II INTRODUCTION TO WATER

1. Water: A Remarkable – Yet Limited – Substance

All the water that has ever or will ever exist on earth is already here. Ninety-seven percent of that water is in the world's oceans; two percent is frozen; and less than one percent of the world's water is accessible fresh water! It is imperative that we zealously protect the earth's water supply. Once a water source, such as a river or ground water aquifer, is polluted, it could remain contaminated for a very long time. Protecting water is of the utmost importance because life on earth could not exist without water.

Water is one of the few substances on earth that may be observed in three forms simultaneously: solid, liquid and gas. It is not uncommon to look at a pond or stream in winter and see all three forms together: ice along the shore, liquid in the middle, and vapor rising from the surface or floating overhead in the form of clouds.

Water is the only substance that expands when it freezes rather than contracting. A volume of solid steel weighs more than an equal volume of molten steel. Ice, on the other hand, floats. Imagine how the world would differ if ice were heavier than water: as bodies of water froze, the ice would sink, sending warmer water to the surface where it too would freeze. Whole bodies of water would freeze solid, and life on earth as we know it could never have evolved. As it is, fortunately, a floating layer of ice protects underwater life from the severe cold rather than threatening it.

Water has an extremely high heat capacity. It can absorb and retain a great deal of thermal energy without undergoing dramatic temperature changes. As a result, oceans serve as highly effective buffers, protecting the earth's land mass from extreme temperature changes despite extreme fluctuations in the atmospheric climate.

Water has the highest surface tension of any liquid on earth except mercury, so it supports objects that are heavier than itself. Thus insects can "walk on water." This high surface tension also promotes "capillary action," which is why plants and trees can pull water "up" through their roots with no visible effort, seeming to defy gravity.

Water is the "universal solvent." What we generally think of as "water," therefore, is really a solution of many different chemicals. As a solvent, water is inert, so few of the chemicals that dissolve in water actually change its chemistry. As a result, water is a truly "renewable" resource that can almost always be separated from its solutes and salvaged for reuse.

2. The Many Types of Water

"Fresh" and "salt," "pure" and "clean" are all adjectives used to describe water. These distinctions are very important in a study of water quality.

The major division in the world of water is between "fresh" water and "salt" water. The terms address the total quantity of salts dissolved in the water. Sea water contains 35 parts per thousand (ppt) of dissolved salts. Fresh water contains measurable amounts of salts, but less than would make the water taste salty or destroy the quality of crop land. Many people consider water to be "fresh" if it contains less that one part per thousand of dissolved salts.

"Brackish" water contains more dissolved salts than "fresh" water and less than "sea" water. It has salt concentrations between 1 ppt and 35 ppt and is generally found in areas where fresh water and sea water meet, such as *estuaries*, which are mixing areas where rivers empty into the ocean. This program covers the testing of any type of water found in nature: fresh water, brackish water, and sea water.

"Pure" water is H_2O. Steam and distilled water are virtually "pure." When water evaporates in nature, it is pure for an instant, but contaminants immediately begin to dissolve in it. As a result, pure water may be produced in a laboratory, but it is virtually impossible to find in nature.

"Clean" water is a subjective term, the meaning of which depends on the intended use

of the water and on state and federal regulations. Drinking water may be considered "clean" if it does not contain toxic contamination or harmful bacteria. Lake or sea water may be considered "clean" if it appears clean (that is, it has low turbidity, or it allows a lot of light to pass through it); it may be considered "clean" if the level of toxicants in the water is sufficiently low to allow fish populations to thrive; or it may be considered "clean" if there are no unsightly algae blooms. In other words, "clean" has meaning in terms of a specific use, and it applies equally well to fresh and salt water.

3. Why Is Water Quality Important and What Factors Affect Water Quality?

All life forms on earth depend on water for survival. When the quality of the water is compromised, they may have problems surviving. Maintaining water quality, therefore, is essential to maintaining life on earth.

Almost everything we do affects water quality. Even our use of water at home can have a significant impact.

At home...

- If we use water wastefully, we could deplete the region's water supplies. As the supplies diminish, the available water has less ability to dilute minerals and contaminants. Good water conservation practices are an important accompaniment to a water quality testing program such as this one.
- Lawn and garden chemicals - fertilizers, insecticides and herbicides - can run off into the storm drains and local waterways during storms.
- Household hazardous wastes, such as solvents, paints, waste oils, and other chemicals flushed down the drain or poured into storm drains quickly make their way to local waterways. The sewer system is designed to handle sewage - human and domestic waste products - not hazardous or toxic materials.
- Improperly maintained or overused septic systems or cesspools allow excess nitrogen and bacteria to enter the region's water supplies.

In society...

- Larger scale lawn and garden chemical runoff - from parks, golf courses, and crop lands - enters the region's waterways during each storm, raising the level of nutrients, such as nitrogen or phosphates, altering the pH, or contributing toxic chemicals, such as pesticides, that might harm the environment.

- Each rain washes road debris, such as oil, bits of tire rubber, and gasoline into the local waterways. This debris adds hydrocarbons and solids to the water, and often raises the turbidity.

- Industrial pollution threatens our waterways, adding a variety of contaminants, often in high concentrations, to our region's water.

4. How Does Water Quality Testing Differ in Fresh Water and Salt Water?

Whether your sample is fresh, sea, or brackish water, all of the tests contained in this kit work the same. The results of the test, however, may vary.

Temperature: Because of the ocean's size and currents, temperature ranges in sea water will generally be less dramatic than in inland water. Thermal pollution (from such sources as industrial cooling) will be apparent in both sea water and fresh water.

Dissolved Oxygen, Biochemical Oxygen Demand, pH, Turbidity: Temperature, water chemistry, sunlight, and plant life affect these factors.

Nitrates: Elevated nitrate levels generally result from chemical fertilizers. While nitrates are present in sea water, particularly in bays, estuaries, and harbors with sewage or agricultural runoff, they will generally be higher in fresh water, particularly around farms, parks, golf courses, and areas with many septic systems.

Total Coliform Bacteria: Coliform bacteria come from the intestines of warm-blooded animals and are found in both fresh water and sea water. You will probably find coliform bacteria in most samples of untreated water. This kit uses a simple presumptive test that merely indicates the presence of - not the quantity of - total coliform bacteria. Thus, you will not be able to discern whether or not they exist at dangerous levels.

Total Dissolved Solids and Salinity: Both of these tests use the same digital meter, but the procedures and the results differ. In fresh water, the total dissolved solids will be less than 1 ppt (1,000 ppm). Sea water from the open ocean has a salt concentration of about 35 ppt in the open ocean. (In Boston Harbor, the salinity varies from about 20 to 30 ppt because of tidal flows and the emptying of rivers.) Brackish water falls between the sea water and fresh water. The digital tester has a range of only about 950 ppm (or 1900µs), so sea water and brackish water must be diluted prior to testing.