality assessment. A diagram of the nitrogen cycle is shown below.

The natural level of ammonia or nitrate in surface water is typically low (less than 1 milligram per liter or mg/L). In the effluent of wastewater treatment plants, it can range up to 30 mg/L.

Phosphorus usually occurs as phosphate (PO₄³⁻). This form is called inorganic phosphorus, orthophosphate, or reactive phosphorus. Phosphate that is bound to plant or animal tissue is called organic phosphorus. Naturally occurring inorganic phosphorus exists in soil. Excessive amounts of inorganic phosphorus are most likely derived from sewage leakage, fertilizers and detergents. Inorganic phosphorus is the form that is most available to plants and the easiest to measure.
4. **Dissolved Oxygen**: As mentioned above, dissolved oxygen (DO) is an essential factor in stream or water body health. While dissolved oxygen content will not be measured in this lesson, it is important to understand how the above factors can and do affect dissolved oxygen content. Oxygen is more easily dissolved in cold water than hot water. Organisms such as trout that rely upon cold water for survival need the higher oxygen concentrations found in cold water. When the temperature of the water increases due to urban runoff, reduced water flows, warm water return flows and/or the removal of streamside vegetation, decreases in dissolved oxygen occur.

Generally, the greater the water volume and velocity, the higher the dissolved oxygen concentrations will be. Faster-flowing whitewater areas incorporate oxygen from the atmosphere into the water. Slow, stagnant areas of water tend to have lower dissolved oxygen contents. This is why larger fish tanks usually have a bubbler or some sort of water movement device to increase the amount of dissolved oxygen in the tank.

The presence of nutrients can indirectly result in decreases in dissolved oxygen concentrations. Initially, dissolved oxygen levels may rise, with oxygen being produced by the aquatic plants and algae that grow in response to the nutrient enrichment. When the algae and other plants die, oxygen is consumed in the decomposition process. The final result is depletion of dissolved oxygen in the water body that can be severe enough to result in fish kills.

Oxygen also dissolves more readily in water that has low levels of dissolved or suspended solids. Because of this, water containing a lot of salts or sediment will tend to have a lower dissolved oxygen content.

If you would like to measure dissolved oxygen with your students, test kits are available from Hach, Project WET, Chemetrics, and other vendors.

### Maximum Dissolved Oxygen Concentrations by Temperature

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Temperature (°F)</th>
<th>Maximum Dissolved Oxygen Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32</td>
<td>14.60</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>12.75</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>11.27</td>
</tr>
<tr>
<td>15</td>
<td>59</td>
<td>10.07</td>
</tr>
<tr>
<td>20</td>
<td>68</td>
<td>9.07</td>
</tr>
<tr>
<td>25</td>
<td>77</td>
<td>8.24</td>
</tr>
<tr>
<td>30</td>
<td>86</td>
<td>7.54</td>
</tr>
<tr>
<td>35</td>
<td>95</td>
<td>6.93</td>
</tr>
</tbody>
</table>
Vocabulary List

**Acidic:** Water or soil that has a pH of less than 7.0, or a higher concentration of hydrogen ions than hydroxyl ions.

**Alkaline (aka Basic):** Water or soil that has a pH greater than 7.0, or a higher concentration of hydroxyl ions than hydrogen ions.

**Ammonia:** The \([\text{NH}_4^+]\) ion, one of the many common ions containing nitrogen. Ammonia is an inorganic form of nitrogen.

**Basic:** See Alkaline.

**Decant:** To pour off or draw off the upper layer of liquid after the heavier material (a solid or a heavier liquid) has settled.

**Dissolved oxygen:** The concentration of oxygen dissolved in water and readily available to fish and other aquatic organisms.

**Hydrogen ion:** The ion \([H^+]\). An ion is an atom or molecule that carries a charge, either positive or negative.

**Hydroxyl ion:** The ion \([\text{OH}^-]\). An ion is an atom or molecule that carries a charge, either positive or negative.

**Metabolic rate:** The rate of metabolism in living organisms. Metabolism includes the continuous chemical and physical processes occurring in living organisms. The rate of this activity can be affected by many environmental factors, including temperature or pH.

**Neutral:** Water or soil with a pH of 7.0, meaning that it is neither acidic nor alkaline (basic).

**Nitrate:** The \([\text{NO}_3^-]\) ion, one of several ionic forms of nitrogen. Nitrate is soluble in water, and plants readily absorb this form of nitrogen.

**Nitrite:** The \([\text{NO}_2^-]\) ion, one of several ionic forms of nitrogen. Nitrite is not absorbed by plants.

**Nitrogen:** Nitrogen, chemical symbol \(\text{N}\), makes up 78 percent of the Earth’s atmosphere as \(\text{N}_2\) gas. Nitrogen is an essential element required for plant growth. Nitrogen is also a major constituent of nonpoint source pollution.

**Nutrient:** A substance such as nitrogen or phosphorus that is necessary for plant growth.
Vocabulary List, continued

**pH:** The term pH is an abbreviation of the French term “pouvoir hydrogène,” which literally means “hydrogen power.” pH is a measure of the activity or concentration of the hydrogen ions \([H^+]\) in a solution, and is used to determine if a solution is acidic or basic (alkaline). The mathematical expression for pH is:

\[
pH = -\log[H^+] \quad (\text{the negative log of the hydrogen ion concentration})
\]

The pH scale ranges from 0 to 14 with 7 being neutral, less than 7 acidic, and greater than 7 basic or alkaline. The acidity of the solution increases as the pH value decreases. As the pH scale is logarithmic, there is a tenfold increase between each pH value.

**Phosphorus:** A chemical element (P) that is one of the three essential elements required for plant growth. Phosphorus is often a major component of nonpoint source pollution and tends to adsorb or stick onto soil particles.

**Water quality:** The chemical, physical, biological, and radiological condition of surface water or groundwater.

**Water velocity:** The rate of motion of a stream measured in terms of the distance its water travels in a unit of time, usually expressed in feet per second.

**Wetland:** An area that is periodically inundated with water, or an area that is saturated by surface or groundwater on an annual or seasonal basis; displays hydric soils; and typically supports or is capable of supporting hydrophytic vegetation.

The Activities

1. **Vocabulary – Crossword Puzzle**

   **Procedure:**

   Have the students complete the crossword puzzle. Definitions of the vocabulary words are given as clues. A list of vocabulary words is included.

2. **Water Quality Testing**

   **Materials:**

   - Water samples, ideally taken the same day. Refrigerate until use.
   - Latex gloves
   - Protective eyewear, such as goggles or safety glasses
   - Clean plastic containers, glass jars, or use Whirl-paks to collect water samples (one per sample)
   - Smaller beakers or glass jars for individual samples of the water (one per sample per group)
Lesson 5: Getting at the Numbers: Measuring Water Quality

The Activities, continued

2. Water Quality Testing, continued

Materials, continued:

- Distilled water for rinsing between samples
- Rinse bottles (one per group)
- 2 or more large containers for contaminated water (You will need two separate containers for the nitrate and phosphate test water.)
- Temperature probe or thermometer (Armored field thermometers are less likely to be broken. Avoid mercury-containing thermometers due to the potential for contamination if broken.)
- Narrow-range pH test strips
- Nitrate testing kit (can be purchased from www.hach.com or www.chemetrics.com)
- Phosphate testing kit (can be purchased from www.hach.com or www.chemetrics.com)
- Orange, wiffle ball, or table tennis ball
- Measuring tape
- Stopwatch
- Water Quality Testing Worksheet

Procedure:

This exercise is designed to familiarize the students with testing methods and procedures before going to the field (Lesson 8). Throughout the procedure, information is provided on procedures for data gathering in the field, locations for sample collection in the field and methods for minimizing disturbance in the field.

For comparison purposes, water quality values from a number of locations along the Truckee River for 2003 are included in the Appendix.

Quality Control
To ensure good quality data, you will repeat each test three times for each sample (three replicates). If one test value is significantly different from the other two values for a single sample, you may want to perform a fourth test. If the values of all three tests are significantly different for a single sample, carefully check your sampling and testing protocols! Additionally, you may wish to include a field blank, or a sample of distilled water that is treated exactly like a field water sample, to identify errors or contamination in sample collection and analysis. It is also desirable to collect field duplicates (individual samples collected at the same time and place) to help determine the accuracy of your testing method.

Other considerations to ensure the data is valid:

- Label all samples clearly.
- Samples should be kept in a cooler for transport to the lab, and analyzed as soon as possible after collection.
Lesson 5: Getting at the Numbers: Measuring Water Quality

The Activities, continued

2. Water Quality Testing, continued

- Each sample should be handled exactly the same.
- Maintain your equipment according to the manufacturer’s instructions.
- Read the instructions that accompany test kits for information on the limits of the testing method.

Sample Collection in the Field

Collect one to five water samples, preferably the same day, from different water bodies or from different areas in a single water body. Tips for collecting samples:

- When collecting samples in the field, wear latex gloves. This prevents your hands from contaminating the sample, and the water from contaminating your hands.
- Sample containers must be clean. Do NOT use containers that have been washed with ordinary household detergents! See the information on Preparation of Sample Containers on page 15 of this lesson.
- Rinse each sample container several times with the water you will be collecting before actually taking the sample. This ensures no contamination from the container will interfere with the results.
- Collect samples from main current, away from banks and well underneath the surface of the water. This will help ensure a well-mixed representative sample. See pages 16 to 18 for more information on collecting samples.

If possible, take temperature and pH readings at the same time (see below for methods). Measure both parameters directly in the stream. Repeat each test three times. Record all values on a data sheet for each individual sample.

Measuring Velocity in the Field

Velocity, or the speed with which the water is flowing, can be determined by placing a buoyant object such as an orange, a wiffle ball, or table tennis ball in the water and measuring the distance it travels over a certain amount of time. Start by measuring a distance along the stream parallel to the direction of flow. Twenty feet is the minimum distance you should use; a 100 foot distance is used in many monitoring programs. Pick a section of the stream that is straight and does not include any slow water areas such as ponds. Drop your floating object in the water above the marked distance and measure how long it takes it to travel the marked distance using a stopwatch. Collect your floating object using a fishing net, and repeat the “time of travel” measurement twice. Average the results.

Calculate the velocity as follows: Velocity (feet/minute) = Distance Traveled / Time. Note the velocity of the water at each sample location, if possible. If time was measured in seconds, be sure to convert it to minutes by dividing by 60.
The Activities, continued

2. Water Quality Testing, continued

Measuring Water Quality Parameters in the Lab

Divide students into small groups (two to four students per group.) Have the students get a sample of the water you have collected. In keeping with the sample protocols, you may want to set up a rinse station to allow the students to rinse their sample container several times, as you did when you collected the sample in the field. Students should wear latex gloves and protective eyewear. Mention that in the field you wore latex gloves and protective eyewear and rinsed the container several times with the stream water before you actually collected the sample. Have the students note the sample number or other identifying information on their worksheets. They will record all sample test values and observations on the worksheet.

Temperature

Note: If temperature was not measured in the field, this reading will reflect the storage temperature.

1. Place the thermometer or meter probe in the water at least four inches below the surface or halfway to the bottom if in a shallow stream or wetland.

2. If using a thermometer, allow enough time for it to reach a stable temperature (at least one minute). If using a meter, allow the temperature reading to stabilize at a constant value.

3. If possible, try to read the temperature with the thermometer bulb beneath the water surface. If it is not possible, quickly remove the thermometer and read the temperature.

4. Record the temperature on the field data sheet.

5. Repeat two more times, recording the measurements on the worksheet.

6. Calculate an average temperature.

pH

pH is the next test. For a quality control check, it is a good idea to try out the pH paper in solutions with a known pH to make sure everyone is interpreting the color scheme the same way. Explain to the students that like temperature, pH should be analyzed in the field immediately because both can change rapidly over time. Ideally, pH should be measured within two hours of the sample collection. After collection, the pH will change as carbon dioxide from the air dissolves in the water, bringing the pH value closer to 7.
The Activities

2. Water Quality Testing, continued

pH, continued

1. Dip the pH paper in the water sample and compare the colors to those on the container. Record the pH value on the worksheet.
2. Repeat the test two more times, recording each value on the worksheet.
3. Calculate the average pH.

Compare the students' temperature and pH measurements with those you took in the field. Note the changes and reinforce the concept that these measurements should ideally be made in the field.

Nitrate

The instructions below are for the HACH 14161-00 nitrate test kit, which has a range of 0 to 10 milligrams per liter or mg/L (you may have to explain mg/L to students). Most of the water in the Truckee River and its tributaries should fall within this range. It may be difficult to determine nitrate concentrations in very clean water using this test kit. If using a different test kit, please provide appropriate directions to the students.

Nitrate should be determined according to the directions on the test kit. Read the directions carefully! Both nitrate and phosphate tests use chemical reagents that are added to a portion of the sample. All wastewater from these tests should be collected in separate containers (one container for each type of test) and disposed of properly (see page 14). Do not pour this water down a drain!

The test kits use reagents that are packaged in foil “pillows” or rectangular envelopes. Before opening, tap the pillow on a hard surface to send the contents to the bottom of the container. Then, tear off the top of the pillow along the tear line. Push the sides of the packet to the center to open the pillow. If you make crease lines in the center of the packet, it will be easier to pour out the contents. To avoid wasting reagents, it is helpful to have the students practice on small salt, pepper or sugar packets.

1. Put on gloves and protective eyewear.
2. Begin by filling one of the color viewing tubes with the liquid to be analyzed. Stopper and shake vigorously. Empty and repeat.
3. Fill the tube to the bottom of the shaded area. Open one NitraVer 6 nitrate reagent powder pillow. Add it to the sample to be tested. Stopper and shake for three minutes. Allow sample to sit undisturbed for 30 seconds. Unused cadmium should sink to the bottom.
The Activities

2. Water Quality Testing, continued

Nitrate, continued

4. Carefully pour (decant) the prepared sample into the other viewing tube so that the cadmium at the bottom remains in the first tube.

5. Open one NitraVer 3 reagent powder pillow. Add the contents to the sample. Stopper the tube and shake for 30 seconds. A red color will develop if nitrate is present. Insert the tube in the opening closest to the center of the container. After 10 minutes (but not more than 20), you can make the reading.

6. Rinse the cadmium metal from the color viewing tube used in step 3. Put the rinse water in the nitrate test wastewater container.

7. Fill the rinsed tube to the mark with the original water sample and place it in the opening nearest the side of the box. You now have 2 tubes: one with the original water sample, and one with the tested sample after decanting. The original water sample is used to account for any effect of discoloration on the reading of the test.

8. Hold the box up to the light and rotate the disc to obtain a color match. Read the number through the scale window and multiply by 4.4 to get the results as mg/L of nitrate. Mention to students that no color does not necessarily mean there are no nitrates present. The nitrate levels may be below the detection limits of the test kit.

9. Dispose of the test water in the nitrate test wastewater container.

10. Repeat the test two more times, recording the values on the worksheet.

Phosphate

The instructions below are for the Phosphate HACH 2250-01 low range test kit. Most of the water in the Truckee River and its tributaries should fall within the range of 0 to 1 mg/L of phosphate. Both nitrate and phosphate tests use chemical reagents that are added to a portion of the sample. All wastewater from these tests should be collected in separate containers (one container for each type of test) and disposed of properly (see page 14). Do not pour this water down a drain!

The test kits use reagents that are packaged in foil “pillows” or rectangular envelopes. Before opening, tap the pillow on a hard surface to send the contents to the bottom of the container. Then, tear off the top of the pillow along the tear line. Push the sides of the packet to the center to open the pillow. If you make crease lines in the center of the packet, it will be easier to pour out the contents.


**The Activities**

2. **Water Quality Testing, continued**

   *Phosphate, continued*

1. Put on gloves and protective eyewear.
2. Rinse the square mixing bottle several times with the water to be analyzed.
3. Fill the square mixing bottle to the 20-ml mark with the water to be tested.
4. Open one PhosVer 3 reagent powder pillow. Add the contents to the bottle and swirl to mix. Allow 2 minutes for color development. If phosphate is present, a blue-violet color will appear.
5. Fill one sample tube with the prepared sample and the other tube with the original water sample. The original water sample is used to account for any effect of discoloration on the reading of the test.
6. Insert the treated sample in the hole closest to the center of the box.
7. Orient the viewer toward a light source, being careful not to spill the sample.
8. Rotate the disc to get a color match. Record the reading in the scale window and divide by 50 to get mg/L phosphate. As with the nitrate test, a zero reading does not necessarily mean that there is no phosphate present. The phosphate levels may just be lower than the detection limits of the test kit.
9. Dispose of test water in the phosphate test wastewater container.
10. Repeat the test two more times, recording all three values on the worksheet.

**Velocity**

Velocity can be measured by placing something buoyant, such as an orange, a wiffle ball, or a table tennis ball in the water, and measuring the distance it travels during a certain amount of time. Explain to the students how this would be done in the field (see the procedure above.) To allow the students to practice determining velocities, give them some sample data (see below). Be sure to give them three replicates so they can calculate the average.

\[
\text{Velocity (feet/minute) = Distance traveled/Time. Time (minutes) = Time (seconds)/60.}\]

Remind students that they will need to convert from time in seconds to time in minutes.

<table>
<thead>
<tr>
<th>Distance traveled (feet)</th>
<th>Time (seconds)</th>
<th>Time (minutes)</th>
<th>Velocity (feet/minute)</th>
<th>Average Velocity (feet/minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>17.2</td>
<td>0.287</td>
<td>52.33</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>17.0</td>
<td>0.283</td>
<td>52.94</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>17.4</td>
<td>0.290</td>
<td>51.72</td>
<td>52.33</td>
</tr>
<tr>
<td>20</td>
<td>23</td>
<td>0.383</td>
<td>52.17</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>22.9</td>
<td>0.382</td>
<td>52.40</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>22.5</td>
<td>0.375</td>
<td>53.33</td>
<td>52.64</td>
</tr>
</tbody>
</table>
The Activities

2. Water Quality Testing, continued

Additional observations

Have the students record any other observations they note about the water samples, including color, clarity or odor. Mention to the students that in the field, they would also note:

- Streambed coatings
- Excessive dead vegetation
- Excessive live vegetation
- Air temperature
- Weather on the sampling date
- Any recent weather trends.

Have the students brainstorm why these additional observations might be important. Ask the following types of questions:

- What are some types of weather changes or patterns that could affect stream health?
- How might these events affect the nature of the sample?
- Do you think your results are truly representative of the conditions in the stream most of the time?

For instance, recent rapid snowmelt or flooding could cause a temporary increase in the sediment load of a stream, making the water cloudy or murky.

Disposal of waste solutions from sample testing:

Water samples and waste solutions must be disposed of properly to avoid water pollution. Follow the directions below:

1. The water from temperature and pH tests can be poured down the drain.

2. The test water from the phosphate test, PhosVer3 test packet, should be diluted with additional water (hence the request for a large container). The pH should be adjusted to between 6 and 9 by adding sodium bicarbonate (baking soda). With the cold tap water running, slowly pour the diluted, pH-adjusted test water down the drain. Allow the cold water to run for 5 minutes afterwards to completely flush the system.

3. The test water from the nitrate test, NitraVer6 test packet, contains cadmium, which is an OSHA listed carcinogen. The test waters are considered a hazardous waste and should be disposed of in an EPA-approved hazardous waste facility. In Washoe County, each middle school and high school has a Designated Science Safety Officer. You should contact this person at your school regarding collection, labeling, and transfer of this waste. Most school districts have an environmental officer or chemical hygiene specialist on staff. In Washoe County, this person can be reached at 775-348-3852 or through the main district line at 775-348-0200. For other school districts, please check with your district office.
Preparation of Sampling Containers

Reused sample containers and glassware must be cleaned and rinsed before the first sampling run and after each run by following either Method A or Method B described below. The most suitable method depends on the parameter being measured. See page 18 for information on clean, disposable collection bags.

Method A: General Preparation of Sampling Containers

The following method should be used when preparing all sample containers and glassware for monitoring conductivity, total solids, turbidity, pH, and total alkalinity. Wear latex gloves!

1. Wash each sample bottle or piece of glassware with a brush and phosphate-free detergent.
2. Rinse three times with cold tap water.
3. Rinse three times with distilled or deionized water.

Method B: Acid Wash Procedure for Preparing Sampling Containers

This method should be used when preparing all sample containers and glassware for monitoring nitrates and phosphates. Wear latex gloves!

1. Wash each sample bottle or piece of glassware with a brush and phosphate-free detergent.
2. Rinse three times with cold tap water.
3. Rinse with 10 percent hydrochloric acid.
4. Rinse three times with deionized water.
Collecting Samples


Please review Safely Issues in the Appendix.

In general, sample away from the stream bank in the main current. Never sample stagnant water. The outside curve of the stream is often a good place to sample, since the main current tends to hug this bank. In shallow stretches, carefully wade into the center current to collect the sample.

When collecting a water sample for analysis in the field or at the lab, follow the steps below.

For Screw-cap Bottles

To collect water samples using screw-cap sample bottles, use the following procedures:
- Samples should be taken in the main current.
- Samplers should face upstream.
- Turn the bottle into the current and scoop in an upstream direction.
Procedure:

1. Label the bottle with the site number, date, and time.

2. Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle or the cap. If you accidentally touch the inside of the bottle, use another one.

3. Try to disturb as little bottom sediment as possible. In any case, be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you. You may also tape your bottle to an extension pole to sample from deeper water.

4. Hold the bottle near its base and plunge it (opening downward) below the water surface. If you are using an extension pole, remove the cap, turn the bottle upside down, and plunge it into the water, facing upstream. Collect a water sample 8 to 12 inches beneath the surface or mid-way between the surface and the bottom if the stream reach is shallow.

5. Turn the bottle underwater into the current and away from you. In slow-moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction.

6. Leave a 1-inch air space. Do not fill the bottle completely, so that the sample can be shaken just before analysis. Recap the bottle carefully, remembering not to touch the inside.

7. Fill in the bottle number and/or site number on the appropriate field data sheet. This is important because it tells the lab coordinator which bottle goes with which site.

8. If the samples are to be analyzed in the lab, place them in a cooler for transport to the lab.
For Whirl-pak® Bags


and other vendors.

Note: Make sure the Whirl-pak bags do not contain sodium thiosulfate to neutralize chlorine. This will make your results invalid.

1. Label the bag with the location, date, and time.

2. Tear off the top of the bag along the perforation above the wire tab just prior to sampling. Avoid touching the inside of the bag. If you accidentally touch the inside of the bag, use another one.

3. Try to disturb as little bottom sediment as possible. In any case, be careful not to collect water that contains bottom sediment. Stand facing upstream. Collect the water sample in front of you.

4. Hold the two white pull tabs in each hand and lower the bag into the water on your upstream side with the opening facing upstream. Open the bag midway between the surface and the bottom by pulling the white pull tabs. The bag should begin to fill with water. You may need to "scoop" water into the bag by drawing it through the water upstream and away from you. Fill the bag no more than three-quarters full.

5. Lift the bag out of the water. Pour out excess water. Pull on the wire tabs to close the bag. Continue holding the wire tabs and quickly flip the bag over at least four to five times quickly to seal the bag. Don’t try to squeeze the air out of the top of the bag. Fold the ends of the wire tabs together at the top of the bag, being careful not to puncture the bag. Twist them together, forming a loop.

6. Record the bag number and/or site location on the appropriate field data sheet. This is important! It is the only way the lab coordinator know which bag goes with which site.

7. If samples are to be analyzed in a lab, place the sample in the cooler with ice or cold packs.

Note: Whirl-pak bags tend to fall over and leak. Have an appropriate container in which to transport them.
Resources

Carolina Biological Supply. No date. Sources for water testing kits and equipment. www.carolina.com

Chemetrics Inc. No date. Source for water test kits and equipment. www.chemetrics.com


Hach Chemical Co. No date. Sources for water testing kits and equipment. www.hach.com


Test, Lesson 5 – Measurement of Water Quality

Name__________________________________

1) True or False  pH is a measure of the concentration of hydrogen ions – the greater the concentration, the higher the pH.

2) True or False  pH scale is logarithmic, which means there is a 10-fold change between each pH number.

3) True or False  The optimal pH range for most life is 6.5 to 8.2.

4) Temperature is a controlling factor for aquatic organisms. Temperature affects:
   a) Metabolic rate
   b) Reproductive activity
   c) Life cycles
   d) The amount of oxygen in the water
   e) All of the above

5) List three things that cause changes in water temperature.
   1._____________________________________________________________________
   2._____________________________________________________________________
   3._____________________________________________________________________

6) List three sources of nutrients in streams or other water bodies
   1._____________________________________________________________________
   2._____________________________________________________________________
   3._____________________________________________________________________

7) List three potential problems excess nutrients can cause in a water body
   1._____________________________________________________________________
   2._____________________________________________________________________
   3._____________________________________________________________________

8) True or False  Oxygen is more easily dissolved in cold water.

9) True or False  Oxygen is more easily dissolved in water with high levels of dissolved or suspended solids.
Lesson 5: Getting at the Numbers: Measuring Water Quality

Test, Lesson 5 – Measurement of Water Quality – Answer Key

1) True or False  pH is a measure of the concentration of hydrogen ions – the greater the concentration, the higher the pH.

2) True or False  pH scale is logarithmic, which means there is a 10-fold change between each pH number.

3) True or False  The optimal pH range for most life is 6.5 to 8.2.

4) Temperature is a controlling factor for aquatic organisms. Temperature affects:
   a) Metabolic rate
   b) Reproductive activity
   c) Life cycles
   d) The amount of oxygen in the water
   e) All of the above

5) List three things that cause changes in water temperature.
   1. Water quantity and/or water velocity
   2. Seasonal and daily variations
   3. Storm water passing over paved surfaces in our environment – streets, sidewalks, parking lots, roofs, driveways, etc.
   4. Water discharges from power plants and industrial uses
   5. Agricultural return flows
   6. Water releases from dams

6) List three sources of nutrients in streams or other water bodies
   1. Fertilizers
   2. Sewage from septic systems and treatment plant
   3. Animal wastes
   4. Detergents
   5. Car exhaust (nitrogen oxides)
   6. Atmospheric (nitrogen)
   7. Sediment with phosphorus attached

7) List three potential problems excess nutrients can cause in a water body
   1. Excessive growth of aquatic plants and algae
   2. When the vegetation dies, decomposition depletes the oxygen
   3. Depleted oxygen can result in fish and aquatic invertebrates kills, reducing diversity in the water body
   4. Plant growth interferes with recreation

8) True or False  Oxygen is more easily dissolved in cold water.

9) True or False  Oxygen is more easily dissolved in water with high levels of dissolved or suspended solids.
Lesson 5: Getting at the Numbers: Measuring Water Quality

Answer Key

Getting at the Numbers: Measuring Water Quality Vocabulary Exercise
Lesson 5: Getting at the Numbers: Measuring Water Quality

**THE pH OF COMMON SUBSTANCES AND LETHAL pH LIMITS FOR AQUATIC ORGANISMS**

- **pH Scale**: 0——1——2——3——4——5——6——7——8——9——10——11——12——13——14
  - **Acidic**
    - All fish dead (begin to die 4.0-4.5)
    - Bass, trout and tadpoles dead (begin to die 5.5-6.0)
    - Caddisflies, mayflies dead (begin to die 4.5-5.0, decline at 6.5)
  - **Optimal range for most life (pH 6.5–8.2)**
  - **Basic**
    - All fish dead (begin to die 11.0-11.5)
    - Salmonids dead (begin to die 10.5-11.0)

- Sea Water
- Human Blood
- Distilled water
- Orange juice
- Vinegar
- Battery acid
- Lemon Juice
- Coca cola
- Rain

- Baking Soda
- Ammonia
- Bleach
- Lye

- **Intoxication limits**:
  - Salmonid eggs dead
  - Reduced salmonid egg production 5.0-5.5
  - Bottom dwelling bacteria (decomposers) begin to die (5.0-5.5); detritus accumulates, locking up essential nutrients
  - Sediment releases metals into water in forms toxic to aquatic life
  - Snails and tadpoles begin to die (6.0-6.5)

Adapted from Streamkeeper’s Field Guide, Chapter 7, Page 167.
Lesson 5: Getting at the Numbers: Measuring Water Quality

Optimal Temperature Ranges for Aquatic Life

Temperatures above 25°C are lethal for salmonids and some aquatic insects

Above 20°C (68°F)
Bass, shiners, bluegills, bullheads, carp, catfish, suckers, peamouth, squawfish, crappie
Dragonflies, trueflies, some caddisflies

Between 13-20°C (55.4-68°F)
Coho, chinook, cutthroat, lamprey, sturgeon, shad, dace, shiners, stickleback, walleye, sculpins
Mayflies, caddisflies, stoneflies, beetles

Below 13°C (55.4°F)
Steelhead, pink, chum, coho, cutthroat, kokanee, rainbow, brown trout, brook trout, dolly varden, artic grayling, smelt, chiselmouth, sculpins
Mayflies, caddisflies, stoneflies

Adapted from Streamkeeper’s Field Guide, Chapter 7, Page 177.
Vocabulary List

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidic</td>
<td>Nitrate</td>
</tr>
<tr>
<td>Alkaline</td>
<td>Nitrite</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Basic</td>
<td>Nutrient</td>
</tr>
<tr>
<td>Decant</td>
<td>pH</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Phosphorus</td>
</tr>
<tr>
<td>Hydrogen Ion</td>
<td>Water Quality</td>
</tr>
<tr>
<td>Hydroxyl Ion</td>
<td>Water Velocity</td>
</tr>
<tr>
<td>Metabolic rate</td>
<td>Wetland</td>
</tr>
</tbody>
</table>

The Activities

1. Vocabulary – Crossword Puzzle

Procedure:

Fill in the boxes on the crossword puzzle, shown on the next page, using the following clues:

ACROSS
3. \([\text{NH}_4]^+\) ion
5. The rate of motion of a stream, measured in terms of the distance traveled in a unit of time
7. To pour off the upper layer of liquid after the heavier liquid or solids have settled
8. Chemical element P, one of the three essential elements for plant growth
10. Water or soil that has a pH less than 7.0
11. Water or soil with a pH of 7.0
12. A substance necessary for plant growth
13. \([\text{OH}^-]\) ion
14. Water or soil that has a pH greater than 7.0
15. \([\text{NO}_2^-]\) ion

DOWN
1. An area that is at least periodically inundated with water, displays hydric soils and is capable of supporting hydrophytic vegetation
2. Chemical element N, it makes up 78 percent of the Earth’s atmosphere as \(\text{N}_2\) gas
4. The continuous chemical and physical processes occurring in living organisms
5. The chemical, physical, biological, and radiological condition of surface water or groundwater.
6. \([\text{NO}_3^-]\) ion
7. The concentration of oxygen dissolved in water and available to fish and other aquatic life
8. A measure of the activity or concentration of the hydrogen ion
9. \([\text{H}^+]\) ion
The Activities, continued

2. Water Quality Testing

Materials:

- Water samples, ideally taken the same day
- Latex gloves
- Protective eyewear, such as goggles or safety glasses
- Clean plastic containers, glass jars, or Whirl-paks to collect water samples (one per sample)
- Smaller beakers or glass jars for individual test samples of the water (one per sample per group)
- Distilled water for rinsing between samples
- Rinse bottles (one per group)
- 2 or more large containers for contaminated water. You will need two separate containers for the nitrate and phosphate test water.
- Temperature probe or thermometer. Armored field thermometers are less likely to be broken. Avoid mercury-containing thermometers due to the potential for contamination if broken.
- Narrow range pH test strips
- Nitrate testing kit
- Phosphate testing kit
- Orange, wiffle ball, or table tennis ball
- Measuring tape
- Stopwatch
- Water Quality Testing Worksheet

Procedure:

This exercise is designed to familiarize you with testing methods and procedures before going out in field (Lesson 8). Throughout the procedure, information is provided on procedures for data gathering in the field, where samples would be collected in the field and methods for minimizing disturbance in the field.

Quality Control

To ensure good quality data, you will repeat each test three times for each sample (three replicates). If one test value is quite different from the other two values for a single sample, you may want to perform a fourth test. If the values of all three tests are significantly different for a single sample, carefully check your sampling and testing protocols! Additionally, you may wish to include a field blank, or a sample of distilled water that is treated exactly like a field water sample, to identify errors or contamination in sample collection and analysis. It is also desirable to collect field duplicates (individual samples collected at the same time and place) to help determine the accuracy of your testing method.

EXPLORE NEVADA’S AMAZING WETLANDS
The Activities, continued

2. Water Quality Testing, continued

Other considerations to ensure the data is valid:

- Label all samples clearly.
- Samples should be kept in a cooler for transport to the lab, and analyzed as soon as possible after collection.
- Each sample should be handled exactly the same.
- Maintain your equipment according to the manufacturer’s instructions.
- Read the instructions that accompany test kits for information on the limits of the testing method.

Sample Collection in the Field

Collect one to five water samples, preferably the same day as they will be analyzed, from different water bodies or from different areas in a single water body. Tips for collecting samples:

- When collecting samples in the field, wear latex gloves. This prevents your hands from contaminating the water sample, and the water from contaminating your hands.
- Sample containers must be clean. Do NOT use containers that have been washed with ordinary household detergents!
- Rinse each sample container several times with the water you will be collecting before actually taking the sample. This ensures no contamination from the container will interfere with the results.
- Collect samples from the main current, away from banks and well underneath the surface of the water. This will help ensure a well-mixed representative sample.

If possible, take temperature and pH readings at the same time (see below for methods). Measure both parameters directly in the stream. Repeat each test three times. Record all values on a data sheet for each individual sample.

Measuring Velocity in the Field

Measure velocity, or the speed with which the water is flowing, by placing a buoyant object such as an orange, a wiffle ball, or a table tennis ball in the water and measuring the distance it travels during a certain amount of time. Start by measuring a distance along the stream parallel to the direction of flow. Twenty feet is the minimum distance you should use; a 100 foot distance is used in many monitoring programs. Pick a section of the stream that is straight and does not include any slow moving areas such as ponds. Drop your floating object in the water above the marked distance and measure how long it takes it to travel the marked distance using a stopwatch. Collect your floating object using a fishing net, and repeat the “time of travel” measurement twice more for a total of three tests. Average the results. Note the velocity of the water at each sample location, if possible. If you are not able to measure stream velocity in the field, your teacher will give you some sample data.
The Activities, continued

2. Water Quality Testing, continued

Measuring Velocity in the Field

Calculate the velocity as follows: Velocity (feet/minute) = Distance Traveled/Time.

If you measure velocity in seconds, make sure to convert it to minutes.
Time (minutes) = Time (seconds)/60.

Measuring Water Quality Parameters in the Lab

Before you do anything else, put on your gloves and goggles. Collect a sample of the stream water. Rinse the sample container several times with the stream water before filling it for testing. You can dump the rinse water down the drain. Write the sample number or description on your worksheet.

Temperature

Note: If you did not measure the water temperature in the field, this reading will only tell you the current temperature of the water, not anything about the temperature of the water in the stream.

1. Place the thermometer or temperature probe in the water as least four inches below the surface or halfway to the bottom if in a shallow stream or wetland.
2. If using a thermometer, allow enough time for it to reach a stable temperature (at least one minute). If using a meter, allow the temperature reading to stabilize at a constant temperature reading.
3. If possible, try to read the temperature with the thermometer bulb beneath the water surface. If it is not possible, quickly remove the thermometer and read the temperature.
4. Record the temperature on the field data sheet.
5. Repeat two more times, recording all three measurements on the worksheet.
6. Calculate an average temperature.

pH

pH is the next test. Ideally, pH should be measured within two hours of sample collection. After collection, the pH will change as carbon dioxide from the air dissolves in the water, bringing the pH value closer to 7.

1. Dip the pH paper in the water sample and compare the colors to those on the container. Record the pH value on the worksheet.
2. Repeat the test two more times, recording all three values on the worksheet.
3. Calculate the average pH.
The Activities, continued

2. Water Quality Testing, continued

**Nitrate**

Both nitrate and phosphate tests use chemical reagents that are added to a portion of the sample. All wastewater from these tests should be collected in separate containers (container for each test) and disposed of properly. Place the wastewater in the container labeled “nitrate waste.” Do not pour this water down a drain!

The test kits use reagents that are packaged in foil “pillows” or rectangular envelopes. Before opening, tap the pillow on a hard surface to send the contents to the bottom of the container. Then, tear off the top of the pillow along the tear line. Push the sides of the packet to the center to open the pillow. If you make crease lines in the center of the packet, it will be easier to pour out the contents.

1. Put on gloves and protective eyewear.

2. Begin by filling one of the color viewing tubes with the water to be analyzed. Stopper and shake vigorously. Empty and repeat.

3. Fill the tube to the bottom of the shaded area.

4. Open one NitraVer 6 nitrate reagent powder pillow. Add it to the sample to be tested. Stopper and shake for three minutes. Allow the sample to sit undisturbed for 30 seconds. Unused cadmium should sink to the bottom.

5. Carefully pour (decant) the prepared sample into the other viewing tube so that the cadmium at the bottom remains in the first tube.

6. Open one NitraVer 3 reagent powder pillow. Add the contents to the sample. Stopper the tube and shake it for 30 seconds. A red color will develop if nitrate is present. Insert the tube in the opening closest to the center of the container. After 10 minutes (but not more than 20), you can make the reading.

7. Rinse the cadmium metal from the color viewing tube used in step 3. Put the rinse water in the nitrate test wastewater container.

8. Fill the rinsed tube to the mark with the original water sample and place it in the opening nearest the side of the box. You now have two tubes: one with the original water sample, and one with the tested sample after decanting. The original water sample is used to account for any effect of discoloration on the reading of the test.
The Activities, continued

2. Water Quality Testing, continued

Nitrate

9. Hold the box up to the light and rotate the disc to match the color. Read the number through the scale window and multiply by 4.4 to get the results as mg/L of nitrate. No color does not necessarily mean there is no nitrate present. The nitrate value may be below the detection limit of the test kit.

10. Dispose of the test water in the nitrate test wastewater container.

11. Repeat the test two more times, recording all three values on the worksheet.

Phosphate

Both nitrate and phosphate tests use chemical reagents that are added to a portion of the sample. All wastewater from these tests should be collected in separate containers and disposed of properly. Place the wastewater from the phosphate test in the container labeled “phosphate waste.” Do not pour this water down a drain!

The test kits use reagents that are packaged in foil “pillows” or rectangular envelopes. Before opening, tap the pillow on a hard surface to send the contents to the bottom of the container. Then, tear off the top of the pillow along the tear line. Push the sides of the packet to the center to open the pillow. If you make crease lines in the center of the packet, it will be easier to pour out the contents. See the diagram in the nitrate test section

1. Put on gloves and protective eyewear.

2. Rinse the square mixing bottle several times with the water to be analyzed.

3. Fill the square mixing bottle to the 20-ml mark with the water to be tested.

4. Open one PhosVer 3 reagent powder pillow. Add the contents to the bottle and swirl it to mix. Allow two minutes for color development. If phosphate is present, a blue-violet color will appear.

5. Fill one sample tube with the prepared sample and the other tube with the original water sample. The original water sample is used to account for any effect of discoloration on the reading of the test.

6. Insert the treated sample in the hole closest to the center of the box.

7. Orient the viewer toward a light source, being careful not to spill the sample.
The Activities, continued

2. Water Quality Testing, continued

Phosphate

8. Rotate the disc to match the color. Record the reading in the scale window and divide by 50 to get mg/L phosphate. As with the nitrate test, a zero reading does not necessarily mean there is no phosphate present. The phosphate value may be below the detection limit of the test kit.

9. Dispose of the test water in the phosphate test wastewater container.

10. Repeat the test two more times, recording the values on the worksheet.

Additional observations

On your worksheet, record any other observations about the water samples, including:

- Color
- Clarity
- Odor

In the field, you would also note:

- Streambed coatings
- Excessive dead vegetation
- Excessive live vegetation
- Air temperature
- Weather on the sampling date
- Any recent weather trends
Lesson 5: Getting at the Numbers: Measuring Water Quality

Water Quality Testing Worksheet

Date____________________  Name__________________________________

Sample ID_________________________________________________________

**General information**

Sample/site description

Weather (include air temperature)

Recent weather trends

**Quantitative Water Quality Data**

<table>
<thead>
<tr>
<th></th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nitrate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phosphate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Water Velocity**

Velocity = measured distance (parallel to the direction of flow)/ time to travel measured distance

<table>
<thead>
<tr>
<th></th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measured distance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Time to travel</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Velocity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average Velocity = (Velocity 1 + Velocity 2 + Velocity 3)/3 = ___________________________

---

[Image: EXPLORE NEVADA’S AMAZING WETLANDS]
# Water Quality Testing Worksheet, page 2

## Qualitative Water Quality Data (check or circle all that apply)

### Water appearance:
- Scum
- Foam
- Muddy
- Milky
- Clear
- Oily Sheen
- Brownish
- Reddish
- Greenish
- Other_____________________________________________________

### Odor:
- Rotten Egg
- Musky
- Chlorine
- None
- Other_____________________________________________________

### Streambed coating
- Orange to red
- Yellowish
- Black
- Brown
- None
- Other_____________________________________________________

### Description of vegetation:
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

### Any other observations:
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

---

---
Lesson 6: Wet and Wild: A Wetland Field Study

Purpose:
This field activity is designed to reinforce concepts learned in Lesson 1. Students will delineate and define a wetland, based on water, soil and vegetation.

Summary:
In Lesson 1, students were provided with the definition of a wetland, introduced to the variety of types of wetlands, and learned the importance of wetlands as ecosystems. This lesson is a hands-on field activity that puts the information presented in Lesson 1 to practical use.

Key Learning Points for Students:
This lesson is a hands-on reinforcement of Lesson 1. The Key Learning Points remain the same.

1. Wetlands have many functions. Students should be able to describe at least four different wetland functions.
2. Wetlands are defined by water, soil and plants. Presence of water alone is not sufficient to define a wetland.
3. Wetland soils are hydric and exhibit changes in color (gleying).
4. Hydrophytic plants live in wetlands and have adaptations that allow them to survive in oxygen-poor soils.
5. Halophytic plants are adapted to high salt concentrations.
6. Wetland vegetation can also be defined by its proximity to the water surface.

Handouts:
1. Important Indicators to Investigate
2. Plant Identification Key
3. Plant Inventory Worksheet
4. Soil Survey Worksheet

Grade Level: 6 to 8

Nevada Educational Standards:
Science
• Scientific Inquiry
• Science, Technology and Society
• Heredity
• Structure of Life
• Organisms and their Environment
• Diversity of Life

Mathematical
• Numbers, Number Sense and Computation
• Measurement
• Mathematical Connections

Activities:
• Plant Inventory
• Soil Survey

Setting:
Field
Lesson 6: Wet and Wild: A Wetland Field Study

Background:

Please review Lesson 1 for all appropriate background materials. The following discussion duplicates the information found in Lesson 1 that is specific to defining wetlands.

What Defines a Wetland?

Despite what its name infers, water is not the only defining characteristic of a wetland. In fact, wetlands are distinguished by the presence of three major characteristics:

1. **Standing water** covering the soil for all or a portion of the time.
2. **Hydric soils** (soils that form under conditions of saturation, ponding, or flooding long enough to develop anaerobic, or oxygen-deprived, conditions).
3. **Hydrophytic** (water tolerant) **plants**.

A combination of these three factors helps to define and delineate a wetland. In a wetland, the substrate or soil is saturated by or covered with water at some time during the growing season each year. When the upper part of the soil is saturated with water at growing-season temperatures, soil organisms consume the oxygen in the soil. This causes an anaerobic condition to develop in the soil, influencing the texture, color and even the odor of the soil. These soils are referred to as hydric. Most plants cannot tolerate these low oxygen conditions, but some plants have developed adaptations that allow them to thrive in wetland soils. These water-tolerant plants are termed hydrophytic (hydro = water; phytic = loving).
The Activities

What better way is there to learn about a wetland than to go and study one! First, review Safety Issues found in the Appendix. Ask the students to brainstorm locations of wetland areas in the vicinity of the school. Try to identify a wetland that is within walking distance of your school. Visit the wetland in advance to determine whether it is, in fact, a wetland, using the identifying factors of soil, water, and plants. If no wetlands are located within walking distance of your school, as an alternative, have one or several of the students visit a wetland on their own and bring their observations back to the class. They will then present their data to the class, which can then discuss whether the area qualifies as a wetland.

1. Plant Inventory

Materials:

- Paper
- Pencils
- Clipboard
- Twine
- Wooden stakes
- Measuring tape
- Important Indicators to Investigate Handout
- Plant Identification Key Handout
- Plant Inventory Worksheet

Procedure:

1. Set up transects across the wetland area. A transect is a line drawn through an area that is used to direct data collection. Use twine and stakes to establish a straight line across the area. Make sure the line crosses all representative zones of the wetland (review the handouts from Lesson 1).

2. Mark off equidistant intervals (one to five feet) along the transect, and flag each interval.

3. On the vegetation data sheet, at the beginning of the transect, at each flagged point along the transect and at the end point, record:
   a. The kind of plant under the flagged point
   b. The approximate height of each plant
   c. The color of the plant
   d. The leaf shape
   e. The number of each type of plant within a certain area at the flagged point (you will need to predetermine this, based on the size of the wetland you are studying; perhaps a square meter would be a good starting point.)
The Activities, continued

1. Plant Inventory, continued

   f. The degree of inundation: Was the entire plant under water (submerged)? Was part of the plant in standing water while some or most of it was above the water? Was it located in soggy ground, or was it in an upland part of the wetland where the ground is fairly dry?

   g. The general appearance of the plant, using a sketch.

4. When possible, collect samples of the plant(s), but do not gather samples if the plant is endangered or if very few individuals of that particular species exist at the site. An alternative is to take photographs of the plants. Note: If you have done this exercise previously, and collected and pressed plant samples, you maybe able to do this exercise in class (bad weather, etc.).

5. Make observations. Are there wetland plant roots visible? Are the plants dead or alive? Are there any unusual smells?

2. Soil Survey

Materials:

- Shovels
- Plastic tarps or large plastic garbage bags
- Paper
- Pencil
- Clipboard
- Soil Survey Worksheet

Procedure:

1. Choose three sites along the transect line at which you will dig soil pits or cores. Try to select sites that are representative of the different terrain in the wetland.

2. At each site, dig a pit that is about one to two feet wide and 18 inches deep. Stop digging if you reach the water table. Put the excavated soil on the plastic tarp or garbage bag.

3. Using the data sheet as a guide, make observations and record the data. Note differences in color, depth of organic material (grass, wood, etc.), texture, smell, and wetness. Fill in the pits carefully before you leave. Replace the plants, if possible.
3. The Activities, continued

Back in Class

Procedure:

1. Press any plant samples you collected according to the directions on pages S-10 and S-11. These samples can be saved and used the next time the lesson is taught.

2. Have the students draw a cross-section or transect of their plant inventory. Students should label the locations of the various species of plants. Add information about the soils to the transect diagram.

3. Have students determine whether the site is a wetland. What information did they use in making their decision? What other information might be useful?

Resources


Montana Plant Life. No date. Photo album of wildflowers, separated by color, etc. This may be useful in identifying flowering broadleaf plants. The second site includes a plant identification key. http://montana.plant-life.org/ http://montana.plant-life.org/index2.html


Sea Grant. 2001. Non-Native Invasive Aquatic and Wetland Plants in the United States. If you know the basic family, (i.e. grasses, etc.), you can search the database. http://plants.ifas.ufl.edu/seagrant/aquinv.html


The Activities

Find a wetland to study and/or adopt, or decide if an area is a wetland. What better way to learn about a wetland than to go and study one!

1. Plant Inventory

Materials:

- Paper
- Pencils
- Clipboard
- Twine
- Wooden stakes
- Measuring tape
- Important Indicators to Investigate Handout
- Plant Identification Key Handout
- Plant Inventory Worksheet

Procedure:

1. Set up transects across the wetland area. A transect is a line drawn through an area that is used to direct data collection. Use twine and stakes to establish a straight line across the area. Make sure the line crosses all representative zones of the wetland (review the handouts from Lesson 1).
2. Mark off equidistant intervals (one to five feet) along the transect and flag each interval.
3. On the vegetation data sheet, at the beginning of the transect, at each flagged point along the transect and at the end point, record:
   a. The kinds of plants under the flagged point
   b. The approximate height of the plant
   c. The color of the plant
   d. The leaf shape
   e. The number of each type of plant within a certain area at the flagged point (within a square meter is a good place to start.)
   f. The degree of inundation: Was the entire plant under the water (submerged)? Was part of the plant in standing water while some or most of it was above the water? Was it located in soggy ground, or was it in an upland part of the wetland where the ground is fairly dry?
   g. The general appearance of the plant, using a sketch
The Activities, continued

1. Plant Inventory, continued

4. When possible, collect samples of the plant(s), but do not gather samples if the plant is endangered or if very few individuals of that particular species exist at the site. An alternative is to take photographs of the plants.

5. Make observations. Are there wetland plant roots visible? Are the plants dead or alive? Are there any unusual smells?

2. Soil Survey:

Materials:

- Shovels
- Plastic tarps or large plastic garbage bags
- Paper
- Pencil
- Clipboard
- Soil Survey Worksheet

1. Choose three sites along the transect line at which you will dig soil pits or cores. Try to select sites that are representative of the different terrains in the wetland.

2. At each site, dig a pit that is about one to two feet wide and 18 inches deep. Stop digging if you reach the water table. Put the excavated soil on a plastic tarp or large plastic garbage bag.

3. Using the data sheet as a guide, make observations and record the data. Note differences in color, depth of organic material (grass, wood, etc.), texture, smell, and wetness. Fill in the pits carefully before you leave. Replace the plants, if possible.

3. Back in Class

1. Press the plant samples according to the directions on pages S - 10 and S - 11. If there is time, try to identify the plants from these samples.

2. Draw a cross section or transect of their plant inventory. Label the locations of the various species of plants. Add information about the soils to the transect diagram.

3. Is the site is a wetland? How did you determine this? What other information might be useful to help you make a decision?
Is there any evidence of seasonal saturation?

- Is there standing water?
- If there is no standing water, look to see whether the soils are saturated by digging a hole. Is the soil damp or wet?
- Are there depressions or low spots with dark water-stained leaves?
- Are there water lines or stains on tree trunks or objects in the area?
- Are there thin layers of sediment that were deposited when water was standing in the area?
- Is there water-transported debris in the area?

Is there any evidence of hydric soils?

- Does the area have organic soils?
- Is it black and mucky?
- Does it leave a dark stain when you rub it between your fingers, which would indicate that it was high in organic matter?
- If the soils are more like sand and clay, what color are they?
  - Are they bluish grey?
  - Are they mottled red, brown or yellow near the surface?
- Does it smell like rotten eggs?

Is there any evidence of hydrophytic plants?

- Are the plant species hydrophytic? Use the Plant ID key provided to determine this.
  - Ferns?
  - Sedges?
  - Rushes?
  - Grasses?
  - Cattails?
  - Wetland trees or shrubs?
Botany, the branch of science that studies plant identification, is very complicated. Here are just a few ways to identify common wetland plants.

**Ferns and horsetails:** Ferns and most horsetails have characteristic paired lacy leaves along a stem, with one leaf at the terminal end. Ferns and horsetails reproduce through spores, not seeds. The spores can be found in little pouches under the leaves.

The next three groups of common wetland plants are often confused with one another. They include the herbaceous (non-woody) plants common in wetlands. At first glance, they may look identical, and you may think they are all grasses. A simple rhyme can help you distinguish these plants:

**Sedges have edges,**  
**Rushes are round,**  
**Grasses are hollow,**  
**Right up from the ground.**

**Sedges:** The edges mentioned in the rhyme are found on the stems of the plants. Sedge stems are triangular. If you roll the stems with your fingers, you can feel the “edges.” The stems have no joints, and the leaves grow in a 120° pattern. If you look down on a stem, the leaves will radiate in three directions. Sedges provide excellent bank stabilization for rivers and lakes. They also provide a food source for waterfowl. Native Americans used sedges to make baskets and other necessities.
Rushes: Rushes have leaves or blades that form in two rows, unlike sedges, which have three rows. Rushes have round solid stems, unlike grasses, which are hollow, or sedge stems, which are triangular. They are an important food source for waterfowl and some mammals. They also provide habitat for fish and invertebrates. Rushes were used by ancient man as weaving material.

Grasses: Grasses can be distinguished from sedges by the leaves, which grow in two rows, not three. Grasses also have round hollow stems. Grass stems often have swellings, called nodes, where the stems are fastened to the grass leaves or blades. Most grasses are an important food source for domesticated livestock and wildlife, with both vegetation and seeds being eaten. Identification of individual species of grasses is very difficult, since they will hybridize with each other, forming plants that do not look like either of the parents.

Cattails: Almost everyone has seen the cigar-shaped seed heads of a cattail. Cattails are tall, have blade-shaped leaves, and form characteristic “tails” or seed heads. Like grasses, there are several species that have the ability to reproduce with each other, forming hybrids. Cattails are an important food source for wildlife and have been used as food by ancient man.
Broadleaf plants: There are an incredible number of broadleaf plants that grow in or near wetlands. Broadleaf plants can be distinguished from grasses by their seed leaves. They provide the striking flower colors and variations of leaf shapes we see in a wetland. Shrubs and trees are woody broadleaf plants. There are so many broadleaf plants that we cannot cover them all here. There are a number of websites you can use to help you identify broadleaf plants. Some of the websites ask you questions about leaf structure and other characteristics to help you identify the plant.

Two important non-native herbaceous (non-woody) broadleaf species tend to invade wetlands in the Great Basin. These two plants are found on the noxious weed list for Nevada, meaning that they cannot be sold in Nevada, and must be controlled by the landowner.

Purple loosestrife is a noxious weed found throughout North America. It is usually found growing along the edges of streams and lakes. It can be come so dense that it will choke waterways. Purple loosestrife can grow to 6 feet tall and 6 feet across. The 2- to 4-inch-long leaves are shaped like a spearhead and are arranged in whorls on the square stems. The flowers are very showy, forming a rose-purple spike. People sometimes plant purple loosestrife in their gardens, not realizing how damaging it can be in a wetland.

Perennial pepperweed, usually called tall whitetop in Nevada, is another noxious weed that troubles us. These plants grow up to 6 feet tall and have spearhead-shaped, bright green to greyish leaves. The leaves at the bottom of the plant are larger than those at the top of the plant. The small white flowers form a cluster at the end of branched flower stalks. These plants appear so attractive that some people collect them as dried flowers! Tall whitetop is a particularly nasty noxious weed throughout the west. It grows in waterways, ditch banks and wet meadows. It will completely take over a wetland, choking out the other plants. Unfortunately, it offers no food or habitat for wildlife and it does not help stabilize the soil along stream banks. It can reproduce by roots and from seed. In fact, if you try to eradicate it by pulling or digging, new plants will grow from the fragments of root left in the ground.
Shrubs/Trees: Shrubs and trees common to our local wetland areas include alders, birch, aspen, cottonwood, willow, Russian olive and saltcedar (also called tamarisk). Remember that for our purposes, trees are greater than 10 feet tall, while shrubs are less than 10 feet tall.

Willow trees have long slender leaves that are:
- alternate (occur at different levels on opposite sides of the stem),
- simple (the leaf blade is undivided),
- spearhead-shaped,
- up to 4 inches long and 1 inch wide,
- pointed at the tip and tapering to the base, and
- with or without teeth on the leaf edges.

The stems are slender, smooth or slightly hairy and are yellow in color when young, becoming brownish black and shiny with age.

Cottonwood trees are members of the willow family. They also:
- have alternate, simple, lance-shaped leaves,
- have leaves up to 4 inches long and 2 inches wide

The leaves are pointed at the tip and rounded or tapering at the base. They can be distinguished from willows by the paler green color on the lower surface of the leaves. The stems form orange-brown twigs at first, becoming tan. The stems are not hairy. Cottonwood trees can grow much larger than willows.
Aspen trees or shrubs are also members of the willow family. The bark is smooth, greenish-white to grayish-white and often thin and peeling. Leaves are almost round and can grow 1.5 to 2.5 inches long, and may have small rounded teeth on the edges. The leaves turn yellow to orange or reddish after the first frost.

Alder trees have alternate, simple, oval-shaped leaves, rounded to pointed at the tip, and rounded or somewhat heart-shaped at the base. The edges of the leaves are very distinctive and have obvious teeth.

Birch trees have alternate, simple, oval leaves up to 2 inches long and not quite as wide. The leaves are usually pointed at the tip and rounded or tapering to the base. Birch leaves are also toothed, but the teeths are smaller than on alder leaves. Birches in our area are generally small trees or large shrubs that have shiny bronze bark that does not peel off.
Some non-native trees are very invasive weeds in wetlands and can cause many problems, from drying up the groundwater to destroying habitat for wildlife.

Saltcedar or tamarisk trees have alternate, simple, nearly scale-like leaves, up to 1/8-inch long. Trunks and twigs are brown to black and smooth. The young stems are a reddish color. This tree is nonnative and tends to take over a site. This can be quite detrimental, since tamarisk has the ability to use large amounts of water and may even dry up a wetland. The flowers are tiny, pink, and grow in long, billowing formations in May and June. These trees are difficult to remove or kill once established.

Russian olive trees or shrubs are also introduced (nonnative) species. These plants have a high tolerance for salt and alkalinity (high pH soils). They also are drought-tolerant, full-sun-tolerant and cold-tolerant. This makes them very competitive here in the Great Basin. The leaves are narrow, 2 to 3 inches long, and have a distinctive silvery appearance, especially on the underside of the leaves. The woody stems are often reddish-brown and have stiff, woody thorns. The flowers are yellow and arranged in clusters. The plant produces very small tan or silvery fruits which resemble olives.
When scientists preserve a specimen of a plant (or part of a plant), they usually flatten it, dry it and mount it on special paper. Preserved in this way, the plant specimen can be stored for many years without falling apart.

To get a good preserved specimen, the plant material that is collected in the field must be of good quality. A half-dead, wilted or dry plant does not press well and will not make a good preserved specimen. Select plant material that is growing well, is healthy and is representative of that type of plant growing in the area. When collecting the specimen, cut it to a size that will fit conveniently in the plant press. If the specimen is small enough, it can be pulled from the ground so that the whole plant, roots and all, can go into the press. Sometimes a specimen will need to be folded over or trimmed a little to make it fit in the press.

Plants that have been collected need to be pressed as soon as possible. Plants can be kept in a paper or plastic bag for an hour or so, but once they start to wilt they make poor specimens. **Press cut specimens as soon as possible.** If possible, take the plant press in the field with you and press your samples as they are collected.

The preservation process begins by flattening the plant specimen in a plant press. A plant press is made of newspapers or blotter paper, cardboard, and plywood and is held together with nylon straps, rope, bungee cords, etc. See the drawing below:

A plywood plant press is an easy to construct tool that will stand the test of time. The standard size is 12 inches wide and 18 inches long. These plant presses can be used time and time again for pressing activities.

To assemble one plywood plant press you will need:
- **Wood:** Two pieces of 12 inch by 18 inch 1/4 - 1/2 inch plywood.
- **Cardboard:** At least 5 to 10 pieces of corrugated cardboard and no more than 20. The cardboard should be cut to 12 X 18 inches with the box cutter.
- **Newspaper:** A supply of newspaper to be used as blotter paper between cardboard layers. It is better to use newspaper that is a couple of weeks old, so the ink won’t smear. You should not use color print newsprint.
- **Tie-downs:** Anything that will hold the layers under pressure is adequate. Suggestions: bungee cords, belts, rope, or canvas strapping with buckles.
- **Tools:** box cutter.
The drying process involves making a plant specimen sandwich. First the plant specimen is placed between two layers of newspaper. Then the newspaper “sandwich” is placed between two pieces of corrugated cardboard. Place this on top of one of the pieces of plywood. Add another layer of newspaper, plant specimen, newspaper and another piece of corrugated cardboard. Continue this layering process until you are out of plant specimens. On top of the last plant specimen, place a final piece of newspaper, a piece of corrugated cardboard and the top piece of plywood. Strap the plant press “sandwich” tightly together using straps, belts, bungee cords or rope.

Whenever specimens with particularly bulky stems, fruits, or flowers are put in the drying press, additional packing with folded blotting paper, newsprint, or thick pieces of corrugated cardboard may need to be inserted. This will help apply proper pressure on the thinner plant parts and also allow the press to stack evenly.

Once the specimens are dry, they can be mounted on special plant paper or poster board and placed in protective plastic sleeves. If the samples are very thin, they can be protected by laminating. Label the samples with date taken, location, species and any other pertinent information.

# Plant Inventory Worksheet

Write down the station number. Mark “yes” or “no” if any of the plants are found in the assigned area (up to _____ feet from the station marker.) If you can identify the plant, write down its name. If not, write down information about the plant, such as its height, or the color of the flowers. You can also draw the leaves and/or flowers. You may need more than one inventory sheet. If you are sure the plant is not poisonous or endangered, you may want to collect a sample to bring back to the classroom. Always check with your teacher before you collect plant samples.

<table>
<thead>
<tr>
<th>Station Number</th>
<th>Cattails (Yes/No)</th>
<th>Sedges (Yes/No)</th>
<th>Rushes (Yes/No)</th>
<th>Grasses (Yes/No)</th>
<th>Broadleaf plant type (tree, shrub, flowering plant)</th>
<th>Height</th>
<th>Leaves or Flowers (color, shape, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil Survey Worksheet</td>
<td>Name_________________________</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Station 1</strong></td>
<td><strong>Station 2</strong></td>
<td><strong>Station 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layer 1</td>
<td>Layer 2</td>
<td>Layer 3</td>
<td>Layer 1</td>
<td>Layer 2</td>
<td>Layer 3</td>
<td>Layer 1</td>
<td>Layer 2</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smell</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture (gritty, fine)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does it stain your fingers?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How wet is it?</td>
<td>(wet, damp, dry)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any organic material? (leaves, roots, other plant debris)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth of plant roots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any living organisms? (insects, earthworms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional notes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 7: Macroinvertebrate Field Survey

Purpose:
This field exercise introduces students to a method for using macroinvertebrates as indicators of stream quality.

Summary:
The students will sort macroinvertebrate samples to determine relative quantities of various organisms and make an assessment of the general stream water quality.

Key Learning Points for Students:
This lesson is a hands-on reinforcement of Lesson 4. Key learning objectives are identical.

1. Many organisms inhabit stream systems.
2. Scientists use many methods to assess stream water quality and health. One method assesses the macroinvertebrates present in the stream.
3. Assessing stream health by surveying the numbers and diversity of macroinvertebrates present is useful for several different reasons:
   a. It is inexpensive.
   b. It is relatively easy.
   c. You can do it for several different sites along a stream to identify trouble spots.
4. Most macroinvertebrates have a 4 to 6 month life cycle. They do not move great distances during this time. Unlike water chemistry samples, which tell you about the water quality at the exact moment the sample was taken, macroinvertebrate surveys provide information about the average water quality during the 4 to 6 month period.
5. Macroinvertebrates can be identified by their body parts and life cycles.
   a. Head, thorax and abdomen
   b. Complete versus incomplete metamorphosis
6. There are at least two methods to assess water quality using macroinvertebrates.
   a. Survey for the variety of organisms.
   b. Survey for indicator species (presence or absence).
**Handouts:**

1. Plan Of Action Worksheet
2. Macroinvertebrate Survey Worksheet
3. Macroinvertebrate Survey Practice Data Set
4. Macroinvertebrate Survey Worksheet, Alternate Method
5. Macroinvertebrate Survey, Alternate Method Sample Calculations
6. Analyze the Macroinvertebrates Results in the Classroom Worksheet

**Background:**

Benthic macroinvertebrates can be used as indicator species to reveal information about the general water quality of a stream or river. Review Lesson 4, Macroinvertebrate Clues, for more information.

Remember, in most streams and rivers, the larval or nymph stages of insects will tend to dominate the macroinvertebrate community. These organisms cannot move far from their immediate habitat, and thus must adjust to changes in water quality, including the food that’s available to them, the kind of stream bottom, predators, the temperature, and the speed of the water. For this reason, these organisms are good indicators of what has happened in the stream during their life cycle. In most cases, the normal life cycle of one generation is four to six months. In the Truckee River and Steamboat Creek, regular macroinvertebrate surveys are used to determine conditions in the river and its tributaries.

<table>
<thead>
<tr>
<th>If you find:</th>
<th>Look for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little variety of macroinvertebrates, with lots of each kind</td>
<td>Water overly enriched with organic matter</td>
</tr>
<tr>
<td>Only one or two kinds of macroinvertebrates in great abundance</td>
<td>Severe organic pollution</td>
</tr>
<tr>
<td>A variety of macroinvertebrates, but only a few of each kind, or NOT insects, but the stream appears clean</td>
<td>Toxic pollution</td>
</tr>
</tbody>
</table>

Adult Mayfly, Stonefly, Caddisfly

EXPLORE NEVADA’S AMAZING WETLANDS
The Activity

1. Macroinvertebrate Field Survey

Materials:

- Bottom samples from several locations along a stream or river. Try to obtain samples both above and below sources of pollutants, such as the influx of water from Steamboat Creek to the Truckee River.
- White ice cube trays, two to four per sample
- Labeling tape and waterproof markers for labeling trays
- Large shallow white trays or dishpans, one to two per sample
- Small shallow white plastic or Styrofoam containers
- Tarp or other plastic sheet
- Tweezers, spatulas, plastic spoons, small paintbrushes, clear plastic pipets, etc. for sorting bugs
- Hand lenses or magnifying glasses
- Disposable gloves
- Protective eyewear, such as goggles or safety glasses (if using preserved samples)
- Rinsing bucket, for rinsing samples
- Macroinvertebrate Survey Worksheets
- Macroinvertebrate Keys from Lesson 4 (laminated Key to Macroinvertebrate Life in the River flowchart)
- Clipboard
- Pencils, colored and regular
- Graph paper

Procedure:

1. Using the Plan of Action Worksheet, the class as a whole should plan the location of the sampling sites. Each student should formulate a hypothesis about which sampling site will have the best water quality, and which the worst. Have them write out their hypothesis and reasoning prior to making the field trip or doing the survey. Review the Safety Issues detailed in the Appendix.

2. Gather stream bottom samples from several locations along a local stream or river where differences in sample composition due to water quality changes might be expected. For example, collect samples (or request samples) from the Truckee River upstream of the confluence with Steamboat Creek, directly downstream of the confluence at Lockwood, and then at a location between Lockwood and Pyramid Lake such as Wadsworth. For a sampling protocol, see p. 129, Streamkeeper’s Field Guide, or the EPA's Streamside Biosurvey instructions on the web, [www.epa.gov/OWOW/monitoring/volunteer/stream/vms42.html](http://www.epa.gov/OWOW/monitoring/volunteer/stream/vms42.html). If you are gathering the samples yourself, this exercise can be done as part of a larger field day exercise, in conjunction with Lessons 6, 8, and 9. If it is unsafe to allow students to access the water body, ask agency staff to collect samples when they do their usual surveys. The samples will need to be preserved. The collected,
The Activity, continued

1. Macroinvertebrate Field Survey, continued

   preserved samples can be used in the field or in the classroom. If you are using preserved samples, they will need to be rinsed with water.

3. Have students label the sections of the ice cube trays with the following major groups:
   
   a. Mayflies
   b. Stoneflies
   c. Caddisflies
   d. Dobsonflies, alderflies, fishflies
   e. Dragonflies, damselflies
   f. True flies (order Diptera: black flies, crane flies, midge flies)
   g. Beetles
   h. Crustaceans
   i. Snails, clams
   j. Worms, leeches
   k. Other

4. Label the long side of the ice cubes trays, so that each group has two cube spaces.

5. Spread out the entire contents of the sample container into a large, shallow white tray or dishpan to make a thin layer of macroinvertebrates and sediment. Add just enough water to cover the sample. If your sample is too large to spread into a thin layer, transfer part into a second tray.

6. Fill the labeled ice cube trays with water. Line them up end-to-end so the labeled edges face you. Carefully sort out the debris, looking at each piece for benthic macroinvertebrates. Some of the macroinvertebrates may blend extremely well into their habitat materials. Use spatula, tweezers, spoons, and paintbrushes to sort the bugs into different sections of ice cube trays. Use the white plastic containers to hold the bugs while you use a hand lens, magnifying glass or viewing cube to examine and identify them. The laminated identification cards and flow chart will help you characterize the macroinvertebrates. Look at the shape of the body and head, and the location, structure, and length of the gills, tails, eyes, mouthparts, and antennae.

7. Record the numbers of different macroinvertebrates on the Macroinvertebrate Survey Worksheet. Calculate the water quality index value. Is it excellent, good, fair, or poor?

   Note: It may be impossible to sample all microhabitats at any given site. Make sure students know this could skew the results. For example, you may only be able to sample the shallow, slow-moving water, so you will only find the macroinvertebrates that live in that microhabitat.

8. Collect equipment and clean up the site.
The Activity, continued

1. Macroinvertebrate Field Survey, continued

9. Back in class
   a. If the student did not have time to finish the Macroinvertebrate Survey Worksheet in the field, have them finish the sheet now (see note under number 6 above).
   b. Have the students use the alternate method to assess water quality. The students are asked to compare the results of the two methods. Are the results different from those found using the Macroinvertebrate Survey Worksheet? Help the students brainstorm reasons for the differences.
   c. Have the students pool their data and construct a graph of the number of species found at the different sample sites. Make sure the students realize this is the number of different species represented, not the number of individuals. An example graph is shown below and on the Analyze the Macroinvertebrate Results in the Classroom student worksheet. Have students finish the worksheet.

```
<table>
<thead>
<tr>
<th>S</th>
<th>SS</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>
```

### Graph

- **Site 1**: 11 species, with S = sensitive, SS = somewhat sensitive, T = tolerant
- **Site 2**: 15 species
- **Site 3**: 12 species

S = sensitive, SS = somewhat sensitive, T = tolerant
Resources

http://www.seanet.com/~leska/Online/Guide.html

www.iwla.org

The Izaak Walton League of America.  www.iwla.org  
This version is sold out.  A new version is scheduled for printing in 2006.

Washington State Department of Ecology, Publication #88-16.  
PO Box 47600, Olympia, WA 98504-7600.  
(360)407-7472.  Publication is available as a pdf in four parts (88-16a, b, c, d) for download at  
www.ecy.wa.gov/pubs/8816a.pdf or the publication can be ordered online for $18.00 at  
www.ecy.wa.gov/biblio/8816a.html

Adopt-a-Stream Foundation, Everett, WA 98208.  
(360)316-8592.  www.streamkeeper.org/catalog/books.htm

www.rayswords.com/bugs/pages/intro.htm

University of Virginia, Department of Environmental Sciences. 1999. Stream Study – Aquatic Macroinvertebrate Identification Key.  
www.people.virginia.edu/~sos-iwla/Stream-Study/Key/MacroKeyIntro.HTML

University of Wisconsin-Extension, in cooperation with the Wisconsin Department of Natural Resources.  
No date. Key to Macroinvertebrate Life in the River.  
http://clean-water.uwex.edu/wav/otherwav/riverkey.pdf


The Activity

1. Macroinvertebrate Field Survey

Materials:

- Bottom samples from several locations along a stream or river (Try to obtain samples both above and below sources of pollutants, such as the influx of water from Steamboat Creek to the Truckee River.)
- White ice cube trays, 2 to 4 trays per sample
- Labeling tape and waterproof markers for labeling trays
- Large shallow white trays or dishpans, 1 to 2 per sample
- Small shallow white plastic or Styrofoam containers
- Tarp or other plastic sheet
- Tweezers, spatulas, plastic spoons, small paintbrushes, clear plastic pipets, etc. for sorting bugs
- Hand lenses, magnifying glasses, or viewing cubes
- Disposable gloves
- Protective eyewear, such as goggles or safety glasses, if using preserved samples
- Rinsing bucket, for rinsing samples
- Macroinvertebrate Survey Worksheets
- Macroinvertebrate Keys from Lesson 4
- Clipboard
- Pencils, colored and regular
- Graph paper

Procedure:

1. Using the Plan of Action Worksheet and working with the whole class, plan out the sampling sites. Then working individually, formulate a hypothesis about which sampling site will have the best water quality, and which the worst. Write out your hypothesis and reasoning prior to making the field trip or doing the survey.

2. Gather stream bottom samples from several locations along a local stream or river where differences in sample composition due to water quality changes might be expected. If it is unsafe for you to collect the samples (the water is too deep, too cold or too fast moving), they may have to be collected for you by agency staff. These previously collected samples should have been preserved. In either case, be sure to use gloves and protective eyewear when handling the samples.
Lesson 7: Macroinvertebrate Field Survey

Student Pages

The Activity

1. Macroinvertebrate Field Survey, continued

3. Label the sections of the ice cube trays with the following major groups. This can be done prior to leaving for the field:

   a. Mayflies
   b. Stoneflies
   c. Caddisflies
   d. Dobsonflies, alderflies, fishflies
   e. Dragonflies, damselflies
   f. True flies (order Diptera: black flies, crane flies, midge flies)
   g. Beetles
   h. Crustaceans
   i. Snails, clams
   j. Worms, leeches
   k. Other

4. Label the long side of the ice cube trays, so that each group has two cube spaces.

5. Spread out the entire contents of the sample container into a large, shallow white tray to make a thin layer of macroinvertebrates and sediment. Add just enough water to cover the sample. If your sample is too large to spread into a thin layer, transfer part into a second tray.

6. Fill the labeled ice cube trays with water. Line them up end to end so the labeled edges face you. Carefully sort out the debris, looking at each piece for benthic macroinvertebrates. Some of the macroinvertebrates may blend extremely well into their habitat materials. Use spatula, tweezers, spoons, and paintbrushes to sort the bugs into different sections of ice cube trays. Use the white plastic containers to hold the bugs while you use a hand lens, magnifying glass or viewing cube to examine and identify them. Use the laminated identification cards and flow chart to help you. Look at the shape of the body and head, and the location, structure, and length of the gills, tails, eyes, mouthparts, antennae and prolegs.

7. Record the numbers of different macroinvertebrates on the Macroinvertebrate Survey Worksheet. Calculate water quality index value. Is it excellent, good, fair, or poor?

8. Collect equipment and clean up the site.

9. Back in class, finish the Analyze the Macroinvertebrate Results in the Classroom.

<table>
<thead>
<tr>
<th>If you find:</th>
<th>Look for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little variety of macroinvertebrates, with lots of each kind</td>
<td>Water overly enriched with organic matter</td>
</tr>
<tr>
<td>Only one or two kinds of macroinvertebrates in great abundance</td>
<td>Severe organic pollution</td>
</tr>
<tr>
<td>A variety of macroinvertebrates, but only a few of each kind, or NOT insects, but the stream appears clean</td>
<td>Toxic pollution</td>
</tr>
</tbody>
</table>

EXPLORE NEVADA’S AMAZING WETLANDS
List all the planned sampling sites and their characteristics. Is the water clear, cloudy, slow-moving, smelly, etc.?

<table>
<thead>
<tr>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
</tr>
</thead>
</table>

HYPOTHESIS: Study the information above about each of the sampling sites. Which site do you think will have the best water quality? Why? Which site do you think will have the worst water quality? Why?
Macroinvertebrate Survey Worksheet

Stream___________________________________  Name_____________________________
Collection Site__________________________________________  Date__________________

Macroinvertebrate Count

Sensitive:

☐ _____ caddisfly larvae
☐ _____ mayfly larvae
☐ _____ stonefly larvae
☐ _____ dobsonfly larvae (hellgrammite)
☐ _____ gilled snails
☐ _____ riffle beetle adult
☐ _____ water penny larvae

Boxes checked X 3 = ________ index value

Somewhat Sensitive:

☐ _____ beetle larvae
☐ _____ clams
☐ _____ crane fly larvae
☐ _____ crayfish
☐ _____ damselfly larvae
☐ _____ dragonfly larvae
☐ _____ scuds
☐ _____ sowbugs
☐ _____ fishfly larvae
☐ _____ alderfly larvae
☐ _____ watersnipe larvae

Boxes checked X 2 = ________ index value

Tolerant:

☐ _____ aquatic worms
☐ _____ black fly larvae
☐ _____ leeches
☐ _____ midge larvae
☐ _____ lunged snails

Boxes checked X 1 = ________ index value

Water Quality Rating:

Total Index Value ____________
☐ Excellent (>22)
☐ Fair (11-16)
☐ Good (17-22)
☐ Poor (<11)
Macroinvertebrate Survey Practice Data Set

Benthic Macroinvertebrates in Sample

Sensitive:

☐ caddisfly larvae
☒ 1 mayfly larvae
☒ 1 stonefly larvae
☐ dobsonfly larvae (hellgrammite)
☐ gilled snails
☒ 2 riffle beetle adult
☒ 1 water penny larvae

Boxes checked X 3 = 4 x 3 = 12 _______ index value

Somewhat Sensitive:

☐ beetle larvae
☐ clams
☐ crane fly larvae
☐ crayfish
☐ damselfly larvae
☒ 3 dragonfly larvae
☐ scuds
☒ 2 sowbugs
☐ fishfly larvae
☐ alderfly larvae
☐ watersnipe larvae

Boxes checked X 2 = 2 x 2 = 4 _______ index value

Tolerant:

☒ 2 aquatic worms
☒ 4 black fly larvae
☐ leeches
☐ midge larvae
☐ lunged snails

Boxes checked X 1 = 2 x 1 = 2 _______ index value

Water Quality Rating: Total Index Value \[12 + 4 + 2 = 18\]

☒ Excellent (>22) ☐ Fair (11-16)
☒ Good (17-22) ☐ Poor (<11)
Lesson 7: Macroinvertebrate Field Survey
Student Pages

Stream____________________________________  Name____________________________
Collection Site__________________________________________  Date__________________

Macroinvertebrate Survey Worksheet
Alternate Method to Assess Water Quality

<table>
<thead>
<tr>
<th>Group 1: Most Intolerant</th>
<th>Group 2: Moderately Intolerant</th>
<th>Group 3: Fairly Tolerant</th>
<th>Group 4: Most Tolerant</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Stonefly larva</td>
<td>□ Caddisfly larva</td>
<td>□ Black fly larva</td>
<td>□ Aquatic worm</td>
</tr>
<tr>
<td>□ Alderfly larva</td>
<td>□ Mayfly larva</td>
<td>□ Midge larva</td>
<td>□ Leech</td>
</tr>
<tr>
<td>□ Dobsonfly larva</td>
<td>□ Riffle beetle larva</td>
<td>□ Sowbug</td>
<td>□ Left-hand/pouch snail</td>
</tr>
<tr>
<td>□ Snipefly larva</td>
<td>□ Water penny adult</td>
<td>□ Right-hand/other snail</td>
<td>□ Bloodworm midge larva</td>
</tr>
<tr>
<td></td>
<td>□ Dragonfly nymph</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Damselfly nymph</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Cranefly larva</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Crayfish</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Clam/mussel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Totals and Weighting

Sample Summary

# of types in Group 1 = # of types in Group 2 = # of types in Group 3 = # of types in Group 4 =
# of types x 1 = # of types x 2 = # of types x 3 = # of types x 4 =

Sum of weighted scores = ____ + ____ + ____ + ____ = ____

Total number of different types = ____

Weighted average = sum of weighted scores divided by the number of types = ____

<table>
<thead>
<tr>
<th>Weighted Average</th>
<th>Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 - 2.0</td>
<td>Excellent</td>
</tr>
<tr>
<td>2.1 – 2.5</td>
<td>Good</td>
</tr>
<tr>
<td>2.6 – 3.5</td>
<td>Fair</td>
</tr>
<tr>
<td>Over 3.6</td>
<td>Poor</td>
</tr>
</tbody>
</table>

EXPLORE NEVADA’S AMAZING WETLANDS
## Macroinvertebrate Survey Alternate Method (Sample Calculations)

<table>
<thead>
<tr>
<th>Group 1: Most Intolerant</th>
<th>Group 2: Moderately Intolerant</th>
<th>Group 3: Fairly Tolerant</th>
<th>Group 4: Most Tolerant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stonefly larva</td>
<td>Caddisfly larva</td>
<td>Black fly larva</td>
<td>Aquatic worm</td>
</tr>
<tr>
<td>Alderfly larva</td>
<td>Mayfly larva</td>
<td>Midge larva</td>
<td>Leech</td>
</tr>
<tr>
<td>Dobsonfly larva</td>
<td>Riffle beetle larva</td>
<td>Sowbug</td>
<td>Left-hand/pouch snail</td>
</tr>
<tr>
<td>Snipefly larva</td>
<td>Water penny adult</td>
<td>Right-hand/other snail</td>
<td>Bloodworm midge larva</td>
</tr>
<tr>
<td></td>
<td>Dragonfly nymph</td>
<td>Scud</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Damselfly nymph</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cranefly larva</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crayfish</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clam/mussel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Totals and Weighting

#### Sample Summary

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td># of types in Group 1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td># of types x 1</td>
<td>1</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

**Sum of weighted scores** = \(1 + 8 + 6 + 4 = 19\)

**Total number of different types** = 8

**Weighted average** = sum of weighted scores divided by the number of types = \(19/8 = 2.375\)

**Water quality** = **Good**

<table>
<thead>
<tr>
<th>Weighted Average</th>
<th>Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 - 2.0</td>
<td>Excellent</td>
</tr>
<tr>
<td>2.1 – 2.5</td>
<td>Good</td>
</tr>
<tr>
<td>2.6 – 3.5</td>
<td>Fair</td>
</tr>
<tr>
<td>Over 3.6</td>
<td>Poor</td>
</tr>
</tbody>
</table>
Lesson 7: Macroinvertebrate Field Survey  S - 8
Student Pages

**Analyze the Macroinvertebrate Results in the Classroom Worksheet**

Name__________________________

1. Using the Macroinvertebrate Survey Worksheet, calculate a water quality rating for the collection site.

2. Use the alternate method to assess water quality. Are the results different from those found using the Macroinvertebrate Survey Worksheet? Why might they be different?

3. Draw a graph showing the relative numbers of sensitive, somewhat sensitive, and tolerant macroinvertebrates. Include data from all sampling sites on the same graph. You will need to share your data with other groups.

Sample graph

![Sample graph](image)

S = sensitive, SS = somewhat sensitive, T = tolerant

**EXPLORE NEVADA’S AMAZING WETLANDS**
4. Which sampling location has the best water quality rating?

5. Which sampling location has the poorest water quality rating?

6. Why do you think the results varied from site to site?

7. Was your hypothesis correct?

8. What other information would you need to collect to confirm your water quality rating results?

9. What can be done to improve or protect the water quality in the Truckee River and its tributaries?
Lesson 8: Natural Processing: Measuring Wetlands Water Quality

Purpose:
This activity focuses on collecting data that demonstrates the importance of wetlands for maintaining water quality. The students will develop hypotheses about the difference in water quality they might find if they measure temperature, pH, nitrate and phosphate concentrations at the inlet and outlet of a wetland or at different points along a stream.

Summary:
The students will develop hypotheses on how the pH, temperature, nitrate and phosphate concentrations of water will change from the inlet to the outlet of a wetland. They will collect data in the field and then determine if their hypotheses were correct.

Key Learning Points for Students:
This lesson is a hands-on reinforcement of concepts learned in Lessons 2, 3, and 5. By the end of this lesson, students should understand the concept that wetlands provide natural processing of a number of pollutants.

Handouts:
1. Field Data Planning Worksheet
2. Field Data Sample Site Worksheet
3. Field Data Summary Worksheet
4. Summary Worksheet

Background:
Review the background information provided in Lesson 5.
Plants and animals need nutrients for cellular activity to sustain life. Phosphorus and nitrogen are essential nutrients. Plant growth depends on phosphorus availability, as it provides energy for metabolism. In many bodies of water, phosphorus can be a growth-limiting constituent. Nitrogen is usually more abundant due to the presence of nitrogen-fixing aquatic organisms. Nitrogen-fixing organisms convert N₂ gas from the atmosphere into organic nitrogen. Plants incorporate nitrogen into proteins, which makes nitrogen available to humans.

An overabundance of nutrients in aquatic systems can cause excess plant growth. The process of plant death and decay results in removal of oxygen from the water. Wetlands can actually help remove excess nutrients through a variety of processes. The nutrients can be taken up by plants, which then die, and subsequently the nitrogen and phosphorus are deposited and buried in the sediments. Some microbes convert nutrients like ammonia and nitrate into gases, which are released to the atmosphere. In some areas, wetlands have been constructed to help with cleanup of wastewater, which is water that is flushed down your toilet or that goes down your sink that goes to a wastewater treatment plant to be cleaned up.

By measuring water quality parameters at the inlet and outlet of one or more wetlands, it is possible to determine how well wetlands function as nutrient sinks. This type of experiment also demonstrates how chemistry changes within a wetland.

The students should first formulate a hypothesis about expected changes within the wetland. Will the concentrations of nitrate and phosphate between the inlet and the outlet vary? How about temperature and pH? What might influence the changes in these four parameters?

Since wetlands are natural water purifiers, the students will most likely hypothesize that nutrient (nitrate and phosphate) concentrations should decrease. Depending on the scale of your wetland, you may or may not observe a change in nutrient concentrations. Water moving through a wetland slows down. The water tends to be shallower in the wetland. Because the water is shallower and slower moving, it tends to warm up in the wetland. For this reason, the temperature at the outlet of the wetland will probably be higher than the temperature at the inlet to the wetland.

What about pH? As plant material decays in the wetland, it is likely that organic acids will be generated. Microbial activity will result in increases in hydrogen sulfide gas (H₂S), which may react with water to make sulfuric acid. These changes will most likely decrease the pH, or make it more acidic. Some wetlands also act as a buffer, balancing pH.
The Activity

1. Water Quality Testing

Materials:

- Water samples, ideally taken the same day
- Latex gloves
- Protective eyewear, such as goggles or safety glasses
- Clean plastic containers, glass jars, or Whirl-paks to collect water samples (one per sample)
- Smaller beakers or glass jars for individual test samples of the water (one per sample per group)
- Distilled water for rinsing between samples
- Rinse bottles (one per group)
- 2 or more large containers for contaminated water (You will need two separate containers for the nitrate and phosphate test water.)
- Paper towels
- Temperature probe or thermometer (Armored field thermometers are less likely to be broken. Avoid mercury-containing thermometers due to the potential for contamination if broken.)
- Narrow range pH test strips
- Nitrate testing kit (can be purchased from www.hach.com, www.chemetrics.com, or other supplier)
- Phosphate testing kit (can be purchased as listed above)
- An orange, a wiffle ball, or a table tennis ball
- Measuring tape
- Stopwatch
- Field Data Planning Worksheet
- Field Data Sample Site Worksheet
- Field Data Summary Worksheet
- Summary Worksheet

Procedure:

Please review Safety Issues in the Appendix. Begin by asking the students develop and write some hypotheses about water quality differences that will occur from the inlet to the outlet of the wetland. Have the students record this data on the Field Data Planning Worksheet. Visit the wetland in advance, and determine several sample locations. Try to locate sample locations that are at the inlet to the wetland, downstream of the outlet of the wetland, and within the wetland. For comparison purposes, water quality values from a number of locations along the Truckee River for 2003 are included in the Appendix.

Quality Control
To ensure good quality data, you will repeat each test three times for each sample (three replicates). If one test value is significantly different than the other two values for a single sample, you may want to perform a fourth test. If the values of all three tests are significantly different for a single sample, carefully check your sampling and testing protocols! Scientists would include a field
The Activity, continued

1. Water Quality Testing, continued

Quality Control, continued

blank, or a sample of distilled water that is treated exactly like a field water sample, to identify errors or contamination in sample collection and analysis. Scientists would also collect field duplicates (individual samples collected at the same time and place) to help determine the accuracy of the testing method and to test for replication of results.

Other considerations to ensure the data is valid:

- Label all samples clearly.
- Keep samples in a cooler for transport to the lab, and analyzed as soon as possible after collection.
- Each sample should be handled in exactly the same way.
- Maintain your equipment according to the manufacturer’s instructions.
- Read the instructions that accompany test kits for information on the limits of the testing method.

Sample Collection in the Field

Divide students into small groups of two to four students per group. Show the students how to collect a water sample. Students should wear latex gloves during this step. After they collect their sample, the students should note the sample number or other identifying information on their worksheets. They will record all sample test values and observations on the worksheet.

Collect one to five water samples, preferably from different areas in a single wetland. Tips for collecting samples:

- When collecting samples in the field, wear latex gloves.
- Sample containers must be clean. Do NOT use containers that have been washed with ordinary household detergents! See the information on Preparation of Sample Containers on page 10 of this lesson.
- Rinse each sample container several times with the water you will be collecting before actually taking the sample. This ensures no contamination from the container will interfere with the results.
- Collect samples from within the main current, away from banks and well underneath the surface of the water. This will help ensure a well-mixed, representative sample. More information on collecting samples may be found on pages 11 to 13 of this lesson.

If possible, take velocity, temperature and pH readings at the same time (see below for methods). Measure all three parameters directly in the stream. Repeat each test three times. Record all values on a Field Data Sample Site Worksheet for each individual sample site.
The Activity, continued

1. Water Quality Testing, continued

**Velocity**

Velocity, or the speed with which the water is flowing, can be determined by placing a buoyant object such as an orange, a wiffle ball, or a table tennis ball in the water and measuring the distance it travels over a certain amount of time. Start by measuring a distance along the stream parallel to the direction of flow. Twenty feet is the minimum distance you should use; a 100 foot distance is used in many monitoring programs. Pick a section of the stream that is straight and does not include any slow water areas such as ponds. Drop your floating object in the water above the marked distance and measure how long it takes it to travel the marked distance using a stopwatch. Collect your floating object using a fishing net, and repeat the “time of travel” measurement twice. Average the results.

Calculate the velocity as follows: Velocity (feet/minute) = Distance Traveled/Time. Note the velocity of the water at each sample location, if possible.

**Temperature**

Temperature should be measured directly in the stream or water body at the same location at which you took a sample. Temperatures in the Truckee River and its tributaries vary with season, site, water depth and other factors. Most temperatures will fall within the range of 2 to 25 degrees Celsius or 33 to 78 degrees Fahrenheit.

1. Place the thermometer or meter probe in the water at least four inches below the surface or halfway to the bottom if in a shallow stream or wetland.

2. If using a thermometer, allow enough time for it to reach a stable temperature (at least one minute). If using a meter, allow the temperature reading to stabilize at a constant temperature reading.

3. If possible, try to read the temperature with the thermometer bulb beneath the water surface. If it is not possible, quickly remove the thermometer and read the temperature.

4. Record the temperature on the field data sheet.

5. Repeat two more times, recording the measurements on the worksheet.

6. Calculate an average temperature.
The Activity, continued

1. Water Quality Testing, continued

**pH**

pH is the next test. For a quality control check, it is a good idea to try out the pH paper in solutions with a known pH to make sure everyone is interpreting the color scheme the same way. If you have completed Lesson 5, you have already done this in class or lab. Explain to the students that like temperature, pH should be analyzed in the field immediately because both can change rapidly over time. Ideally, pH should be measured directly in the stream or water body at the same location that you took your sample. After collection, the pH will change as carbon dioxide from the air dissolves in the water, bringing the pH value closer to 7. The pH of the Truckee River and its tributaries varies with season, water temperature, water flow rate and recent weather patterns. Most measurements should fall within the 6.5 to 8.5 range.

1. Dip the pH paper into the water sample and compare the colors to those on the container. Record the pH value on the worksheet.
2. Repeat the test two more times, recording all three values on the worksheet.
3. Calculate the average pH.

**Nitrate**

The instructions below are for the HACH 14161-00 nitrate test kit, which has a range of 0 to 10 mg/L. Most water in the Truckee River and its tributaries should fall within this nitrate range (0-10 mg/L). It may be difficult to determine nitrate concentrations in very clean water using this test kit. If using a different test kit, please provide appropriate directions to the students.

Nitrate should be determined according to the directions on the test kit. Read the directions carefully! Both nitrate and phosphate tests use chemical reagents that are added to a portion of the sample. All wastewater from these tests should be collected in separate containers (container for each test) and disposed of properly (see page 9 for proper disposal instructions.) **Do not pour this water on the ground or in a water body**!

The test kits use reagents that are packaged in foil “pillows” or rectangular envelopes. Before opening, tap the pillow on a hard surface to send the contents to the bottom of the container. Then, tear off the top of the pillow along the tear line. Push the sides of the packet to the center to open the pillow. If you make crease lines in the center of the packet, it will be easier to pour out the contents.
The Activity, continued

1. Water Quality Testing, continued

Nitrate (continued)

1. Put on gloves and protective eyewear.
2. Begin by filling one of the color viewing tubes with the liquid to be analyzed. Stopper and shake vigorously. Empty and repeat.
3. Fill the tube to the bottom of the shaded area.
4. Open one NitraVer 6 nitrate reagent powder pillow. Add it to the sample to be tested. Stopper and shake for three minutes. Allow sample to sit undisturbed for 30 seconds. Unused cadmium should sink to the bottom.
5. Carefully pour (decant) the prepared sample into the other viewing tube so that the cadmium at the bottom remains in the first tube.
6. Open one NitraVer 3 reagent powder pillow. Add the contents to the sample. Stopper the tube and shake for 30 seconds. A red color will develop if nitrate is present. Insert the tube in the opening closest to the center of the container. After 10 minutes (but not more than 20), you can make the reading.
7. Rinse the cadmium metal from the color viewing tube used in step 3. Put the rinse water in the nitrate test wastewater container.
8. Fill the rinsed tube to the mark with the original water sample and place it in the opening nearest the side of the box. You now have two tubes: one with the original water sample, and one with the tested sample after decanting. The original water sample is used to account for any effect of discoloration on the reading of the test.
9. Hold the box up to the light and rotate the disc to obtain a color match. Read the number through the scale window and multiply by 4.4 to get the results as mg/L of nitrate. Mention to the students that an absence of color does not necessarily mean there is no nitrate present. The nitrate level may be below the detection limit of the test kit.
10. Dispose of the test water in the nitrate test wastewater container.
11. Repeat the test two more times, recording all three values on the worksheet.

Phosphate

The instructions below are for the Phosphate HACH 2250-01 low range test kit. Most water in the Truckee River and its tributaries should have phosphate values of 0 to 1.0 mg/L. Again, if using a different test kit, please provide appropriate directions to the students. Both nitrate and phosphate tests use chemical reagents that are added to a portion of the sample. All wastewater from these tests should be collected in separate containers (container for each test) and disposed of properly (see page 9 for proper disposal instructions.) Do not pour this water on the ground or in a water body!
The Activity, continued

1. Water Quality Testing, continued

*Phosphate*

The test kits use reagents that are packaged in foil “pillows” or rectangular envelopes. Before opening, tap the pillow on a hard surface to send the contents to the bottom of the container. Then, tear off the top of the pillow along the tear line. Push the sides of the packet to the center to open the pillow. If you make crease lines in the center of the packet, it will be easier to pour out the contents.

1. Put on gloves and protective eyewear.
2. Rinse the square mixing bottle several times with the water to be analyzed.
3. Fill the square mixing bottle to the 20-ml mark with the water to be tested.
4. Open one PhosVer 3 reagent powder pillow. Add the contents to the bottle and swirl to mix. Allow two minutes for color development. If phosphate is present, a blue-violet color will appear.
5. Fill one sample tube with the prepared sample and the other tube with the original water sample. The original water sample is used to account for any effect of discoloration on the reading of the test.
6. Insert the treated sample in the hole closest to the center of the box.
7. Orient viewer toward a light source and be careful not to spill the sample.
8. Rotate the disc to get a color match. Record the reading in the scale window and divide by 50 to get mg/L phosphate. As with the nitrate test, a zero value or no color does not necessarily mean there is no phosphate present. The phosphate levels may be below the detection limit of the test kit.
9. Dispose of test water in the phosphate test wastewater container.
10. Repeat the test two more times, recording all three values on the worksheet.

*Additional observations*

Have the students record any other observations they make about the water samples, including color, clarity or odor. Mention to the students that the following field observations may be important:

- Streambed coatings
- Excessive dead vegetation
- Excessive live vegetation
The Activity, continued

1. Water Quality Testing, continued

Additional Observations, continued

- Air temperature
- Weather on the sampling date
- Any recent weather trends.

Have the students brainstorm why these additional observations might be important. Ask the following types of questions:

- What are some types of weather changes or patterns that could affect stream health?
- How might these events affect the nature of the sample?
- Do you think they are truly representative of the conditions in the stream most of the time?

For instance, recent rapid snowmelt could cause temporary increase in sediment load of a stream, making the water cloudy or murky.

Disposal of waste solutions from sample testing:

Water samples and waste solutions must be disposed of properly to avoid water pollution. Follow the directions below:

1. The water from temperature and pH tests can be poured down the drain.
2. The test water from the phosphate test, PhosVer3 test packet, should be diluted with additional water (hence the request for a large container). The pH should be adjusted to between 6 and 9 by adding sodium bicarbonate (baking soda). With the cold tap water running, slowly pour the diluted, pH-adjusted test water down the drain. Allow the cold water to run for five minutes afterwards to completely flush the system.
3. The test water from the nitrate test, NitraVer6 test packet, contains cadmium, which is an OSHA listed carcinogen. The test waters are considered a hazardous waste and should be disposed of in an EPA-approved hazardous waste facility. In Washoe County, each middle school and high school has a Designated Science Safety Officer. You should contact this person at your school regarding collection, labeling, and transfer of this waste. Most school districts have an environmental officer or chemical hygiene specialist on staff. In Washoe County, this person can be reached at 775-348-3852 or through the main district line at 775-348-0200. For other school districts, please check with your district office.
Preparation of Sampling Containers
(from Chapter 5, Water Quality Conditions in Monitoring and Assessing Water Quality, USEPA)

Reused sample containers and glassware must be cleaned and rinsed before the first sampling run and after each run by following either Method A or Method B described below. The most suitable method depends on the parameter being measured.

Method A: General Preparation of Sampling Containers

The following method should be used when preparing all sample containers and glassware for monitoring conductivity, total solids, turbidity, pH, and total alkalinity. Wear latex gloves!

1. Wash each sample bottle or piece of glassware with a brush and phosphate-free detergent.
2. Rinse three times with cold tap water.
3. Rinse three times with distilled or deionized water.

Method B: Acid Wash Procedure for Preparing Sampling Containers

This method should be used when preparing all sample containers and glassware for monitoring nitrates and phosphates. Wear latex gloves!

1. Wash each sample bottle or piece of glassware with a brush and phosphate-free detergent.
2. Rinse three times with cold tap water.
3. Rinse with 10 percent hydrochloric acid.
4. Rinse three times with deionized water.
Collecting Samples
(adapted from Chapter 5, Water Quality Conditions in Monitoring and Assessing Water Quality, USEPA)

Please review Safety Issues in the Appendix. In general, sample away from the streambank in the main current. Never sample stagnant water. The outside curve of the stream is often a good place to sample, since the main current tends to hug this bank. In shallow stretches, carefully wade into the center current to collect the sample.

When collecting a water sample for analysis in the field or at the lab, follow the steps below.

For Screw-cap Bottles

To collect water samples using screw-cap sample bottles, use the following procedures:
- Samples should be taken in the main current.
- Samplers should face upstream.
- Turn the bottle into the current and scoop in an upstream direction.
1. Label the bottle with the site number, date, and time.

2. Remove the cap from the bottle just before sampling. Avoid touching the inside of the bottle or the cap. If you accidentally touch the inside of the bottle, use another one.

3. Try to disturb as little bottom sediment as possible. In any case, be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you. You may also tape your bottle to an extension pole to sample from deeper water.

4. Hold the bottle near its base and plunge it (opening downward) below the water surface. If you are using an extension pole, remove the cap, turn the bottle upside down, and plunge it into the water, facing upstream. Collect a water sample 8 to 12 inches beneath the surface or mid-way between the surface and the bottom if the stream reach is shallow.

5. Turn the bottle underwater into the current and away from you. In slow-moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction.

6. Leave a one-inch air space. Do not fill the bottle completely, so that the sample can be shaken just before analysis. Recap the bottle carefully, remembering not to touch the inside.

7. Fill in the bottle number and/or site number on the appropriate field data sheet. This is important because it tells the lab coordinator which bottle goes with which site.

8. If the samples are to be analyzed in the lab, place them in the cooler for transport to the lab.
For Whirl-pak® Bags


and other vendors.

Note: Make sure the Whirl-pak bags do not contain sodium thiosulfate to neutralize chlorine. This will make your results invalid.

1. Label the bag with the site number, date, and time.

2. Tear off the top of the bag along the perforation above the wire tab just prior to sampling. Avoid touching the inside of the bag. If you accidentally touch the inside of the bag, use another one.

3. Try to disturb as little bottom sediment as possible. In any case, be careful not to collect water that contains bottom sediment. Stand facing upstream. Collect the water sample in front of you.

4. Hold the two white pull tabs in each hand and lower the bag into the water on your upstream side with the opening facing upstream. Open the bag midway between the surface and the bottom by pulling the white pull tabs. The bag should begin to fill with water. You may need to "scoop" water into the bag by drawing it through the water upstream and away from you. Fill the bag no more than three-quarters full!

5. Lift the bag out of the water. Pour out excess water. Pull on the wire tabs to close the bag. Continue holding the wire tabs and flip the bag over at least four to five times quickly to seal the bag. Don't try to squeeze the air out of the top of the bag. Fold the ends of the wire tabs together at the top of the bag, being careful not to puncture the bag. Twist them together, forming a loop.

6. Fill in the bag number and/or site number on the appropriate field data sheet. This is important! It is the only way the lab coordinator will know which bag goes with which site.

7. If samples are to be analyzed in a lab, place the sample in the cooler with ice or cold packs.

Note: Whirl-pak bags tend to fall over and leak. Have an appropriate container in which to transport them.
Resources

Carolina Biological Supply. No date. Sources for water testing kits and equipment. www.carolina.com

Chemetrics Inc. No date. Source for water test kits and equipment. www.chemetrics.com


Hach Chemical Co. No date. Sources for water testing kits and equipment. www.hach.com


The Activity

1. Water Quality Testing

Materials:

- Water samples, ideally taken the same day
- Latex gloves
- Protective eyewear, such as goggles or safety glasses
- Clean plastic containers, glass jars, or Whirl-paks to collect water samples (one per sample)
- Smaller beakers or glass jars for individual test samples of the water (one per sample per group)
- Distilled water for rinsing between samples
- Rinse bottles (one per group)
- Two or more large containers for contaminated water (You will need two separate containers for the nitrate and phosphorus test water.)
- Paper towels
- Temperature probe or thermometer
- Narrow range pH test strips
- Nitrate testing kit
- Phosphate testing kit
- An orange, a wiffle ball or a table tennis ball
- Measuring tape
- Stopwatch
- Field Data Planning Worksheet
- Field Data Sample Site Worksheet
- Field Data Summary Worksheet
- Summary Worksheet

Procedure:

First, develop and write down some hypotheses on the Field Data Planning Worksheet about water quality from the inlet to the outlet of the wetland. Will the water quality change? If so, how will it change? Look at the wetland and select several sample locations. Try to find locations that are at the inlet to the wetland, the outlet of the wetland and within the wetland. Then collect the water samples and temperature and pH data.

Quality Control

To ensure good quality data, you will repeat each test three times for each sample (three replicates). If one test value is quite different than the other two values for a single sample, you may want to perform a fourth test. If the values of all three tests are very different for a single sample, carefully check your sampling and testing protocols. Scientists would include a field blank, or a sample of distilled water that is treated exactly like a field water sample, to identify errors or contamination in sample collection and analysis. Scientists would also collect field duplicates (individual samples collected at the same time and place) to help determine the accuracy of the testing method and to test for replication of results.
The Activity, continued

1. Water Quality Testing, continued

Quality Control, continued

Other considerations to ensure the data is valid:

- Label all samples clearly.
- Keep samples in a cooler for transport to the lab, and analyzed as soon as possible after collection.
- Handle each sample should be exactly the same way.
- Maintain your equipment according to the manufacturer’s instructions.
- Read the instructions that accompany test kits for information on the limits of the testing method.

Sample Collection in the Field

Collect one to five water samples, preferably from different areas in a single water body. Tips for collecting samples:

- When collecting samples in the field, wear latex gloves.
- Sample containers must be clean. Do NOT use containers that have been washed with ordinary household detergents!
- Rinse each sample container several times with the water you will be collecting before actually taking the sample. This ensures no contamination from the container will interfere with the results.
- Collect samples from main current, away from banks and well underneath the surface of the water. This will help ensure a well-mixed representative sample.

If possible, take velocity, temperature and pH readings at the same time (see below for methods). Measure all three parameters directly in the stream. Repeat each test three times. Record all values on a Field Data Sample Site Worksheet for each individual sample site.

Velocity

Measure velocity, or the speed with which the water is flowing, by placing a buoyant object such as an orange, a wiffle ball, or a table tennis ball in the water and measuring the distance it travels over a certain amount of time. Start by measuring a distance along the stream parallel to the direction of flow. Twenty feet is the minimum distance you should use. If a straight reach of 100 feet in length is available, it will increase measurement accuracy. Pick a section of the stream that is straight and does not include any slow water areas such as ponds. Drop your floating object in the water above the marked distance and measure how long it takes it to travel the marked distance using a stopwatch. Collect your floating object using a fishing net, and repeat the “time of travel” measurement twice more. Average the results.
The Activity, continued

1. Water Testing Exercise, continued

Velocity, continued

Calculate the velocity as follows: \( \text{Velocity (feet/minute)} = \frac{\text{Distance Traveled}}{\text{Time}}. \)

If you measure velocity in seconds, make sure to convert it to minutes.

\[ \text{Time (minutes)} = \frac{\text{Time (seconds)}}{60}. \]

Note the velocity of the water at each sample location, if possible.

Temperature

Measure temperature directly in the stream, if possible. Temperatures in the Truckee River and its tributaries vary with season, site, water depth and other factors. Most temperatures will fall within the range of 2 to 25 degrees Celsius or 33 to 78 degrees Fahrenheit.

1. Place the thermometer or temperature probe in the water at least four inches below the surface or halfway to the bottom if in a shallow stream or wetland.

2. If using a thermometer, allow enough time for it to reach a stable temperature (at least one minute). If using a meter, allow the temperature reading to stabilize at a constant temperature reading.

3. If possible, try to read the temperature with the thermometer bulb beneath the water surface. If it is not possible, quickly remove the thermometer and read the temperature.

4. Record the temperature on the field data sheet.

5. Repeat two more times, recording all three measurements on the Field Data Sample Site Worksheet.

6. Calculate an average temperature.

pH

pH is the next test. Ideally, pH should be measured at the sample collection. After collection, the pH will change as carbon dioxide from the air dissolves in the water, bringing the pH value closer to 7. The pH of the Truckee River and its tributaries varies with season, water temperature, water flow rate and recent weather patterns. Most measurements should fall within the 6.5 to 8.5 range.

1. Dip the pH paper directly in the stream or water body where you took the sample and compare the colors to those on the container. Record the pH value on the worksheet.

2. Repeat the test two more times, recording all three values on the worksheet.

3. Calculate the average pH.
The Activity, continued

1. Water Quality Testing, continued

Nitrate

Most water in the Truckee River and its tributaries should fall between 0-10 mg/L nitrate.

Both nitrate and phosphate tests use chemical reagents that are added to a portion of the sample. All wastewater from these tests should be collected in separate containers (container for each test) and disposed of properly. **Do not pour this water on the ground or in a water body!**

The test kits use reagents that are packaged in foil “pillows” or rectangular envelopes. Before opening, tap the pillow on a hard surface to send the contents to the bottom of the container. Then, tear off the top of the pillow along the tear line. Push the sides of the packet to the center to open the pillow. If you make crease lines in the center of the packet, it will be easier to pour out the contents.

1. Put on gloves and protective eyewear.
2. Begin by filling one of the color viewing tubes with the liquid to be analyzed. Stopper and shake vigorously. Empty and repeat.
3. Fill the tube to the bottom of the shaded area.
4. Open one NitraVer 6 nitrate reagent powder pillow. Add it to the sample to be tested. Stopper and shake for three minutes. Allow sample to sit undisturbed for 30 seconds. Unused cadmium should sink to the bottom.
5. Carefully pour (decant) the prepared sample into the other viewing tube so that the cadmium at the bottom remains in the first tube.
6. Open one NitraVer 3 reagent powder pillow. Add the contents to the sample. Stopper the tube and shake for 30 seconds. A red color will develop if nitrate is present. Insert the tube in the opening closest to the center of the container. After 10 minutes (but not more than 20), you can make the reading.
7. Rinse the cadmium metal from the color viewing tube used in step 3. Put the rinse water in the nitrate test wastewater container.
8. Fill the rinsed tube to the mark with the original water sample and place it in the opening nearest the side of the box. You now have 2 tubes: one with the original water sample, and one with the tested sample after decanting. The original water sample is used to account for any effect of discoloration on the reading of the test.
The Activity, continued

1. Water Quality Testing, continued

*Nitrate*

9. Hold the box up to the light and rotate the disc to obtain a color match. Read the number through the scale window and multiply by 4.4 to get the results as mg/L. If your test sample has no color, it does not necessarily mean there is no nitrate present. The nitrate level may be below the detection limit of the test kit.

10. Dispose of the test water in the nitrate test wastewater container.

11. Repeat the test two more times, recording all three values on the worksheet.

*Phosphate*

Most water in the Truckee River and its tributaries should have phosphate values of 0 to 1.0 mg/l.

Both nitrate and phosphate tests use chemical reagents that are added to a portion of the sample. Before you do anything else, put on your gloves and goggles. All wastewater from these tests should be collected in separate containers (container for each type of test) and disposed of properly. **Do not pour this water on the ground or in a water body!**

The test kits use reagents that are packaged in foil “pillows” or rectangular envelopes. Before opening, tap the pillow or a hard surface to send the contents to the bottom of the container. Then, tear off the top of the pillow along the tear line. Push the sides of the packet to the center to open the pillow. If you make crease lines in the center of the packet, it will be easier to pour out the contents.

1. Put on gloves and protective eyewear.

2. Rinse the square mixing bottle several times with the water to be analyzed.

3. Fill the square mixing bottle to the 20-ml mark with the water to be tested.

4. Open one PhosVer 3 reagent powder pillow. Add the contents to the bottle and swirl to mix. Allow two minutes for color development. If phosphate is present, a blue-violet color will appear.

5. Fill one sample tube with the prepared sample and the other tube with the original water sample. The original water sample is used to account for any effect of discoloration on the reading of the test.

6. Insert the treated sample in the hole closest to the center of the box.

7. Orient viewer toward a light source and be careful not to spill the sample.
The Activity, continued

2. Water Quality Testing, continued

**Phosphate**

8. Rotate the disc to get a color match. Record the reading in the scale window and divide by 50 to get mg/L phosphate. As with the nitrate test, a zero value or no color does not necessarily mean there is no phosphate present. The phosphate levels may be below the detection limit of the test kit.

9. Dispose of test water in the phosphate test wastewater container.

10. Repeat the test two more times, recording all three values on the Field Data Sample Site Worksheet.

Additional observations

Record any other observations about the water samples and sample locations, including:

- Color
- Clarity
- Odor
- Streambed coatings
- Excessive dead vegetation
- Excessive live vegetation
- Air temperature
- Weather on the sampling date
- Any recent weather trends

At a constructed wetland, you can measure the volume of water moving through the system as a function of time. This allows you to calculate the amount of water treated per day. Collect water in a gallon bucket and monitor the time it takes to collect a gallon of water. You can then calculate flow in the units of gallons/minute.

Use the Field Data Summary Worksheet and the Summary Worksheet to describe what your findings related to water chemistry. Write a report following the scientific method. Be sure to include a question, hypothesis, materials, procedure, results, discussion, and conclusion.
Field Data Planning Worksheet

Name______________________________ Date____________ Time__________

Record the following information for the wetland you study. If you are visiting more than one wetland, fill out a separate form for each wetland.

Hypothesis:

Method to test the hypothesis:

Wetland description:

Wetland location:

Locations at which samples will be collected:
# Field Data Sample Site Worksheet

(complete one sheet for each sample site)

Name______________________________________ Date______________ Time ________________

Sample description / location: __________________________________________________________

__________________________________________________________________________________

Area of the wetland: _________________________________________________________________

**Descriptive Water Quality Data (check or circle all that apply)**

<table>
<thead>
<tr>
<th>Water appearance:</th>
<th>Scum</th>
<th>Foam</th>
<th>Muddy</th>
<th>Milky</th>
<th>Clear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oily Sheen</td>
<td>Brownish</td>
<td>Reddish</td>
<td>Greenish</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Odor:</th>
<th>Rotten Egg</th>
<th>Musky</th>
<th>Chlorine</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stream bed coating:</th>
<th>Orange to red</th>
<th>Yellowish</th>
<th>Black</th>
<th>Brown</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description of vegetation: _____________________________________________________________

__________________________________________________________________________________

**Water Quality Measurements**

<table>
<thead>
<tr>
<th></th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Temperature, °F</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nitrate, mg/L</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phosphate, mg/L</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Velocity, feet/minute</strong></td>
<td>in</td>
<td>out</td>
<td>circle one</td>
<td></td>
</tr>
<tr>
<td><strong>Volume, gallons/minute</strong></td>
<td>in</td>
<td>out</td>
<td>circle one</td>
<td></td>
</tr>
</tbody>
</table>

[Explore Nevada’s Amazing Wetlands]
Enter the averaged values for each of the parameters at each of the sites. Note if the site is a water inlet ("in"), outlet ("out"), or falls within the wetland.

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Temperature °F</th>
<th>pH</th>
<th>Nitrogen mg/L</th>
<th>Phosphorus mg/L</th>
<th>Velocity feet/min</th>
<th>Volume Treated gallons/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>in</td>
<td>out</td>
<td>within (circle one)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in</td>
<td>out</td>
<td>within (circle one)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in</td>
<td>out</td>
<td>within (circle one)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in</td>
<td>out</td>
<td>within (circle one)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in</td>
<td>out</td>
<td>within (circle one)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in</td>
<td>out</td>
<td>within (circle one)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in</td>
<td>out</td>
<td>within (circle one)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using the Field Data Summary Worksheet you completed, answer the following questions:

Is there a difference in pH and temperature between the inlet and outlet of the wetland? If you note a difference, why do you think it is different?

Does the velocity of the water change between the inlet and outlet of the wetland? Is the velocity significantly different within the wetland? Where does the water move most slowly, and why?

What happened to the nitrate and phosphate concentrations of the water as it moved through the wetland? Calculate the percent removal of nitrate and phosphate.

\[
\text{Percent removal} = \left( \frac{\text{Concentration at the outlet} - \text{concentration at the inlet}}{\text{Concentration at the inlet}} \right) \times 100\%
\]

Nitrate:

Phosphate:

If you tested more than one wetland, is there a difference in the percent removal of nutrients for the different wetlands? Why?
Lesson 9: Winning Solutions to Community Pollution: Comparing the values of wastewater treatment by a treatment facility to those of a constructed wetland

**Purpose:**
Students reach conclusions about the efficiency and values of wastewater treatment by high tech facilities as compared to constructed (or natural) wetlands.

**Summary:**
This exercise combines the data collected during the previous lessons to allow students to draw conclusions about treatment efficiency, relative cost of treatment, and relative benefit to society. This lesson incorporates data synthesis and group presentations, and may require more than one class period.

**Key Learning Points for Students:**
1. Communities require wastewater treatment, which is complex.
2. Wastewater treatment is very effective and provides good-quality effluent.
3. As communities grow, more waste is produced, and it becomes more difficult to meet water quality standards.
4. Wetlands provide some level of water quality improvement, but less than that provided by a wastewater treatment plant.
5. Wetlands provide additional benefits to communities, including recreation, flood mitigation, water storage, wildlife habitat, and aesthetics.
6. It can take many years for a constructed wetland to mature in the desert.
7. Both wetlands and wastewater treatment plants are needed.
Handouts:

1. Vocabulary Activity- Words to Define
2. Summary Lesson Worksheet – Macroinvertebrates
3. Summary Lesson Worksheet – Water Treatment by Constructed Wetlands

Background:

Communities nationwide are facing choices in wastewater treatment. As growth occurs in the Truckee Meadows, more wastewater is produced. This contaminated water must be treated before it can be returned to the Truckee River or applied for irrigation.

State water quality standards are based on the uses designated for that segment of the water body as well as on existing water quality data. If a water body has a TMDL (Total Maximum Daily Load, or allocation of pollutants), those allocations are translated into permit limits in National Pollutant Discharge Elimination System (NPDES) permits for point source discharges. TMDLs provide a specific numerical limit for individual pollutants, generally in pounds per day. A given TMDL is calculated as the sum of all allocated loads of pollutants set at a level necessary to meet water quality standards, including inputs from wastewater treatment (wasteload allocation), loads from nonpoint sources (load allocation), and natural background conditions. TMDLs must include a margin of safety as well as a consideration of seasonal variations.

For example, the TMDL for total nitrogen in the Truckee River at Lockwood is 1000 pounds per day. Five hundred pounds are allocated to the wastewater treatment plant, 50 pounds to other point sources, and the remaining 450 pounds to all nonpoint sources of pollution, including tributary inputs and stormwater runoff, and natural background conditions. After formulation of the load and wasteload allocations, the EPA approves the TMDLs. The TMDLs are then used to develop NPDES permit limits for point sources and Best Management Practices (BMPs) for nonpoint sources (NPS).

TMDLs are one of the limiting factors at the Truckee Meadows Water Reclamation Facility (TMWRF), which treats wastewater in the urban Truckee Meadows and is the major point source discharger to the Truckee River. Its permit includes waste load allocations for total nitrogen, total phosphorus, and total dissolved solids. Continuing our example, TMWRF has been given a load allocation of 500 pounds per day for nitrogen. This means that they can only discharge treated wastewater into the Truckee River until that limit is reached.

Alternatives include costly high-tech innovations and expansions to the facility, application of effluent to golf courses and landscapes, or pollutant trading. If one source of pollution regularly exceeds its allocation of the TMDL, there are two possible solutions: the source that is exceeding its allocation will be fined and required to improve their water treatment, regardless of cost, or another source will have to reduce its load to allow the other source to increase its load. This
type of pollutant trading could occur if local water quality in tributaries and ditches is improved by better practices at the source to reduce NPS, or restoration of stream form and function to allow for enhanced pollutant uptake and decreased erosion and sedimentation.

Currently, Truckee Meadows Water Reclamation Facility (TMWRF) is nearing its capacity for removal of nitrogen. Scientists and engineers are studying ways to clean up water in local tributaries as a way to allow TMWRF to increase the amount of nitrogen it discharges. Not only must our community adhere to TMDL limitations, there is some fear that we may be subject to increasingly onerous and costly federal and state regulations in the future if voluntary reductions in NPS pollution and improvement in surface water quality are not measured. Voluntary actions implemented now help protect our community from incurring future federal mandates.

Wetlands may provide us with options to expensive wastewater treatment plant expansions. Wetland creation as part of stream restoration can be used as a method of NPS reduction. Construction of the wetlands is likely to be less expensive than construction of a wastewater treatment plant, but it can take a number of years for the wetland to mature and provide reliable benefits. Also, the degree of wastewater treatment from a wetland will be less than that provided by a treatment plant and benefits are likely to fluctuate throughout the year. If well-designed, relatively little maintenance should be required for a wetland, and ongoing costs should be much lower than that of operating a treatment plant.

Wetlands also provide us with multiple benefits, including stream stabilization, water storage, flood mitigation, natural processing of pollutants, recreation, and aesthetic amenities. Wastewater treatment plants are designed for one purpose only, to improve wastewater quality, and cannot duplicate the benefits of wetlands.

It may well be more cost-effective to control NPS than to impose additional point source controls. A combination of the two methods will allow us to continue to protect water quality as our community grows.
Vocabulary List:

**Best Management Practice (BMP):** A generally accepted, appropriate practice for some aspect of natural resources management, such as water conservation measures, drainage management measures or erosion control measures.

**Contamination:** The addition of any substance to water that makes it unfit for use.

**Load allocation:** The portion of the pollution load of a stream attributable to human nonpoint sources of pollution and/or natural background sources. The total amount of each pollutant from all combined point sources is called the wasteload allocation.

**Natural background:** The naturally occurring amount of a pollutant, such as nitrate or mercury. Natural background pollution sources include geologic formations, groundwater and surface waters.

**Nonpoint Discharge Elimination System (NPDES):** The program established by the Clean Water Act that requires all point sources of pollution discharging into any waters of the United States to obtain a permit for that discharge. The permit lists permissible discharges and the level of cleanup technology required for the wastewater before discharge.

**Nonpoint source pollution:** Pollution that enters water from a variety of land use activities over a widespread area. It is also known as polluted runoff. It is considered the main source of water quality degradation today.

**Nutrient:** A substance, such as nitrogen or phosphorus, that is necessary for plant growth.

**Point source pollution:** Pollution that can be traced to a single, identifiable source, such as a pipe or culvert.

**Pollutant:** Something that causes an undesirable change in the physical, chemical, or biological characteristics of air, water, or land. Something that may harm or affect humans or other living organisms.

**Runoff:** Precipitation or excess irrigation water that flows overland to streams, rivers and lakes.

**Surface water:** All water on the surface of the earth, including lakes, rivers, streams, ponds, oceans, and runoff.

**Total Maximum Daily Load (TMDL):** The maximum quantity of a particular water pollutant that can be discharged into a body of water without violating a water quality standard.
Truckee Meadows Water Reclamation Facility (TMWRF): Our main water reclamation or treatment facility, located in East Sparks along the Truckee River. Effluent discharges from TMWRF enter the Truckee River via Steamboat Creek.

Wasteload Allocation: The total amount of a specific pollutant allowed by the total point sources of that pollutant. Each point source polluter is allowed a fraction of the wasteload allocation. Pollution from nonpoint sources is termed the load allocation. The load allocation includes background levels of the specific pollutant.

Wastewater: All water and associated waste materials that go down a drain.

The Activities

1. Interpreting the Data (primarily a mathematical/analysis activity)

Materials:

- Student data sheets from the macroinvertebrate field survey (Lesson 7)
- Water quality measurements made at the field sites (Lesson 8)
- Information about the wastewater treatment plant (Lesson 3)
- Summary Lesson Worksheet – Macroinvertebrates
- Summary Lesson Worksheet – Water Treatment by Wetlands
- Graph paper
- Colored pencils

Note: If you were unable to complete the field exercises, you can complete this lesson using the data provided in the lessons.

1. Provide students with the locations at which the macroinvertebrate samples were collected. Help them find the locations on a map.

2. If graphs of the macroinvertebrate data have not yet been completed, have students draw them now. Using the results seen on their graphs, have them complete the worksheet.

3. Complete the water quality data worksheet. Calculate the percent removal of nutrients by the wetlands and the residence time. Help the students calculate:
   - How much nitrate is removed in one day by the wetland? In one year?
   - Assuming removal in the small wetland is representative of what might occur in a larger real-life setting, how big would a wetland need to be to remove 100 pounds per day of nitrates? 100 pounds per day of nitrates represents 10% of the total load for the Truckee River.

4. From information collected during the tour of the wastewater treatment plant, determine about how much nitrate is removed in one day and in one year.
The Activities, continued

2. Promote a Local Wetland (incorporating art and language into science)
   1. Assign a group of students to develop materials that promote a specific wetland in the community. This may be a local stream, pond, or other neighborhood feature. The materials should focus on a single theme or message selected by the students.
   2. The students may choose to include such elements as:
      - A video/DVD of local wetland footage with voice-over
      - Posters or other artwork
      - Educational signs for placement at wetlands, including photos, artwork, or other graphics
      - A PowerPoint presentation that could be used at meetings of clubs and other local groups. The presentation should be scripted.
      - Other creative materials
   3. Have students present their materials to the class, explaining what they developed, the message of each piece, and how the materials would be used.
   4. Students should include an estimated cost for commercial production of their materials. To accomplish this, they should contact a local production company for ideas and estimated costs.

3. Debate the Issues (incorporating public policy and needs into science)
   1. Divide students into two groups of about five to six students per group.
   2. One group represents developers who wish to build a new subdivision in a wetland area. The other group represents residents who wish to preserve the wetland.
   3. Assign each group to prepare a presentation that incorporates their plan for the wetland, the benefits of their plan, and the relative cost of their plan. These might include:
      **Developers:**
      - Increased property tax revenues
      - Growth pressures necessitating more housing
      - Affordable housing or a style of housing desired by the community
      - Good access to the property
The Activities, continued

3. Debate the Issues (continued)

**Developers, continued:**

- Mitigation by creating more wetland acreage (mitigation is an action taken to avoid, lessen or reduce an impact or potential impact. The developer is proposing to construct wetlands somewhere else to replace the wetlands that will be destroyed by the proposed development.)
- “Progress”
- “We need to grow as a community.”

**Wetlands Preservationists:**

- Community desire for open space
- Loss of wildlife habitat causing harm to migratory birds or other animals
- Flood protection benefits of wetlands – building in wetlands occupies volume and raises flood heights and potential damage
- Natural processing of pollutants
- Potential water quality impairment that leads to fees or fines if the wetland is developed
- Replacement constructed wetlands will not have the same functions as the natural wetlands

4. Beginning with the developers, have each group make a presentation of their case before the class.

5. Allow the class to ask questions after each presentation.

6. Ask the class which case is more convincing, and how decisions about these types of developments are made in their community.

4. Other suggested activities:

1. Have students research the laws and regulations relating to wetland alterations. Who makes decisions about wetland development? What must be considered? How long does the process take? What must the developer do in exchange for filling a wetland?

2. Research the birds, mammals, amphibians, fish, and other creatures found in Nevada wetlands. Are any of these species threatened or endangered? What special habitat needs do they have? Within a wetland, where would each be found? What effect would water pollution have on these organisms?
Resources


Truckee Meadows Water Reclamation Facility. No date. [www.tmwrf.com](http://www.tmwrf.com)


Water Environment Federation. No date. [www.wef.org](http://www.wef.org)
Lesson 9: Winning Solutions to Community Pollution

**Vocabulary Activity - Words to Define**

Name______________________________

Best Management Practice (BMP)

Contamination

Load allocation

Natural background

National Pollutant Discharge Elimination System (NPDES)

Nonpoint source pollution

Nutrient

Point source pollution

Pollutant

Runoff

Surface water

Total Maximum Daily Load (TMDL)

Truckee Meadows Water Reclamation Facility (TMWRF)

Wasteload allocation

Wastewater
1. Make two bar graphs showing the water quality at each of the macroinvertebrate sampling locations (A, B and C). Make sure to collect data from all the groups. Each graph will show the results from a single method for calculating approximate water quality. Show the results of each sample on the graph. It should look similar to this. Your data will vary:

![Bar Graph Example]

2. According to the results of the macroinvertebrate sampling, which location had the best water quality? ____________________________ Which had the worst? ____________________________

3. How did you decide that one location had better water quality than another?

4. Why do you think there was a difference in the samples?

5. Your teacher will show you the macroinvertebrate sample locations on a map. Add this information to your graph along the x-axis. What sources of pollution might influence the water quality at the different sample locations?
1. Complete your data worksheet from the field trip. Use the percent removal of nutrients you calculated to determine the difference in treatment between the different wetlands.

2. Which design removed more nitrogen? ____________________________________________
_________________________________________________________________________

3. Which removed more phosphorus? ____________________________________________
_________________________________________________________________________

4. Why do you think there were differences? _______________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

5. How many pounds per day of nitrogen did each unit remove?

- To calculate pounds per day from mg/L, first convert the gallons per minute of flow through the wetlands to gallons per day by multiplying by 1440 (60 minutes/hour X 24 hours/day)

  Gallons per day: ____________________________________________________________

- Next, calculate the amount removed in mg/L (amount going in minus amount going out)

- Now, convert mg/L to mg/gallon (multiply by 3.78 liters per gallon)

- Then, convert mg/gallon to pounds/gallon (divide by 454,000)

- Ok, you’re almost there! Now multiply the pounds/gallon you calculated in the last step by the flow through the wetland in gallons/day to get pounds/day!

<table>
<thead>
<tr>
<th>Nitrogen Removal</th>
<th>Amount Removed</th>
<th>mg/gallon</th>
<th>Pounds/gallon</th>
<th>Pounds/day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Which design would you pick if you were restoring wetlands? Why?

7. How much nitrogen does the water treatment plant remove in a day?

8. Which method is more efficient?

9. Which do you think costs more? Why?

10. List the benefits of water treatment by a facility and the benefits of constructed wetlands. How should we decide which to use?
Glossary

**Abdomen**: The rear body section of some invertebrates.

**Acidic**: Water or soil that has a pH of less than 7.0, or a higher concentration of hydrogen ions than hydroxyl ions.

**Activated sludge**: Sludge particles produced by the growth of microorganisms in aerated tanks as a part of the activated sludge process to treat wastewater.

**Aeration**: Process of stirring or bubbling air through a liquid. This adds oxygen to the wastewater and allows other trapped gasses to escape.

**Algal bloom**: A heavy growth of algae in and on a body of water, usually resulting from high nutrient concentrations in the water. May occur naturally under certain conditions, but usually occurs as the result of pollution.

**Alkaline (aka Basic)**: Water or soil that has a pH greater than 7.0, or a higher concentration of hydroxyl ions than hydrogen ions.

**Ammonia**: The NH₄⁺ ion, one of the many common ions containing nitrogen. Ammonia is an inorganic form of nitrogen.

**Anaerobic**: Living in the absence of air or free oxygen.

**Antennae**: Flexible sensory appendages, generally occurring in pairs, on the heads of some invertebrates.

**Basic**: see Alkaline.

**Benthic**: At or near the bottom of a water body.

**Best Management Practice (BMP)**: A generally accepted, appropriate practice for some aspect of natural resources management, such as water conservation measures, drainage management measures or erosion control measures.

**Chlorine**: Chemical element Cl. Various forms of chlorine are used as a disinfectant in drinking and wastewater treatment processes.

**Collectors**: Animals that feed on fine organic matter, such as plant fragments, bacteria, stream bed deposits and waste products from other organisms.

**Complete metamorphosis**: Insect development consisting of egg, larva, pupal and adult stages. During the pupal stage, the insect is immobile. The physical appearance of the larva stages is much different from the adult stages.

**Contamination**: The addition of any substance to water that makes it unfit for use.

**Debris**: Trash. Any accumulated material, including floating or submerged trash.
Decant: To pour off or draw off the upper layer of liquid after the heavier material (a solid or a heavier liquid) has settled.

Dilution: The reduction of the concentration of a substance in air or water.

Disinfection: Process by which most microorganisms in or on a substance are killed.

Dissolved oxygen: The concentration of oxygen dissolved in water and readily available to fish and other aquatic organisms.

Ecosystem: A community of living organisms and their interrelated physical and chemical environment. An ecosystem can be as small as a rotting log or a puddle of water, but most management efforts focus on larger geographic areas, such as a mountain range, river basin or a watershed.

Emergent vegetation: Plants that emerge above the soil and/or water level; upright plants.

Effluent: Discharged wastewater, such as the treated wastes from municipal sewage plants, brine wastewater from desalting operations, and coolant waters from a nuclear power plant. Effluent is generally considered point source pollution.

Fertilizer: Any organic or inorganic material of natural or synthetic origin that is added to the soil to supply elements essential to plant growth.

Filtration: A mechanical process that involves moving water through a material, usually sand, designed to catch and remove particles.

Flocculation: Process by which clay and other suspended solid particles are chemically stuck together so they can be removed from water by sedimentation or settling.

Gleying: Characteristic soil colors of black, dark gray, green gray and blue-gray found in hydric soils. Low oxygen levels in water-saturated hydric soils create a reducing environment. The iron in the soil becomes reduced, changing the color from the typical red, orange, yellow and/or brown commonly found in oxygenated soils.

Groundwater: All subsurface water that fills the pores, voids, fractures and other spaces between soil particles and in rock strata within the saturated zones of geologic formations.

Halophytic plants: Plants that are salt-tolerant, ranging from cacti to sea grass. Some of these plants also have the ability to absorb salts and heavy metals, such as cadmium and arsenic.

Head: The front body section of invertebrates.

Hydric soil: Soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions that favor the growth of hydrophytic plants.

Hydrocarbons: Chemical compounds that consist entirely of carbon and hydrogen, such as petroleum, natural gas and coal.

Hydrogen ion: The ion [H⁺]. An ion is an atom or a molecule that carries a charge, either positive or negative.
**Hydrophytic plants**: Plants that grow in water or in saturated soils that are periodically deficient in oxygen as a result of high water content.

**Hydroxyl ion**: The ion \([\text{OH}^-]\). An ion is an atom or a molecule that carries a charge, either positive or negative.

**Incomplete metamorphosis**: Insect development consisting of egg, nymph and adult stages. Nymphs resemble adults. The adult stage is reached when wings develop.

**Larvae**: Immature insect stage of life, generally occurring in insects that undergo complete metamorphosis. Commonly referred to as grub, caterpillar or maggot.

**Leachate**: Liquid which has percolated through the ground, picking up chemicals, metals, pathogens or other hazardous or toxic substances.

**Load allocation**: The portion of the pollution load of a stream attributable to human nonpoint sources of pollution and/or natural background sources. The total amount of each pollutant from all combined point sources is called the wasteload allocation.

**Macroinvertebrates**: Animals that lack a backbone and are visible with the naked eye.

**Metamorphosis**: Insect development involving a change of form. All insects start as an egg and end as an adult. There are two types of metamorphosis: complete metamorphosis and incomplete metamorphosis.

**Metabolic rate**: The rate of metabolism in living organisms. Metabolism includes the continuous chemical and physical processes occurring in living organisms. The rate of this activity can be affected by many environmental factors, including temperature or pH.

**Natural background**: The naturally occurring amount of a pollutant, such as nitrate or mercury. Natural background pollution sources include geologic formations, groundwater and surface waters.

**Natural processing**: The natural ability of undisturbed water systems and soils to retain water, adsorb nutrients, absorb other pollutants, slow or reduce surface runoff, and aid in infiltrating storm water.

**Neutral**: Water or soil with a pH of 7.0, meaning that it is neither acidic nor alkaline (basic).

**Nitrate**: The \([\text{NO}_3^-]\) ion, one of the several ionic forms of nitrogen. Nitrate is soluble in water and plants readily uptake this form of nitrogen.

**Nitrite**: The \([\text{NO}_2^-]\) ion, one of the several ionic forms of nitrogen. Nitrite is not absorbed by plants.

**Nitrogen**: Nitrogen makes up 78 percent of the Earth’s atmosphere as \(\text{N}_2\) gas. Nitrogen is an essential element required for plant growth. Nitrogen is also a major constituent of nonpoint source pollution.
Nonpoint Discharge Elimination System (NPDES): The program established by the Clean Water Act that requires all point sources of pollution discharging into any waters of the United States to obtain a permit for that discharge. The permit lists permissible discharges and the level of cleanup technology required for the wastewater before discharge.

Nonpoint source pollution: Pollution that enters water from a variety of land-use activities over a widespread area. It is also known as polluted runoff. It is considered the main source of water quality degradation today.

Nutrient: A substance, such as nitrogen or phosphorus, that is necessary for plant growth.

Nymph: An immature insect with undeveloped wings. This stage generally occurs in insects that undergo incomplete metamorphosis.

Organic material: Material derived from living things that contains carbon compounds.

Pathogen: Disease-causing microorganisms, such as bacteria and viruses, that come from the fecal wastes of humans and other animals.

Peat: A mass of semi-carbonized material formed by partial decomposition of various plants in water, especially mosses. Peat varies in consistency from turf to slime. As it decomposes, the color deepens, with old peat being dark brown to black in color.

Pesticide: Any chemical agent used to control specific pests. Includes insecticides, herbicides and fungicides.

pH: The term pH is an abbreviation of the French term “pouvoir hydrogène”, which literally means “hydrogen power.” pH is a measure of the activity or concentration of the hydrogen ion [H⁺] in a solution, and is used to determine if a solution is acidic or basic (alkaline). The mathematical expression for pH is:

\[ pH = -\log [H^+] \]  (the negative log of the hydrogen ion concentration)

The pH scale ranges from 0 to 14, with 7 being neutral, less than 7 acidic, and greater than 7 basic or alkaline. The acidity of the solution increases as the pH value decreases. As the pH scale is logarithmic, there is a tenfold increase between each whole number pH value.

Phosphorus: A chemical element (P) that is one of the three essential elements required for plant growth. Phosphorus tends to adsorb or stick onto soil particles. Phosphorus is a major constituent in nonpoint source pollution.

Point source pollution: Pollution that can be traced to a single, identifiable source, such as a pipe or culvert.

Pollutant: Something that causes an undesirable change in the physical, chemical, or biological characteristics of air, water, or land. Something that may harm or affect humans or other living organisms.

Predators: Animals that feed on other animals. In this instance, aquatic macroinvertebrates that feed on smaller, live, aquatic organisms.
**Pretreatment:** The stage of wastewater treatment in which wastewater is screened to remove large objects and a grit chamber is used to allow sand, grit and small stones to settle out.

**Primary treatment:** The first stage of wastewater treatment, in which settleable or floating solids are removed.

**Pupa:** The stage between the larva and the adult stages in insects that undergo complete metamorphosis. This is a non-feeding, inactive stage where adult features develop and grow.

**Runoff:** Precipitation or excess irrigation water that flows overland to streams, rivers and lakes.

**Scrapers:** Aquatic macroinvertebrates that remove and eat green plants and algae attached to the rocks they are growing on and graze on surface plants.

**Secondary treatment:** A stage of wastewater treatment in which biological treatment processes such as activated sludge are used to convert dissolved and suspended pollutants into a form that can be removed.

**Sediment:** Fragmented material from weathered rock and organic matter that is suspended in, transported by, and eventually deposited by air or water.

**Settling:** The process during which a substance, such as heavy organic solids or sediment, sinks to the bottom.

**Shredders:** Insects that chew up pieces of dead plants.

**Sludge:** Any solid or semisolid waste that settles to the bottom of sedimentation tanks or septic tanks.

**Storm drain:** A man-made system of underground pipes that drains water from a paved surface and discharges the storm water into a water body. The storm water is generally not treated to remove pollutants.

**Storm water:** The water produced as a result of a storm.

**Surface water:** All water on the surface of the earth, including lakes, rivers, streams, ponds, oceans, and runoff.

**Tertiary treatment:** Any level of treatment beyond secondary treatment, including filtration, nutrient removal, and removal of toxic chemicals and metals.

**Thermal stress:** An increase or decrease in the temperature of surface water. The increase or decrease in temperature can be harmful to aquatic life. Removal of streamside vegetation, paved surfaces, shallow water impoundments, and concrete water canals all contribute to thermal stress or temperature pollution.

**Thorax:** The middle body segment or section of an insect, between the head and the abdomen. This is generally the body segment where legs and wings are located.

**Total Maximum Daily Load (TMDL):** The maximum quantity of a particular water pollutant that can be discharged into a body of water without violating a water quality standard.
**Toxic chemical (Toxic contaminant):** A chemical that can harm the health of human beings and/or have a detrimental effect on the propagation, cultivation or conservation of animals or other aquatic life.

**Truckee Meadows Water Reclamation Facility (TMWRF):** Our main water reclamation or treatment facility, located in East Sparks along the Truckee River. Effluent discharges from TMWRF enter the Truckee River via Steamboat Creek.

**Wasteload allocation:** The total amount of a specific pollutant allowed by the total point sources of that pollutant. Each point source polluter is allowed a fraction of the wasteload allocation. Pollution from nonpoint sources is termed the load allocation. The load allocation includes natural background levels of the specific pollutant.

**Wastewater:** All water and associated waste materials that go down a drain.

**Water quality:** The chemical, physical, biological, and radiological condition of surface water or groundwater.

**Water table:** The upper boundary or top surface of the zone of saturation in a soil profile or geologic formation.

**Water velocity:** The rate of motion of a stream measured in terms of the distance its water travels in a unit of time, usually expressed in feet per second.

**Wetland:** An area that is periodically inundated with water, or an area that is saturated by surface or groundwater on an annual or seasonal basis; displays hydric soils; and typically supports or is capable of supporting hydrophytic vegetation.
Resources


Carolina Biological Supply. No date. Sources for water testing kits and equipment. www.carolina.com

 Chemetrics, Inc. no date. Source for water testing kits and equipment. www.chemetrics.com


Gelt, Joe. 1997. Constructed Wetlands: Using Human Ingenuity, Natural Processes to Treat Water, Build Habitat. Arroyo, Volume 9, No. 4


Hach Chemical Co. No date. Source for water testing kits and equipment. www.hach.com


Montana Plant Life. No date. Photo album of wildflowers, separated by color, etc. This may be useful in identifying flowering broadleaf plants. The second site includes a plant identification key.
http://montana.plant-life.org/
http://montana.plant-life.org/index2.html

Montana State University, Bozeman. 2004(?). Constructed Wetlands for Ecosystem Restoration.
http://ecorestoration.montana.edu/mineland/guide/construction/water/surface/passive/wetlands.htm

www.streamkeeper.org/catalog/books.htm


Natural Resources Conservation Service (NRCS). No date. Plants Classification Database.
http://plants.usda.gov/index.html

North American Association for Environmental Education. No date. www.eelink.net


Sea Grant. 2001. Non-Native Invasive Aquatic and Wetland Plants in the United States. If you know the basic family, (i.e. grasses, etc.), you can search the database.
http://plants.ifas.ufl.edu/seagrant/aquinv.html
www.rayswords.com/bugs/pages/intro.htm

Truckee Meadows Water Reclamation Facility. No date. www.tmwrf.com


United States Environmental Protection Agency. No date. Polluted Runoff (Nonpoint Source Pollution) website. www.epa.gov/owow/nps/nps_edu/index.html Articles and Activities for Middle School Students.


University of Virginia, Department of Environmental Sciences. 1999. Stream Study – Aquatic Macroinvertebrate Identification Key. 
www.people.virginia.edu/~sos-iwla/Stream-Study/Key/MacroKeyIntro.HTML

University of Wisconsin – Extension, in cooperation with the Wisconsin Department of Natural Resources. No date. Key to Macroinvertebrate Life in the River. http://clean-water.uwex.edu/wav/otherwav/riverkey.pdf


Water Environment Federation. No date. www.wef.org


Safety Issues

Sampling Safety
The Explore Nevada’s Amazing Wetlands curriculum allows both teachers and students to experience hands-on discovery of wetlands. Of the nine lessons, four are designed to be done in the field. Additionally, several require data collection by the instructor in the field prior to using the activity in class. The following guidelines, adapted from Stream Side Science, Utah State University Water Quality Extension, should be carefully followed to ensure the safety of both teachers and students.

Teacher Sample Collection

• Visit your planned sampling sites before the actual sampling date. Try to check the sites at the same time of day as your class will attend.
• Leave detailed description of where you are planning to go with the school and/or your family.
• Take another person with you when you go to sampling sites to ensure your safety.
• Follow the additional safety guidelines listed below.

How to Choose a Safe Site

• Visit all potential sites before the field trip. Several sites have been field-checked for you (see appendix), but situations change. Make sure there is:
  o Public access
  o Adequate parking
  o Facilities (restrooms, tables to work on, etc.) if the class will be there for any length of time.
• Check for any hazards, such as broken glass, other trash, poisonous plants, undesirable occupants (two- or four-legged), etc.
• Avoid areas with steep, slippery banks or areas that are too densely vegetated to permit access to the water or wetland.

How to Manage a Group in the Field

• Make sure permission slips are signed before the trip. Include a place for parents or guardians to indicate any special considerations, such as allergies to bee stings.
• Have an adult supervisor accompany each group of six to eight students in the field.
• Keep all groups within visual or hearing range.
• Establish a meeting place and time to check in, if your groups are scattered.
• Make sure each group has access to a first aid kit, and knows how to use it, if your groups are scattered. Watch for heat exhaustion in warm weather or hypothermia during cold weather.
Stream Sampling Safety

- Discuss safety issues with class and adult helpers before going to the field.
- Make sure students know they are not allowed to enter the water without adult supervision.
- Moving water can be extremely dangerous. Do not let students wade in water over their knees, especially if it is very fast-moving.
- Cold water can cause hypothermia even on warm days. Students who enter cold water should wear appropriate clothing, especially waders or rubber boots. Students should bring an extra set of clothes.
- Avoid waters that are obviously polluted or directly downstream from a pollution discharge pipe.
- Never sample during a lightning storm.
- Be aware of surrounding weather, especially storms in the higher portions of the watershed, as these could cause flash floods at your site.

Chemical Tests Safety

- Always wear protective eyewear and gloves when conducting chemical tests. The tests are designed to be safe, but it is best to avoid contact between chemicals and eyes, nose, mouth and skin. NEVER TEAR THE PACKETS OPEN WITH YOUR TEETH!
- Do not pour the wastewater from the tests down the drain or on the ground. Collected them in separate, labeled containers and dispose of them in the following manner:
  - The water from temperature and pH tests can be poured down the drain.
  - The test water from the phosphorus test, PhosVer3 test packet, should be diluted with additional water (hence the request for a large container). The pH should be adjusted to between 6 and 9 by adding sodium bicarbonate (baking soda). With the cold tap water running, slowly pour the diluted, pH-adjusted test water down the drain. Allow the cold water to run for five minutes afterwards to completely flush the system.
  - The test water from the nitrate test, NitraVer6 test packet, contains cadmium, which is an OSHA listed carcinogen. The test waters are considered a hazardous waste and should be disposed of in an EPA-approved hazardous waste facility. In Washoe County, each middle school and high school has a Designated Science Safety Officer. You should contact this person at your school regarding collection, labeling, and transfer of this waste. Most school districts have an environmental officer or chemical hygiene specialist on staff. In Washoe County, this person can be reached at 348-3852 or through the main district line at 348-0200. For other school districts, please check with your district office.
## List of Potential Wetland Sites in the Truckee Meadows
### Truckee River, from West to East

<table>
<thead>
<tr>
<th>City or County Park</th>
<th>Sample Access to River</th>
<th>School Bus Access and Parking</th>
<th>Safety (would you be safe sampling here in the early morning?)</th>
<th>Facilities (restrooms, picnic tables, etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystal Peak Park (Washoe County Park)</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>yes</td>
</tr>
<tr>
<td>Mayberry Park (Washoe County Park)</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>yes</td>
</tr>
<tr>
<td>Dorostkar Park (Washoe County Park)</td>
<td>fair (path to river)</td>
<td>poor</td>
<td>fair</td>
<td>no</td>
</tr>
<tr>
<td>Ambrose Park (Washoe County Park)</td>
<td>fair (path to river)</td>
<td>poor</td>
<td>fair</td>
<td>no</td>
</tr>
<tr>
<td>Schiappacasse Park (City of Reno)</td>
<td>poor (neighborhood)</td>
<td>poor (neighborhood)</td>
<td>fair</td>
<td>no</td>
</tr>
<tr>
<td>Chrissie Caughlin Park (City of Reno)</td>
<td>fair (path to river)</td>
<td>poor</td>
<td>fair</td>
<td>yes</td>
</tr>
<tr>
<td>Ivan Sack Park (City of Reno)</td>
<td>poor (river incised)</td>
<td>poor</td>
<td>fair</td>
<td>no</td>
</tr>
<tr>
<td>Oxbow Nature Study Area (City of Reno)</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>yes</td>
</tr>
<tr>
<td>Idlewild Park (City of Reno)</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>yes</td>
</tr>
<tr>
<td>Barbara Bennett Park (City of Reno)</td>
<td>good</td>
<td>poor</td>
<td>good</td>
<td>yes</td>
</tr>
<tr>
<td>Brodhead Park (City of Reno)</td>
<td>poor</td>
<td>poor</td>
<td>poor (unsafe)</td>
<td>no</td>
</tr>
<tr>
<td>Kuenzli River Belt Park (City of Reno)</td>
<td>poor</td>
<td>poor</td>
<td>poor (unsafe)</td>
<td>no</td>
</tr>
<tr>
<td>Fisherman's Park (City of Reno)</td>
<td>poor</td>
<td>poor</td>
<td>poor (unsafe)</td>
<td>no</td>
</tr>
<tr>
<td>Gateway Park</td>
<td>good</td>
<td>poor</td>
<td>fair</td>
<td>no</td>
</tr>
<tr>
<td>Rock Park (City of Sparks)</td>
<td>good</td>
<td>good</td>
<td>good</td>
<td>yes</td>
</tr>
<tr>
<td>Glendale Park (City of Sparks)</td>
<td>poor (river incised)</td>
<td>fair</td>
<td>fair</td>
<td>yes</td>
</tr>
<tr>
<td>Cottonwood Park (City of Sparks)</td>
<td>poor (river incised)</td>
<td>fair</td>
<td>fair</td>
<td>yes</td>
</tr>
</tbody>
</table>
Additional Wetland Areas

County or city parks:

Rancho San Rafael Regional Park
Galena Creek Regional Park
Thomas Creek Park
Shadow Ridge Park (White's Creek)
Davis Creek Park
Bartley Ranch Park
Swan Lake (Lemmon Valley Mash Interpretive Center)

These sites may be useful, but will require permission for access and collection:

Chalk Bluff Water Treatment Plant (access is controlled)
Truckee Meadows Water Reclamation Facility (access is controlled)

Tributary Streams

Most of the tributary streams in the Truckee Meadows are accessible at several points along their reaches. The following is a list of tributaries. If the locations were field-checked, additional information is provided.

Davis Creek

Dog Creek

Dry Creek: There are two sites to sample off Longley Lane: one at the end of Airway Drive and the other off Sierra Center Parkway (behind the Mervyn’s and Target stores). Neither really has facilities for a busload of students and some of the creek banks at the second site are vegetated with invasive weeds. Upstream, sites are not accessible for sampling because there is either no place to park or the site is within a gated community.

Evans Creek: Sampling access is difficult due to a lack of roads and private property restrictions.

Franktown Creek
Tributary Streams, continued

**Galena Creek:** Access for instructor or small group/single van sampling exists in Pleasant Valley off Galena Pines Road and off Callahan Ranch Road at Callahan Park. Access is also available to sample Jones Creek at the intersection of Callahan Ranch Road and Chatelaine Circle. Jones Creek flows through the Montreux Golf Course just above this sampling site and ties into Galena Creek just below this site. Access for a standard-sized school bus exists at Galena Creek Regional Park. There are picnic tables to set up sample testing in the field. This site also has a nature hike for students. During a field trip, students could collect samples, travel to Galena Creek Regional Park, collect the last sample there, test all the samples, have lunch and walk the nature trail.

**Hunter Creek**

**North Truckee Drain**

**Ophir Creek**

**Steamboat Creek:** Difficult access due to incised channels and private property.

**Thomas Creek:** Access for instructor or small group/single van sampling at the trailhead for Thomas Creek off Timberline Drive and downstream off Arrow Creek Parkway, just before the community gate. There is no access from Foothills Road. There is access for instructor or small group/single van sampling at a site off South Meadows Parkway. This site would show the influence of the Lake Ditch, which feeds into the creek upstream.

**White's Creek:** Access for instructor or small group/single van sampling on Timberline Drive and downstream on Thomas Creek Road. Contact the Galena Creek Market on the Mount Rose Highway to request permission to park a school bus at the market and walk up the street to the sampling site. Otherwise, there is no good place to park a full-sized school bus. There are two more sites further downstream that must be accessed via Foothill Road, but there is no access for a school bus at either site and they appear to be private property.
Additional Web Sites for Local Water Quality Data

General

California Department of Water Resources, Division of Flood Management.  
http://cdec.water.ca.gov/river/rivcond.html  This site monitors river heights for Rivers in California.  Go to the North Lahontan Region, and you will find data for the Truckee River from Lake Tahoe to Prosser Creek and from the Little Truckee River to Reno.  Site also has information on the Carson and Walker Rivers.

National Weather Service Advanced Hydrologic Prediction Service.  

Real-Time Data for Nevada.  http://waterdata.usgs.gov/nv/nwis/rt  This site has lake and reservoir data (storage in acre-ft, but not % of total volume filled), groundwater data, precipitation totals for last 7 days and a water quality table.

Surf Your Watershed.  http://www.epa.gov/surf/  If you enter the zip code for your immediate area, your immediate watershed will be show.  If you enter your county, this website will show the watersheds and subwatersheds within your county.

http://nevada.usgs.gov/wateractivities.htm

Truckee River

Nevada Department of Environmental Protection, Truckee River Basin  
http://ndep.nv.gov/bwqp/truckeemap.html  This site will show a map of the Truckee River, with monitor stations.  Click on each monitoring station and you can download water quality data for that site.


Truckee Meadows Water Authority Drinking Water Quality Lookup.  
http://www.truckeemeadowswater.com/water_system/quality/lookup/  
(Note: blank space is an underscore.)

Truckee Meadows Water Reclamation Facility, River Monitoring Data.  
http://www.tmwrf.com/facility_data/river_monitoring/  
(Note: blank spaces are underscores.)

Truckee River Chronology.  http://water.nv.gov/Water%20planning/truckee/tchrono.htm
Truckee River, continued

United States Department of Agriculture Forest Service, Lake Tahoe Basin Management Unit. 
http://www.fs.fed.us/r5/ltbmu/conditions Links to other sites, current weather and more.


Carson River


Nevada Department of Environmental Protection, Carson River Basin 
http://ndep.nv.gov/bwgp/carsonmap.html This site will show a map of the Carson River, with monitor stations . Click on each monitoring station and you can download water quality data for that site.


Walker River

Nevada Department of Environmental Protection, Walker River Basin 
http://ndep.nv.gov/bwgp/walkermap.html This site will show a map of the Walker River, with monitor stations . Click on each monitoring station and you can download water quality data for that site.


Humboldt River


Humboldt River Chronology.  http://water.nv.gov/Water%20planning/humboldt/hrchrono.htm

Nevada Department of Environmental Protection, Humboldt River Basin http://ndep.nv.gov/bwgp/humboldtmap.html This site will show a map of the Humboldt River, with monitor stations. Click on each monitoring station and you can download water quality data for that site.
# Truckee River 2003 Water Quality Data from NDEP Files

<table>
<thead>
<tr>
<th>Station</th>
<th>Date</th>
<th>Temperature, °C</th>
<th>pH, field</th>
<th>pH, lab</th>
<th>Dissolved Oxygen, mg/l</th>
<th>Nitrogen, as Nitrate, mg/l</th>
<th>Phosphorus, as Ortho P, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tahoe City</td>
<td>1/16/2003</td>
<td>4.66</td>
<td>7.89</td>
<td>7.28</td>
<td>10.83</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>2/11/2003</td>
<td>4.18</td>
<td>7.4</td>
<td>6.96</td>
<td>10.08</td>
<td>&lt;0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>3/11/2003</td>
<td>6.78</td>
<td>7.6</td>
<td>7.38</td>
<td>10.2</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>4/15/2003</td>
<td>5.94</td>
<td>7.79</td>
<td>7.08</td>
<td>11.2</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>5/14/2003</td>
<td>8.4</td>
<td>7.72</td>
<td>7.34</td>
<td>10.04</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>6/10/2003</td>
<td>12.75</td>
<td>7.97</td>
<td>7.12</td>
<td>8.93</td>
<td>&lt;0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>7/15/2003</td>
<td>16.4</td>
<td>8.08</td>
<td>7.4</td>
<td>8.24</td>
<td>0.001</td>
<td>0.004</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>8/12/2003</td>
<td>17.8</td>
<td>8.04</td>
<td>7.56</td>
<td>7.54</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>9/15/2003</td>
<td>8.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tahoe City</td>
<td>10/21/2003</td>
<td>13.5</td>
<td>8.09</td>
<td>7.61</td>
<td>5.48</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>11/18/2003</td>
<td>4.4</td>
<td>6.64</td>
<td>6.94</td>
<td>7.6</td>
<td>0.056</td>
<td>0.004</td>
</tr>
<tr>
<td>Tahoe City</td>
<td>12/16/2003</td>
<td>1.6</td>
<td>7.32</td>
<td>7.21</td>
<td>10.42</td>
<td>0.007</td>
<td>0.002</td>
</tr>
<tr>
<td>Farad</td>
<td>1/16/2003</td>
<td>2.06</td>
<td>7.86</td>
<td>7.46</td>
<td>12.97</td>
<td>0.082</td>
<td>0.004</td>
</tr>
<tr>
<td>Farad</td>
<td>2/11/2003</td>
<td>2.72</td>
<td>7.1</td>
<td>7.34</td>
<td>11.33</td>
<td>0.131</td>
<td>0.006</td>
</tr>
<tr>
<td>Farad</td>
<td>3/11/2003</td>
<td>7.29</td>
<td>7.96</td>
<td>7.67</td>
<td>10.72</td>
<td>0.044</td>
<td>0.005</td>
</tr>
<tr>
<td>Farad</td>
<td>4/15/2003</td>
<td>7.38</td>
<td>7.56</td>
<td>7.14</td>
<td>11.8</td>
<td>0.014</td>
<td>0.002</td>
</tr>
<tr>
<td>Farad</td>
<td>5/14/2003</td>
<td>8.92</td>
<td>7.96</td>
<td>7.3</td>
<td>10.52</td>
<td>0.049</td>
<td>0.003</td>
</tr>
<tr>
<td>Farad</td>
<td>6/10/2003</td>
<td>11.37</td>
<td>7.89</td>
<td>7.02</td>
<td>9.14</td>
<td>0.016</td>
<td>0.004</td>
</tr>
<tr>
<td>Farad</td>
<td>7/15/2003</td>
<td>15.1</td>
<td>8.1</td>
<td>7.44</td>
<td>8.67</td>
<td>0.006</td>
<td>0.005</td>
</tr>
<tr>
<td>Farad</td>
<td>8/12/2003</td>
<td>16.5</td>
<td>8.1</td>
<td>7.71</td>
<td>8.35</td>
<td>0.095</td>
<td>0.003</td>
</tr>
<tr>
<td>Farad</td>
<td>9/15/2003</td>
<td></td>
<td></td>
<td>7.62</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farad</td>
<td>10/21/2003</td>
<td>12.6</td>
<td>8.11</td>
<td>7.59</td>
<td>9.24</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>Farad</td>
<td>11/18/2003</td>
<td>7.3</td>
<td>7.88</td>
<td>7.33</td>
<td>9.15</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>Farad</td>
<td>12/16/2003</td>
<td>1.8</td>
<td>7.84</td>
<td>7.34</td>
<td>12.55</td>
<td>0.042</td>
<td>0.007</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>1/16/2003</td>
<td>3.06</td>
<td>8.37</td>
<td>8</td>
<td>16.28</td>
<td>0.011</td>
<td>0.003</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>2/11/2003</td>
<td>2.81</td>
<td>7.35</td>
<td>7.44</td>
<td>11.77</td>
<td>0.123</td>
<td>0.008</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>3/11/2003</td>
<td>9.41</td>
<td>7.94</td>
<td>8</td>
<td>10.54</td>
<td>0.027</td>
<td>0.007</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>4/15/2003</td>
<td>8.26</td>
<td>7.74</td>
<td>7.22</td>
<td>12.08</td>
<td>0.011</td>
<td>0.005</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>5/14/2003</td>
<td>13.58</td>
<td>8.12</td>
<td>7.36</td>
<td>9.82</td>
<td>0.014</td>
<td>0.005</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>6/10/2003</td>
<td>15.6</td>
<td>8.27</td>
<td>7.14</td>
<td>8.85</td>
<td>0.011</td>
<td>0.005</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>7/15/2003</td>
<td>18.2</td>
<td>8.37</td>
<td>7.59</td>
<td>8.59</td>
<td>0.009</td>
<td>0.006</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>8/12/2003</td>
<td>19.2</td>
<td>8.46</td>
<td>8.16</td>
<td>8.41</td>
<td>0.014</td>
<td>0.007</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>9/15/2003</td>
<td></td>
<td></td>
<td>7.9</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>10/21/2003</td>
<td>13.6</td>
<td>8.66</td>
<td>7.93</td>
<td>9.85</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>11/18/2003</td>
<td>7.2</td>
<td>8.41</td>
<td>7.45</td>
<td>10.09</td>
<td>0.005</td>
<td>0.006</td>
</tr>
<tr>
<td>Idlewild Park</td>
<td>12/16/2003</td>
<td>1.6</td>
<td>8.1</td>
<td>7.56</td>
<td>13.55</td>
<td>0.053</td>
<td>0.01</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>1/16/2003</td>
<td>5.55</td>
<td>8.06</td>
<td>7.93</td>
<td>16.2</td>
<td>0.061</td>
<td>0.023</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>2/11/2003</td>
<td>4.47</td>
<td>7.51</td>
<td>7.87</td>
<td>12.8</td>
<td>0.109</td>
<td>0.1</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>3/11/2003</td>
<td>10.27</td>
<td>7.75</td>
<td>7.8</td>
<td>10.86</td>
<td>0.076</td>
<td>0.04</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>4/15/2003</td>
<td>9.18</td>
<td>7.7</td>
<td>7.44</td>
<td>12.52</td>
<td>0.03</td>
<td>0.018</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>5/14/2003</td>
<td>14.5</td>
<td>7.95</td>
<td>7.45</td>
<td>10.26</td>
<td>0.003</td>
<td>0.022</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>6/10/2003</td>
<td>16.97</td>
<td>8.1</td>
<td>7.5</td>
<td>9.31</td>
<td>0.036</td>
<td>0.032</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>7/15/2003</td>
<td>19.7</td>
<td>8.08</td>
<td>7.68</td>
<td>8.87</td>
<td>0.011</td>
<td>0.033</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>8/12/2003</td>
<td>20.2</td>
<td>7.96</td>
<td>7.92</td>
<td>8.61</td>
<td>0.017</td>
<td>0.039</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>9/15/2003</td>
<td></td>
<td></td>
<td>8.02</td>
<td>0.039</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vista Gage</td>
<td>10/21/2003</td>
<td>14.9</td>
<td>8.02</td>
<td>7.7</td>
<td>10.19</td>
<td>0.011</td>
<td>0.064</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>11/18/2003</td>
<td>8.6</td>
<td>7.97</td>
<td>7.54</td>
<td>10.87</td>
<td>0.024</td>
<td>0.04</td>
</tr>
<tr>
<td>Vista Gage</td>
<td>12/16/2003</td>
<td>4.5</td>
<td>7.83</td>
<td>7.33</td>
<td>12.98</td>
<td>0.081</td>
<td>0.069</td>
</tr>
</tbody>
</table>
## Truckee River 2003 Water Quality Data from TMWRF Files

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Time</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Flow, cfs</th>
<th>Dissolved Oxygen, mg/l</th>
<th>Phosphorus, as Ortho P, mg/l</th>
<th>Nitrogen as Nitrate, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>McCarran</td>
<td>14-Jan-03</td>
<td>820</td>
<td>3.9</td>
<td>7.7</td>
<td>300</td>
<td>11.5</td>
<td>0.024</td>
<td>0.001</td>
</tr>
<tr>
<td>McCarran</td>
<td>11-Feb-03</td>
<td>830</td>
<td>2.0</td>
<td>7.6</td>
<td>265</td>
<td>12.2</td>
<td>0.020</td>
<td>0.101</td>
</tr>
<tr>
<td>McCarran</td>
<td>11-Mar-03</td>
<td>838</td>
<td>5.6</td>
<td>7.7</td>
<td>275</td>
<td>11.7</td>
<td>0.029</td>
<td>0.039</td>
</tr>
<tr>
<td>McCarran</td>
<td>15-Apr-03</td>
<td>1036</td>
<td>6.6</td>
<td>8.0</td>
<td>874</td>
<td>11.5</td>
<td>0.025</td>
<td>0.019</td>
</tr>
<tr>
<td>McCarran</td>
<td>13-May-03</td>
<td>1014</td>
<td>11.9</td>
<td>8.1</td>
<td>525</td>
<td>11.6</td>
<td>0.012</td>
<td>0.019</td>
</tr>
<tr>
<td>McCarran</td>
<td>10-Jun-03</td>
<td>941</td>
<td>14.0</td>
<td>7.7</td>
<td>759</td>
<td>9.5</td>
<td>0.010</td>
<td>0.001</td>
</tr>
<tr>
<td>McCarran</td>
<td>15-Jul-03</td>
<td>950</td>
<td>16.8</td>
<td>7.9</td>
<td>357</td>
<td>9.8</td>
<td>0.017</td>
<td>0.001</td>
</tr>
<tr>
<td>McCarran</td>
<td>19-Aug-03</td>
<td>1009</td>
<td>19.3</td>
<td>7.0</td>
<td>242</td>
<td>9.0</td>
<td>0.028</td>
<td>0.006</td>
</tr>
<tr>
<td>McCarran</td>
<td>16-Sep-03</td>
<td>1014</td>
<td>14.0</td>
<td>8.6</td>
<td>252</td>
<td>9.8</td>
<td>0.030</td>
<td>0.008</td>
</tr>
<tr>
<td>McCarran</td>
<td>21-Oct-03</td>
<td>1004</td>
<td>11.8</td>
<td>7.5</td>
<td>268</td>
<td>10.3</td>
<td>0.021</td>
<td>0.009</td>
</tr>
<tr>
<td>McCarran</td>
<td>18-Nov-03</td>
<td>1123</td>
<td>6.3</td>
<td>7.7</td>
<td>318</td>
<td>12.7</td>
<td>0.012</td>
<td>0.033</td>
</tr>
<tr>
<td>McCarran</td>
<td>16-Dec-03</td>
<td>1033</td>
<td>0.4</td>
<td>7.5</td>
<td>174</td>
<td>14.4</td>
<td>0.018</td>
<td>0.037</td>
</tr>
<tr>
<td>McCarran</td>
<td>Average</td>
<td></td>
<td>9.4</td>
<td>7.8</td>
<td>384</td>
<td>11.2</td>
<td>0.021</td>
<td>0.023</td>
</tr>
<tr>
<td>McCarran</td>
<td>Maximum</td>
<td></td>
<td>19.3</td>
<td>8.6</td>
<td>874</td>
<td>14.4</td>
<td>0.030</td>
<td>0.101</td>
</tr>
<tr>
<td>McCarran</td>
<td>Minimum</td>
<td></td>
<td>0.4</td>
<td>7.0</td>
<td>174</td>
<td>9.0</td>
<td>0.010</td>
<td>0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Time</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Flow, cfs</th>
<th>Dissolved Oxygen, mg/l</th>
<th>Phosphorus, as Ortho P, mg/l</th>
<th>Nitrogen as Nitrate, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Truckee Drain</td>
<td>14-Jan-03</td>
<td>856</td>
<td>7.3</td>
<td>7.9</td>
<td>8</td>
<td>9.7</td>
<td>0.141</td>
<td>0.520</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>11-Feb-03</td>
<td>900</td>
<td>6.7</td>
<td>7.8</td>
<td>8</td>
<td>10.4</td>
<td>0.151</td>
<td>0.371</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>11-Mar-03</td>
<td>908</td>
<td>9.0</td>
<td>7.9</td>
<td>11</td>
<td>10.6</td>
<td>0.135</td>
<td>0.396</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>15-Apr-03</td>
<td>1132</td>
<td>12.8</td>
<td>8.2</td>
<td>7</td>
<td>10.8</td>
<td>0.155</td>
<td>0.664</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>13-May-03</td>
<td>1046</td>
<td>15.4</td>
<td>8.6</td>
<td>6</td>
<td>17.2</td>
<td>0.206</td>
<td>0.022</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>10-Jun-03</td>
<td>1020</td>
<td>19.1</td>
<td>7.9</td>
<td>9</td>
<td>7.9</td>
<td>0.207</td>
<td>0.109</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>15-Jul-03</td>
<td>1048</td>
<td>20.3</td>
<td>8.1</td>
<td>6</td>
<td>10.4</td>
<td>0.241</td>
<td>0.014</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>19-Aug-03</td>
<td>1042</td>
<td>21.3</td>
<td>7.4</td>
<td>8</td>
<td>9.5</td>
<td>0.136</td>
<td>0.152</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>16-Sep-03</td>
<td>1105</td>
<td>15.3</td>
<td>9.1</td>
<td>12</td>
<td>11.5</td>
<td>0.119</td>
<td>0.171</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>21-Oct-03</td>
<td>1050</td>
<td>14.5</td>
<td>7.8</td>
<td>5</td>
<td>8.3</td>
<td>0.198</td>
<td>0.488</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>18-Nov-03</td>
<td>1206</td>
<td>10.9</td>
<td>7.6</td>
<td>7</td>
<td>11.1</td>
<td>0.130</td>
<td>0.768</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>16-Dec-03</td>
<td>1129</td>
<td>8.7</td>
<td>7.6</td>
<td>9</td>
<td>9.5</td>
<td>0.201</td>
<td>0.996</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>Average</td>
<td></td>
<td>13.4</td>
<td>8.0</td>
<td>8</td>
<td>10.6</td>
<td>0.168</td>
<td>0.389</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>Maximum</td>
<td></td>
<td>21.3</td>
<td>9.1</td>
<td>12</td>
<td>17.2</td>
<td>0.241</td>
<td>0.996</td>
</tr>
<tr>
<td>North Truckee Drain</td>
<td>Minimum</td>
<td></td>
<td>6.7</td>
<td>7.4</td>
<td>5</td>
<td>7.9</td>
<td>0.119</td>
<td>0.014</td>
</tr>
</tbody>
</table>
## Truckee River 2003 Water Quality Data from TMWRF Files

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Time</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Flow, cfs</th>
<th>Dissolved Oxygen, mg/l</th>
<th>Phosphorus, as ortho P, mg/l</th>
<th>Nitrogen as Nitrate, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steamboat</td>
<td>14-Jan-03</td>
<td>742</td>
<td>5.8</td>
<td>8.0</td>
<td>24</td>
<td>9.5</td>
<td>0.117</td>
<td>0.539</td>
</tr>
<tr>
<td>Steamboat</td>
<td>11-Feb-03</td>
<td>730</td>
<td>4.1</td>
<td>8.0</td>
<td>34</td>
<td>10.5</td>
<td>0.102</td>
<td>0.543</td>
</tr>
<tr>
<td>Steamboat</td>
<td>11-Mar-03</td>
<td>744</td>
<td>7.5</td>
<td>8.1</td>
<td>26</td>
<td>9.1</td>
<td>0.120</td>
<td>0.466</td>
</tr>
<tr>
<td>Steamboat</td>
<td>15-Apr-03</td>
<td>913</td>
<td>8.7</td>
<td>8.1</td>
<td>39</td>
<td>8.5</td>
<td>0.145</td>
<td>0.447</td>
</tr>
<tr>
<td>Steamboat</td>
<td>13-May-03</td>
<td>856</td>
<td>15.1</td>
<td>8.3</td>
<td>24</td>
<td>10.8</td>
<td>0.133</td>
<td>0.422</td>
</tr>
<tr>
<td>Steamboat</td>
<td>10-Jun-03</td>
<td>826</td>
<td>19.9</td>
<td>8.0</td>
<td>56</td>
<td>6.2</td>
<td>0.222</td>
<td>0.136</td>
</tr>
<tr>
<td>Steamboat</td>
<td>15-Jul-03</td>
<td>817</td>
<td>20.2</td>
<td>8.0</td>
<td>15</td>
<td>6.0</td>
<td>0.115</td>
<td>0.120</td>
</tr>
<tr>
<td>Steamboat</td>
<td>19-Aug-03</td>
<td>848</td>
<td>22.1</td>
<td>7.1</td>
<td>31</td>
<td>5.7</td>
<td>0.098</td>
<td>0.199</td>
</tr>
<tr>
<td>Steamboat</td>
<td>16-Sep-03</td>
<td>910</td>
<td>14.9</td>
<td>7.8</td>
<td>51</td>
<td>7.5</td>
<td>0.117</td>
<td>0.220</td>
</tr>
<tr>
<td>Steamboat</td>
<td>21-Oct-03</td>
<td>854</td>
<td>10.7</td>
<td>8.0</td>
<td>9</td>
<td>8.7</td>
<td>0.128</td>
<td>0.038</td>
</tr>
<tr>
<td>Steamboat</td>
<td>18-Nov-03</td>
<td>958</td>
<td>6.3</td>
<td>8.2</td>
<td>17</td>
<td>13.2</td>
<td>0.114</td>
<td>0.544</td>
</tr>
<tr>
<td>Steamboat</td>
<td>16-Dec-03</td>
<td>912</td>
<td>2.5</td>
<td>7.4</td>
<td></td>
<td>10.7</td>
<td>0.215</td>
<td>0.523</td>
</tr>
<tr>
<td>Steamboat</td>
<td>Average</td>
<td></td>
<td>11.5</td>
<td>7.9</td>
<td>30</td>
<td>8.9</td>
<td>0.136</td>
<td>0.350</td>
</tr>
<tr>
<td>Steamboat</td>
<td>Maximum</td>
<td></td>
<td>22.1</td>
<td>8.3</td>
<td>56</td>
<td>13.2</td>
<td>0.222</td>
<td>0.544</td>
</tr>
<tr>
<td>Steamboat</td>
<td>Minimum</td>
<td></td>
<td>2.5</td>
<td>7.1</td>
<td>9</td>
<td>5.7</td>
<td>0.098</td>
<td>0.038</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Time</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Flow, cfs</th>
<th>Dissolved Oxygen, mg/l</th>
<th>Phosphorus, as ortho P, mg/l</th>
<th>Nitrogen as Nitrate, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockwood</td>
<td>14-Jan-03</td>
<td>930</td>
<td>5.9</td>
<td>7.8</td>
<td>374</td>
<td>11.1</td>
<td>0.049</td>
<td>0.060</td>
</tr>
<tr>
<td>Lockwood</td>
<td>11-Feb-03</td>
<td>1005</td>
<td>3.7</td>
<td>8.0</td>
<td>329</td>
<td>12.9</td>
<td>0.058</td>
<td>0.133</td>
</tr>
<tr>
<td>Lockwood</td>
<td>11-Mar-03</td>
<td>940</td>
<td>8.3</td>
<td>7.9</td>
<td>245</td>
<td>11.7</td>
<td>0.044</td>
<td>0.065</td>
</tr>
<tr>
<td>Lockwood</td>
<td>15-Apr-03</td>
<td>1230</td>
<td>8.0</td>
<td>8.1</td>
<td>935</td>
<td>11.5</td>
<td>0.031</td>
<td>0.039</td>
</tr>
<tr>
<td>Lockwood</td>
<td>13-May-03</td>
<td>1147</td>
<td>13.6</td>
<td>8.0</td>
<td>647</td>
<td>11.2</td>
<td>0.030</td>
<td>0.024</td>
</tr>
<tr>
<td>Lockwood</td>
<td>10-Jun-03</td>
<td>1115</td>
<td>15.6</td>
<td>7.8</td>
<td>898</td>
<td>9.2</td>
<td>0.040</td>
<td>0.008</td>
</tr>
<tr>
<td>Lockwood</td>
<td>15-Jul-03</td>
<td>1142</td>
<td>19.3</td>
<td>8.0</td>
<td>442</td>
<td>9.9</td>
<td>0.049</td>
<td>0.001</td>
</tr>
<tr>
<td>Lockwood</td>
<td>19-Aug-03</td>
<td>1201</td>
<td>22.0</td>
<td>8.0</td>
<td>285</td>
<td>10.5</td>
<td>0.052</td>
<td>0.006</td>
</tr>
<tr>
<td>Lockwood</td>
<td>16-Sep-03</td>
<td>1204</td>
<td>16.1</td>
<td>8.8</td>
<td>388</td>
<td>10.0</td>
<td>0.070</td>
<td>0.033</td>
</tr>
<tr>
<td>Lockwood</td>
<td>21-Oct-03</td>
<td>1139</td>
<td>13.5</td>
<td>8.0</td>
<td>329</td>
<td>10.3</td>
<td>0.056</td>
<td>0.019</td>
</tr>
<tr>
<td>Lockwood</td>
<td>18-Nov-03</td>
<td>1251</td>
<td>7.8</td>
<td>8.3</td>
<td>416</td>
<td>12.9</td>
<td>0.031</td>
<td>0.077</td>
</tr>
<tr>
<td>Lockwood</td>
<td>16-Dec-03</td>
<td>1220</td>
<td>3.8</td>
<td>7.8</td>
<td>254</td>
<td>12.8</td>
<td>0.057</td>
<td>0.089</td>
</tr>
<tr>
<td>Lockwood</td>
<td>Average</td>
<td></td>
<td>11.5</td>
<td>8.0</td>
<td>462</td>
<td>11.2</td>
<td>0.047</td>
<td>0.104</td>
</tr>
<tr>
<td>Lockwood</td>
<td>Maximum</td>
<td></td>
<td>22.0</td>
<td>8.8</td>
<td>935</td>
<td>12.9</td>
<td>0.070</td>
<td>0.770</td>
</tr>
<tr>
<td>Lockwood</td>
<td>Minimum</td>
<td></td>
<td>3.7</td>
<td>7.8</td>
<td>245</td>
<td>9.2</td>
<td>0.030</td>
<td>0.001</td>
</tr>
</tbody>
</table>
### Truckee River 2003 Water Quality Data from TMWRF Files

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Time</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Flow, cfs</th>
<th>Dissolved Oxygen, mg/l</th>
<th>Phosphorus, as ortho P, mg/l</th>
<th>Nitrogen as Nitrate, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clark</td>
<td>15-Jan-03</td>
<td>830</td>
<td>5.6</td>
<td>7.9</td>
<td>367</td>
<td>10.6</td>
<td>0.043</td>
<td>0.031</td>
</tr>
<tr>
<td>Clark</td>
<td>12-Feb-03</td>
<td>753</td>
<td>4.0</td>
<td>8.0</td>
<td>349</td>
<td>11.7</td>
<td>0.072</td>
<td>0.065</td>
</tr>
<tr>
<td>Clark</td>
<td>12-Mar-03</td>
<td>815</td>
<td>9.4</td>
<td>7.7</td>
<td>334</td>
<td>9.4</td>
<td>0.057</td>
<td>0.047</td>
</tr>
<tr>
<td>Clark</td>
<td>16-Apr-03</td>
<td>1019</td>
<td>7.9</td>
<td>7.5</td>
<td>959</td>
<td>10.6</td>
<td>0.024</td>
<td>0.305</td>
</tr>
<tr>
<td>Clark</td>
<td>14-May-03</td>
<td>929</td>
<td>15.3</td>
<td>7.7</td>
<td>612</td>
<td>9.2</td>
<td>0.034</td>
<td>0.018</td>
</tr>
<tr>
<td>Clark</td>
<td>11-Jun-03</td>
<td>928</td>
<td>17.1</td>
<td>7.6</td>
<td>686</td>
<td>8.6</td>
<td>0.027</td>
<td>0.001</td>
</tr>
<tr>
<td>Clark</td>
<td>16-Jul-03</td>
<td>938</td>
<td>20.5</td>
<td>7.8</td>
<td>383</td>
<td>7.5</td>
<td>0.039</td>
<td>0.001</td>
</tr>
<tr>
<td>Clark</td>
<td>20-Aug-03</td>
<td>929</td>
<td>22.4</td>
<td>7.2</td>
<td>289</td>
<td>7.1</td>
<td>0.055</td>
<td>0.001</td>
</tr>
<tr>
<td>Clark</td>
<td>17-Sep-03</td>
<td>945</td>
<td>14.6</td>
<td>8.1</td>
<td>371</td>
<td>8.3</td>
<td>0.045</td>
<td>0.023</td>
</tr>
<tr>
<td>Clark</td>
<td>22-Oct-03</td>
<td>919</td>
<td>13.7</td>
<td>7.8</td>
<td>345</td>
<td>8.3</td>
<td>0.045</td>
<td>0.027</td>
</tr>
<tr>
<td>Clark</td>
<td>19-Nov-03</td>
<td>944</td>
<td>7.3</td>
<td>7.8</td>
<td>422</td>
<td>11.6</td>
<td>0.028</td>
<td>0.022</td>
</tr>
<tr>
<td>Clark</td>
<td>17-Dec-03</td>
<td>1031</td>
<td>3.2</td>
<td>7.7</td>
<td>273</td>
<td>12.4</td>
<td>0.060</td>
<td>0.061</td>
</tr>
<tr>
<td>Clark</td>
<td>Average</td>
<td></td>
<td>11.8</td>
<td>7.7</td>
<td>449</td>
<td>9.6</td>
<td>0.044</td>
<td>0.050</td>
</tr>
<tr>
<td>Clark</td>
<td>Maximum</td>
<td></td>
<td>22.4</td>
<td>8.1</td>
<td>959</td>
<td>12.4</td>
<td>0.072</td>
<td>0.305</td>
</tr>
<tr>
<td>Clark</td>
<td>Minimum</td>
<td></td>
<td>3.2</td>
<td>7.2</td>
<td>273</td>
<td>7.1</td>
<td>0.024</td>
<td>0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Time</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Flow, cfs</th>
<th>Dissolved Oxygen, mg/l</th>
<th>Phosphorus, as ortho P, mg/l</th>
<th>Nitrogen as Nitrate, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derby</td>
<td>15-Jan-03</td>
<td>915</td>
<td>5.5</td>
<td>7.9</td>
<td>331</td>
<td>10.5</td>
<td>0.040</td>
<td>0.052</td>
</tr>
<tr>
<td>Derby</td>
<td>12-Feb-03</td>
<td>819</td>
<td>3.8</td>
<td>8.1</td>
<td>26</td>
<td>11.3</td>
<td>0.043</td>
<td>0.097</td>
</tr>
<tr>
<td>Derby</td>
<td>12-Mar-03</td>
<td>857</td>
<td>9.7</td>
<td>7.9</td>
<td>13</td>
<td>9.3</td>
<td>0.051</td>
<td>0.050</td>
</tr>
<tr>
<td>Derby</td>
<td>16-Apr-03</td>
<td>1047</td>
<td>8.2</td>
<td>7.6</td>
<td>75</td>
<td>9.9</td>
<td>0.030</td>
<td>0.025</td>
</tr>
<tr>
<td>Derby</td>
<td>14-May-03</td>
<td>959</td>
<td>15.5</td>
<td>7.7</td>
<td>435</td>
<td>8.8</td>
<td>0.036</td>
<td>0.008</td>
</tr>
<tr>
<td>Derby</td>
<td>11-Jun-03</td>
<td>954</td>
<td>17.3</td>
<td>7.5</td>
<td>468</td>
<td>8.0</td>
<td>0.032</td>
<td>0.001</td>
</tr>
<tr>
<td>Derby</td>
<td>16-Jul-03</td>
<td>1000</td>
<td>20.2</td>
<td>7.7</td>
<td>141</td>
<td>6.4</td>
<td>0.044</td>
<td>0.001</td>
</tr>
<tr>
<td>Derby</td>
<td>20-Aug-03</td>
<td>1000</td>
<td>22.3</td>
<td>6.8</td>
<td>74</td>
<td>5.7</td>
<td>0.049</td>
<td>0.001</td>
</tr>
<tr>
<td>Derby</td>
<td>17-Sep-03</td>
<td>1014</td>
<td>14.6</td>
<td>7.9</td>
<td>82</td>
<td>7.5</td>
<td>0.046</td>
<td>0.014</td>
</tr>
<tr>
<td>Derby</td>
<td>22-Oct-03</td>
<td>951</td>
<td>13.8</td>
<td>7.6</td>
<td>82</td>
<td>7.5</td>
<td>0.052</td>
<td>0.049</td>
</tr>
<tr>
<td>Derby</td>
<td>19-Nov-03</td>
<td>1020</td>
<td>7.3</td>
<td>7.1</td>
<td>54</td>
<td>10.6</td>
<td>0.029</td>
<td>0.031</td>
</tr>
<tr>
<td>Derby</td>
<td>17-Dec-03</td>
<td>1102</td>
<td>3.0</td>
<td>7.3</td>
<td>48</td>
<td>12.1</td>
<td>0.051</td>
<td>0.079</td>
</tr>
<tr>
<td>Derby</td>
<td>Average</td>
<td></td>
<td>11.8</td>
<td>7.6</td>
<td>152</td>
<td>9.0</td>
<td>0.042</td>
<td>0.034</td>
</tr>
<tr>
<td>Derby</td>
<td>Maximum</td>
<td></td>
<td>22.3</td>
<td>8.1</td>
<td>468</td>
<td>12.1</td>
<td>0.052</td>
<td>0.097</td>
</tr>
<tr>
<td>Derby</td>
<td>Minimum</td>
<td></td>
<td>3.0</td>
<td>6.8</td>
<td>13</td>
<td>5.7</td>
<td>0.029</td>
<td>0.001</td>
</tr>
</tbody>
</table>
## Truckee River 2003 Water Quality Data from TMWRF Files

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Time</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Flow, cfs</th>
<th>Dissolved Oxygen, mg/l</th>
<th>Phosphorus, as ortho P, mg/l</th>
<th>Nitrogen as Nitrate, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painted Rock</td>
<td>15-Jan-03</td>
<td>935</td>
<td>5.5</td>
<td>7.9</td>
<td></td>
<td>11.4</td>
<td>0.046</td>
<td>0.041</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>12-Feb-03</td>
<td>849</td>
<td>4.4</td>
<td>8.2</td>
<td></td>
<td>12.5</td>
<td>0.035</td>
<td>0.028</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>12-Mar-03</td>
<td>923</td>
<td>11.1</td>
<td>7.9</td>
<td></td>
<td>10.5</td>
<td>0.060</td>
<td>0.076</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>16-Apr-03</td>
<td>1116</td>
<td>8.7</td>
<td>8.1</td>
<td></td>
<td>12.0</td>
<td>0.038</td>
<td>0.041</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>14-May-03</td>
<td>1026</td>
<td>15.9</td>
<td>8.0</td>
<td></td>
<td>9.7</td>
<td>0.036</td>
<td>0.008</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>11-Jun-03</td>
<td>1024</td>
<td>17.7</td>
<td>7.9</td>
<td></td>
<td>9.1</td>
<td>0.048</td>
<td>0.001</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>16-Jul-03</td>
<td>1030</td>
<td>20.6</td>
<td>8.1</td>
<td></td>
<td>8.7</td>
<td>0.040</td>
<td>0.009</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>20-Aug-03</td>
<td>1030</td>
<td>22.0</td>
<td>7.4</td>
<td></td>
<td>8.4</td>
<td>0.063</td>
<td>0.015</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>17-Sep-03</td>
<td>1040</td>
<td>14.2</td>
<td>8.4</td>
<td></td>
<td>9.5</td>
<td>0.035</td>
<td>0.013</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>22-Oct-03</td>
<td>1018</td>
<td>13.4</td>
<td>8.2</td>
<td></td>
<td>9.4</td>
<td>0.033</td>
<td>0.018</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>19-Nov-03</td>
<td>1047</td>
<td>7.2</td>
<td>8.2</td>
<td></td>
<td>12.8</td>
<td>0.040</td>
<td>0.017</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>17-Dec-03</td>
<td>1128</td>
<td>3.2</td>
<td>7.6</td>
<td></td>
<td>14.5</td>
<td>0.032</td>
<td>0.034</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.0</td>
<td>10.7</td>
<td>0.042</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22.0</td>
<td>14.5</td>
<td>0.063</td>
</tr>
<tr>
<td>Painted Rock</td>
<td>Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.2</td>
<td>8.4</td>
<td>0.032</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>15-Jan-03</td>
<td>1000</td>
<td>5.5</td>
<td>8.0</td>
<td>321</td>
<td>11.6</td>
<td>0.034</td>
<td>0.049</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>12-Feb-03</td>
<td>920</td>
<td>3.8</td>
<td>8.1</td>
<td>43</td>
<td>11.8</td>
<td>0.030</td>
<td>0.020</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>12-Mar-03</td>
<td>959</td>
<td>11.4</td>
<td>7.8</td>
<td>26</td>
<td>9.6</td>
<td>0.041</td>
<td>0.027</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>16-Apr-03</td>
<td>1215</td>
<td>9.5</td>
<td>8.0</td>
<td>103</td>
<td>10.8</td>
<td>0.018</td>
<td>0.008</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>14-May-03</td>
<td>1133</td>
<td>16.7</td>
<td>8.1</td>
<td>476</td>
<td>9.8</td>
<td>0.047</td>
<td>0.001</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>11-Jun-03</td>
<td>1132</td>
<td>18.3</td>
<td>8.1</td>
<td>655</td>
<td>9.2</td>
<td>0.035</td>
<td>0.001</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>16-Jul-03</td>
<td>1105</td>
<td>21.2</td>
<td>8.0</td>
<td>229</td>
<td>8.6</td>
<td>0.042</td>
<td>0.019</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>20-Aug-03</td>
<td>1115</td>
<td>23.2</td>
<td>7.6</td>
<td>166</td>
<td>7.9</td>
<td>0.061</td>
<td>0.001</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>17-Sep-03</td>
<td>1127</td>
<td>14.7</td>
<td>8.9</td>
<td>212</td>
<td>9.5</td>
<td>0.035</td>
<td>0.008</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>22-Oct-03</td>
<td>1106</td>
<td>14.2</td>
<td>7.8</td>
<td>279</td>
<td>9.5</td>
<td>0.046</td>
<td>0.029</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>19-Nov-03</td>
<td>1140</td>
<td>6.8</td>
<td>7.9</td>
<td>72</td>
<td>11.8</td>
<td>0.030</td>
<td>0.001</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>17-Dec-03</td>
<td>1222</td>
<td>3.0</td>
<td>7.9</td>
<td>62</td>
<td>13.8</td>
<td>0.040</td>
<td>0.001</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.4</td>
<td>10.3</td>
<td>0.038</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23.2</td>
<td>13.8</td>
<td>0.061</td>
</tr>
<tr>
<td>Wadsworth</td>
<td>Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.0</td>
<td>7.9</td>
<td>0.018</td>
</tr>
<tr>
<td>Site</td>
<td>Date</td>
<td>Time</td>
<td>Temperature °C</td>
<td>pH</td>
<td>Flow, cfs</td>
<td>Dissolved Oxygen, mg/l</td>
<td>Phosphorus, as ortho P, mg/l</td>
<td>Nitrogen as Nitrate, mg/l</td>
</tr>
<tr>
<td>-------</td>
<td>-----------</td>
<td>------</td>
<td>----------------</td>
<td>----</td>
<td>-----------</td>
<td>------------------------</td>
<td>------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Nixon</td>
<td>16-Jan-03</td>
<td>817</td>
<td>4.9</td>
<td>8.0</td>
<td>358</td>
<td>11.6</td>
<td>0.016</td>
<td>0.001</td>
</tr>
<tr>
<td>Nixon</td>
<td>13-Feb-03</td>
<td>811</td>
<td>4.6</td>
<td>7.9</td>
<td>59</td>
<td>11.2</td>
<td>0.021</td>
<td>0.055</td>
</tr>
<tr>
<td>Nixon</td>
<td>13-Mar-03</td>
<td>822</td>
<td>10.3</td>
<td>7.9</td>
<td>38</td>
<td>8.8</td>
<td>0.018</td>
<td>0.010</td>
</tr>
<tr>
<td>Nixon</td>
<td>17-Apr-03</td>
<td>918</td>
<td>9.7</td>
<td>7.9</td>
<td>162</td>
<td>10.3</td>
<td>0.019</td>
<td>0.005</td>
</tr>
<tr>
<td>Nixon</td>
<td>15-May-03</td>
<td>917</td>
<td>16.4</td>
<td>7.7</td>
<td>579</td>
<td>10.5</td>
<td>0.046</td>
<td>0.024</td>
</tr>
<tr>
<td>Nixon</td>
<td>12-Jun-03</td>
<td>914</td>
<td>18.8</td>
<td>7.7</td>
<td>634</td>
<td>8.5</td>
<td>0.034</td>
<td>0.001</td>
</tr>
<tr>
<td>Nixon</td>
<td>17-Jul-03</td>
<td>950</td>
<td>23.8</td>
<td>8.8</td>
<td>218</td>
<td>8.9</td>
<td>0.053</td>
<td>0.001</td>
</tr>
<tr>
<td>Nixon</td>
<td>21-Aug-03</td>
<td>1305</td>
<td>24.7</td>
<td>7.5</td>
<td>203</td>
<td>8.1</td>
<td>0.056</td>
<td>0.010</td>
</tr>
<tr>
<td>Nixon</td>
<td>18-Sep-03</td>
<td>930</td>
<td>14.5</td>
<td>8.2</td>
<td>233</td>
<td>9.3</td>
<td>0.038</td>
<td>0.012</td>
</tr>
<tr>
<td>Nixon</td>
<td>23-Oct-03</td>
<td>921</td>
<td>14.2</td>
<td>7.9</td>
<td>285</td>
<td>9.0</td>
<td>0.037</td>
<td>0.025</td>
</tr>
<tr>
<td>Nixon</td>
<td>20-Nov-03</td>
<td>946</td>
<td>6.5</td>
<td>7.6</td>
<td>68</td>
<td>11.8</td>
<td>0.043</td>
<td>0.010</td>
</tr>
<tr>
<td>Nixon</td>
<td>18-Dec-03</td>
<td>1205</td>
<td>2.5</td>
<td>8.1</td>
<td>73</td>
<td>13.7</td>
<td>0.020</td>
<td>0.001</td>
</tr>
<tr>
<td>Nixon</td>
<td>Average</td>
<td></td>
<td>12.6</td>
<td>7.9</td>
<td>243</td>
<td>10.1</td>
<td>0.033</td>
<td>0.013</td>
</tr>
<tr>
<td>Nixon</td>
<td>Maximum</td>
<td></td>
<td>24.7</td>
<td>8.8</td>
<td>634</td>
<td>13.7</td>
<td>0.056</td>
<td>0.055</td>
</tr>
<tr>
<td>Nixon</td>
<td>Minimum</td>
<td></td>
<td>2.5</td>
<td>7.5</td>
<td>38</td>
<td>8.1</td>
<td>0.016</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Explore Nevada’s Amazing Wetlands