TEACHER GUIDE SAMPLER

WATER QUALITY SAMPLE PACK

CONTENTS:
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Water Quality

MWD

The Qualities and Science of Water

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

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The case studies were field-tested by more than 110 secondary science and social studies teachers from throughout Metropolitan's service area. MWD's Outreach and Water Quality Division staffs were critically important in round upon round of revisions and proofing. The final product is a result of the program development team incorporating and balancing the input, observations, reaction and suggestions from member agencies, education advisors, water quality and outreach division staff, teachers and students. Our sincere thanks go to all those involved in this challenging and important water education project.

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What's in the Teacher's Guide

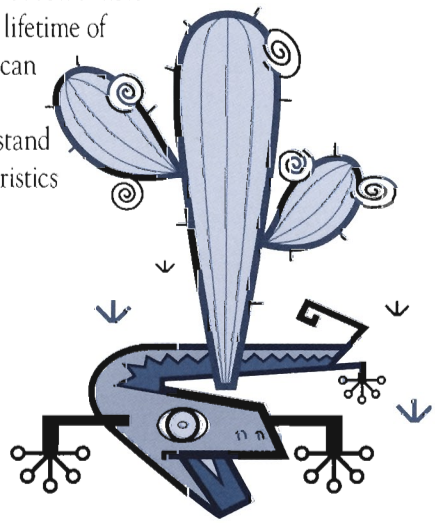
We have designed this program to provide a multi-faceted approach to the teaching of water quality. By combining up-to-date information about water quality and the related science with inquiry-based methods, we hope to challenge and help enlighten our region's students.

The Water Quality Program

Southern California is a densely populated, heavily industrialized, semiarid desert region with limited local water supplies. About two-thirds of our water must be imported. It comes from the mountains of Northern California, the Colorado River and the Owens Valley. The remaining one-third of the water we use comes from local sources – the groundwater and surface water that exist naturally within Southern California. That water, *like all the fresh water on earth*, is a precious natural resource, and we must all share the responsibility of ensuring its high-quality. Because of the unique conditions which are so much a part of Southern California, the Metropolitan Water District of Southern California has developed this school program on water quality.

The Goal of the Program

- We believe it is important for students to appreciate water – both as a natural resource and as a miracle of nature:
  - to know about sources and source protection;
  - to understand distribution and treatment;
  - to contemplate their role in using water wisely, which, we believe, will help develop a sense of stewardship.
- We hope that students will understand that the vitality of our community and our society depends upon the quality of our water.
- We are certain that the water issues discussed in this program will become more complex during the lifetime of your students. They can better safeguard its future if they understand its physical characteristics and social impacts.



PROGRAM OBJECTIVES

Our principal objective is to nurture a sense of respect for the vulnerability and fragility of our water resources in relation to water quality, especially in light of our densely populated, urban desert region.

To meet this overriding objective, students will:

- Use hands-on, inquiry-based, engaging investigations;
- Gain familiarity with some of the fundamental qualities of water, including its density, its role as the universal solvent, its high surface tension and the water cycle and water's self-cleaning properties;
- Devise their own experiments to experience and learn about such fundamental water quality parameters as dissolved oxygen, pH, turbidity, total dissolved solids, hardness, nutrients, taste and odor and microbiology;
- Examine the role of watersheds, aquifers and nature in storing and cleaning water;
- Apply objective, scientific information by analyzing data and grappling with difficult public policy issues related to water quality and water use;
- Model gene probe testing and DNA to show how water is tested for the presence of specific organisms in the public water supply.

OVERVIEW

This water quality program incorporates different water-based themes and uses a variety of teaching methods to accommodate different types of content. The themes and teaching methods have been selected to meet the objectives of the California Science Content Standards and the History/Social Science Content Standards.

In using this program, students construct investigations and experiments to examine their theories and hypotheses. In learning about how water resources affect the ecosystem and human society, students undertake critical thinking and decision making.

The program consists of three sections which are described here.

The Qualities of Water introduces basic water concepts. In the "Think About This" sections, students are gradually introduced to inquiry-based methods that challenge them to think about and demonstrate a specific water quality concept. The chapter culminates in two investigations on testing water and cleaning up pollution which serve as a transition to the next section.

Basic Science of Water Quality covers eight essential concepts and measures related to water quality. Each of the eight student sections contains two components: a problem and inquiry-based investigation, and a related fact sheet. Each investigation poses a question to students, which they will attempt to answer by designing an appropriate experiment. Each fact sheet is a primer of the basic information the students may use to develop the investigation.

Applying Science to Your Life and the Development of Public Policy includes three separate units: "Watersheds and the Environment," "Protecting the Public Health" and "Water Quality and Rights." They focus on social applications of water quality science. Providing high quality water is not easy and has spawned many public policy arguments. These debates are based on interpretation of scientific evidence, conflicts of interests, trade-offs of one good for another and the cost of eliminating all risks and protecting our most vulnerable populations.

These investigations, thus, give your students an opportunity to interpret scientific data, weigh the pros and cons of different options and model the kind of public debate that forms the basis of our democracy. The investigations and case studies in these chapters involve model building, problem solving, cooperative groups, risk assessment, decision making, persuasive reasoning in speaking and writing, critical reading and critical thinking.

PEDAGOGY

In the student investigations, we present students with a problem to solve but do not give them the explicit procedure or "recipe" for solving it. Rather, we challenge them to:

- Develop a hypothesis about what they expect to happen (called "*Make a prediction*") in which they can use their prior knowledge;
- Design a procedure to test that hypothesis (called "*Figure it out*");
- Compare the results of the experiment with the hypothesis, in which they can reflect, confirm, modify and expand their results (called "*What does it mean?*");
- Assess by drawing conclusions about the results and hypothesis, and if necessary, revise the hypothesis and/or revise the experiment (called "*Make connections*").

The inquiry-based/constructivist method challenges students to:

1. Bring prior knowledge to the surface
2. Explore
3. Reflect
   a. confirm understanding
   b. expand understanding
   c. modify understanding
4. Apply new understanding and make learning relevant

The inquiry-based model is process driven. Students design and do research; then they develop ideas. Lead them to explore. Allow them to interpret their available data on their own. There are many approaches to solving problems, and your students' approaches may be creatively different. By following this model, investigations will take longer, but student understanding will be deeper and richer.

To facilitate your classroom management, we provide sample experimental procedures that you may want to use. Students do not need to develop the same procedures as the ones suggested. If students obtain conflicting or contradictory results, discuss the possible sources of error with them so they can learn from their mistakes.

KEEPING A JOURNAL

An important part of the inquiry-based approach is having students keep journal records of what they do and observe. They are, in effect, individual science diaries. We recommend that your students keep a journal to record their hypotheses, modifications to their understandings, notes on procedures, observations and data as they participate in the program. In using the journal, emphasize the importance of proper documentation as in real-life science. Your students should learn to record whatever they do, when they do it and what they observe in an organized way.

Students should also use their journals for responding to questions posed in the investigations. A journal provides a vehicle for maintaining a portfolio of progress. Having students keep these journals in three-ring binders allows you to collect individual pages for grading and evaluation. If students use binders, they can include the worksheets from the investigations.

A TOOL FOR TEACHING ACROSS THE CURRICULUM

In addition to extensive science, this program also contains considerable mathematics, social studies and language arts. Thus, it is an ideal tool for team teaching and for teaching across the curriculum.

ASSESSING STUDENT PERFORMANCE

① Review and assess the students' journals.

② Use the set of questions in the Teacher's Guide at the end of "Basic Science of Water Quality" and throughout "Applying Science to Your Life and the Development of Public Policy" as unit assessments or to ensure student comprehension during each investigation.

A General Correlation of Water Quality: The Qualities and Science of Water with the Science Content Standards

GRADE 7: FOCUS ON LIFE SCIENCE

- the nucleus is the repository for genetic information in plant and animal cells
- DNA is the genetic material of living organisms
- traits may be modified by environmental influences
- light travels in straight lines except when the medium it travels through changes

GRADE 8: FOCUS ON PHYSICAL SCIENCE

- all matter is comprised of elements
- compounds are formed by combining two or more different elements
- compounds have properties that are different from the constituent elements
- how to determine whether a solution is acidic, basic or neutral
- chemical compounds interact to form products with different chemical properties

GRADES 9-12

- the importance of water to society, the origins of California's fresh water, the relationship between supply and need
- the geology of California underlies the state's wealth of natural resources
- oxygen cycles via photosynthesis and respiration
- how to analyze changes in an ecosystem as a result of human activity
- how to apply base-pairing rules to explain precise copying of DNA
- temperature, pressure, and surface area affect the dissolving process
- how to use the pH scale to characterize acid and base solutions
- the observable properties of acids and bases
- in a liquid the inter-molecular forces are weaker than in a solid

GRADES 7-12: INVESTIGATION AND EXPERIMENTATION

- plan and conduct a scientific investigation to test a hypothesis
- investigate a science-based societal issue by researching the literature, analyzing data and communicating findings
- communicate the logical connection among hypothesis, science concepts, tests conducted, data collected and conclusions drawn from scientific evidence
- analyze situations and solve problems that require combining and applying concepts from more than one area of science

A General Correlation of Water Quality: The Qualities and Science of Water with the History/Social Science Content Standards

GRADE 11: UNITED STATES HISTORY AND GEOGRAPHY

- the impact, need and controversies associated with environmental conservation and protection

GRADE 12: PRINCIPLES OF AMERICAN DEMOCRACY

- how public policy is formed
- the role of electronic, broadcast, print media, and the Internet as means of communication in American politics
- how public officials use the media to communicate with the citizenry and to shape public opinion

PRINCIPLES OF ECONOMICS

- the factors that may cause the costs of government actions to outweigh the benefits
- the casual relationship between scarcity and the need for choices
- the relationship of the concept of incentives to the law of supply and the relationship of the concept of incentives and substitutes to the law of demand
- how the role of government in a market economy often includes addressing environmental concerns and protecting consumer rights

HISTORICAL AND SOCIAL SCIENCES ANALYSIS SKILLS: HISTORICAL INTERPRETATION

- students analyze human modifications of landscapes and examine the resulting environmental policy issues
- students show the connections, casual and otherwise, between particular historical events and larger social, economic and political trends and developments

APPLICATIONS & INVESTIGATIONS

The curriculum contains eight inquiry-based investigations which encourage students to develop their own experiments. Doing so will help them develop their own independent research skills. The applications provide students with the opportunity to interpret scientific data and model public debate. In additon, students are challenged to weigh the pros and cons of different options and to justify their conclusions.

Protecting the Public Health

APPLICATION STUDY 3

Source Protection and Body Contact

BRIEF GLIMPSE

In simple terms, "body contact" means swimming in water supply reservoirs. Choosing to allow or not allow that activity raises the issue of "trade-offs" (which students began to consider in Part 2). When trade-offs intersect with public policy issues, they can lead to impassioned debates, as your class may experience in this "Town Meeting" activity. In this decision-making activity, groups of students develop arguments for their positions and weigh trade-offs.

OVERVIEW OF "SOURCE PROTECTION AND BODY CONTACT"

- Source protection means efforts aimed at preventing microbial and chemical contamination of the water supply.
- It is better to prevent pollution in a watershed than to purify water that has become contaminated because:
  1) it saves money;
  2) water treatment cannot cleanse all contaminants; and
  3) there are negative side effects to the heavy use of disinfection.
- Whether to allow "body contact" (exposure of a person's body to a water supply) is a heated issue in some communities where people would like to be able to swim in the public drinking water supply.
- Water agencies would sometimes like to ban body contact in drinking supplies because it increases the "pathogen loading," which is the quantity of disease-causing microorganisms that enter the water through body contact or other sources of contamination.

TIME REQUIRED

Two class periods.

THE DATA ABOUT BODY CONTACT

Groups may use this data in preparing their statements and/or presentations:

AVERAGE PATHOGEN LOADING (which peaks at this level after 20 minutes of exposure)	
ADULT: .14 grams	CHILD: >.14 grams

INVESTIGATION

Body Contact Town Meeting

Getting started

Before beginning the activity, review the function of town meeting government and its history in this country.

PROCEDURE

Before dividing your class into different interest groups, read over the descriptions of their positions and choose appropriate students for several of the positions. For instance, the moderator needs to be responsible and able to control the group. If need be, you can fill this position. The Public Health Official needs to be comfortable with math so he/she can provide statistics about the predicted pathogen loading and increasing disease based on the predicted number of swimmers. This official can have a partner to help prepare charts for the meeting.

① Provide at least 30 minutes for groups and students to complete their group worksheets before the meeting and their individual worksheet after the meeting and before the vote.

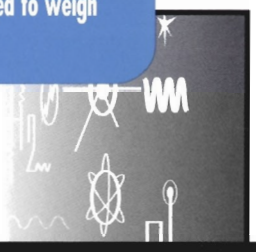
② Following the meeting, organize a class vote on whether to accept or reject the proposal to open the reservoir for swimming.

③ Following the vote, have the class summarize pros and cons of their united decisions.

④ Discuss the town meeting process. Do they think it "works?" Is it a fair way to decide public policy?

⑤ Discuss any local issues that relate to body contact, such as allowing jet skiing on a reservoir.

Application Study 3: Source Protection and Body Contact is an example of an activity that requires students to analyze and interpret scientific data to reach an objective conclusion.



FACT SHEET 1

Dissolved Oxygen (DO) and pH

Part 1: Dissolved Oxygen

Dissolved oxygen (DO) is an important measure of the quality of lakes, ponds, rivers and the ocean. Fish and plants cannot live without enough oxygen. When you breathe, you inhale air and your blood extracts the oxygen. When fish breathe, they force water through their gills and their blood extracts the oxygen. Plants produce oxygen during the day when the sun shines and photosynthesis is taking place, but the also use oxygen at night when there is no sun.

Sources of Dissolved Oxygen in Water

1. *Plant life:* Plants are the primary source of oxyge in water – as they are on land. When the sun shines on green plants, they undergo photosynthesis and produce oxygen. During photosynthesis, plants take in energy from

FACT SHEETS

Each investigation has a fact sheet containing enough basic research information for the students to construct their experiment. Below is an overview of the material in the student fact sheets.

FACT SHEET 1: DISSOLVED OXYGEN (DO) AND PH

- Dissolved oxygen is an important measure of healthy water quality.
- Healthy oxygen levels are essential to a thriving ecosystem.
- The main sources of DO in water are photosynthesis and turbulence.
- During the diurnal cycle, DO and pH levels in water change as plants photosynthesize.
- pH is a measure of the hydrogen ions present in a substance.

FACT SHEET 2: TURBIDITY

- Turbidity is the measure of the water's cloudiness caused by suspended, undissolved solids.
- The main treatments for turbidity are settling and filtration.
- Turbidity affects water quality on both aesthetic and health levels: it is unappealing, and the materials that cause turbidity also provide good habitat for microorganisms, some of which maybe pathogenic and difficult to kill with conventional disinfection.

FACT SHEET 3: TOTAL DISSOLVED SOLIDS AND SALINITY

- Water in nature contains dissolved minerals such as sodium, calcium, magnesium and potassium.
- The measurement of these minerals is called "Total Dissolved Solids" or TDS.
- TDS is significant for water quality because it relates to the water's level of dissolved minerals. TDS levels determine whether water is considered fresh, brackish or salt water.
- Many of these solids are salts, and when salts dissolve in water, they conduct electricity. TDS can be tested by measuring the water's electrical conductivity.

FACT SHEET 4: HARDNESS

- The term "hard water" describes water with high levels of calcium and magnesium. "Soft water" has fewer of these minerals.
- Students may have experiences with these features of hard water: soap or detergent does not lather very much in hard water, hard water leaves a ring of scum around the bathtub and hard water causes scale to build up inside pipes.

FACT SHEET 5: NUTRIENTS

- Nutrients include chemicals such as nitrogen, phosphates and potassium that plants need to grow and stay healthy.
- The natural sources for nutrition include dead organic material and animal wastes.
- In an unhealthy ecosystem, too many nutrients cause too much plant life to develop, leading to algal blooms and eutrophication – the gradual death of a body of water.

FACT SHEET 6: TASTE AND ODOR

- Algae can make drinking water smell and taste bad. Although this algae is harmless to human health, water agencies try to eliminate it because of its unpleasant effects.
- Reservoirs stratify into layers and the algae that cause taste problems in drinking water do not grow uniformly in all layers. Water agencies can adjust their intake so they only withdraw water from layers without algae.

FACT SHEET 7: MICROORGANISMS: SIZE, SCALE AND FILTRATION

- Water provides a perfect environment for a remarkable number of microorganisms, some of which are disease-causing pathogens.
- The bacterium *Escherichia coli* is used as an indicator species in water quality tests for microorganisms.
- Filtration can eliminate most microorganisms, reducing the amount of disinfection needed and the harmful side effects.

FACT SHEET 8: *CRYPTOSPORIDIUM* AND GENETIC TESTS

- *Cryptosporidium* parvum causes the disease cryptosporidiosis, which may be fatal to people with compromised immune systems or who are very young or very old.
- *Cryptosporidium* parvum is a challenge to public health and water treatment because as a parasitic oocyst, it has a protective shell that allows it to survive a long time until it is ingested by a host.
- Microbiology and genetics offer a promising research approach to testing for *Cryptosporidium*.
- Genes are the molecular instructions or blueprints for the growth and development of an organism.

sunlight and convert carbon dioxide and water into food (carbohydrates) and oxygen. At night, these plants consume oxygen and release carbon dioxide as a byproduct, just as humans do.

The tiniest plants, called *phytoplankton*, produce the bulk of the oxygen that exists both in the water and in the atmosphere. Phytoplankton is part of the mix of microscopic plants and animals we call *plankton*.

In addition to providing oxygen, phytoplankton serves two other important services. It is the bottom of the food chain, and it recycles the chemicals and nutrients in the water into forms that other plants and animals can use. A body of water without phytoplankton cannot support life, clean itself or provide oxygen for living creatures.

Turbulence: When water mixes with air, like in a waterfall or a rushing stream, it absorbs oxygen from the air. As a result, moving water usually has more oxygen than standing water. Fast-moving streams, waterfalls and ocean surf can contain a lot of oxygen. Likewise, water near the surface of a lake or pond has higher oxygen levels on windy days.

tors That Affect the Oxygen Level of Water

Temperature: Warm water holds less oxygen than cool water. Thus, the same healthy stream will have lower DO levels in the summer than in the winter. Sometimes, high summer temperatures can reduce the oxygen level so much that fish suffocate. To make matters worse, fish metabolism usually increases in warmer temperatures, so fish need more oxygen just when there is less of it.

MISSION STATEMENT

The mission of the Metropolitan Water District of Southern California is to provide its service area with adequate and reliable supplies of high-quality water to meet present and future needs in an environmentally and economically responsible way.

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