1. PUBLIC HEALTH STATEMENT

This public health statement tells you about cyanide and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. EPA then places these sites on the National Priorities List (NPL) and targets them for federal long-term cleanup activities. Cyanide has been found in at least 471 of the 1,647 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the number of sites at which cyanide is found could increase as more sites are evaluated. This information is important because these sites may be sources of exposure, and exposure to this substance can harm you.

When a substance is released either from a large area, such as an industrial plant, or a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be exposed to a substance only when you contact it—by breathing, eating, or drinking the substance or by skin contact.

Many factors will determine whether exposure to cyanide will harm you. These factors include the dose (how much), the duration (how long), and the way you contacted it. You also must consider any other chemicals to which you are exposed and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT ARE CYANIDES?

Cyanides are compounds (substances formed by the joining of two or more atoms) that can both occur naturally or be man-made. Many cyanides are powerful and rapid-acting poisons. Hydrogen cyanide, which is a gas, and the simple cyanide salts (sodium cyanide and potassium cyanide) are common examples of cyanide compounds. Certain bacteria, fungi, and algae can produce cyanide, and cyanide is found in a number of foods and plants. In certain plant foods, including almonds, millet sprouts, lima beans, soy, spinach, bamboo shoots, and cassava roots (which are a major source of food in tropical countries), cyanides occur naturally as part of

sugars or other naturally-occurring compounds. However, the edible parts of plants that are eaten in the United States, including tapioca which is made from cassava roots, contain relatively low amounts of cyanide.

Many of the cyanides in soil and water come from industrial processes. The major sources of cyanides in water are discharges from some metal mining processes, organic chemical industries, iron and steel plants or manufacturers, and publicly owned wastewater treatment facilities. Other cyanide sources include vehicle exhaust, releases from certain chemical industries, burning of municipal waste, and use of cyanide-containing pesticides. Much smaller amounts of cyanide may enter water through storm water runoff where road salts are used that contain cyanide. Cyanide in landfills can contaminate underground water. Hydrogen cyanide, sodium cyanide, and potassium cyanide are the forms of cyanide most likely to be in the environment as a result of industrial activities. Hydrogen cyanide is a colorless gas with a faint, bitter, almond-like odor. Sodium cyanide and potassium cyanide are both white solids with a slight, bitter, almond-like odor in damp air. Cyanide salts and hydrogen cyanide are used in electroplating, metallurgy, organic chemicals production, photographic developing, manufacture of plastics, fumigation of ships, and some mining processes. Hydrogen cyanide has also been used in gas-chamber executions and as a war gas. Chlorination of water contaminated with cyanide produces the compound cyanogen chloride. Four incidents of cyanide in soil resulted from disposal of cyanide-containing wastes in landfills and use of cyanide-containing road salts. See Chapters 4 and 5 for more information about physical and chemical properties and about production and use of cyanide.

Thiocyanates are a group of compounds formed from a combination of sulfur, carbon, and nitrogen. Thiocyanates are found in various foods and plants; they are produced primarily from the reaction of free cyanide with sulfur. This reaction occurs in the environment (for example, in industrial waste streams that contain cyanide) and in the human body after cyanide is swallowed or absorbed. Thiocyanate is the major product formed from cyanide that passes into the body as the body attempts to rid itself of cyanide. Although thiocyanates are less harmful than cyanide in humans, they are known to affect the thyroid glands, reducing the ability of the gland to produce hormones that are necessary for the normal function of the body.

Ammonium thiocyanate is used in antibiotic preparations, pesticides, liquid rocket fuels, adhesives, and matches. It also is used in photographic processes, to improve the strength of silks, and as a weed killer.

Thiocyanates are present in water primarily because of discharges from coal processing, extraction of gold and silver, and mining industries. Thiocyanates in soil result from direct application of herbicides (weed killers), insecticides, and rodenticides and from disposal of byproducts from industrial processes. Less important sources include release from damaged or decaying tissues of certain plants, such as mustard, kale, and cabbage.

1.2 WHAT HAPPENS TO CYANIDE WHEN IT ENTERS THE ENVIRONMENT?

Cyanide enters air, water, and soil from both natural processes and industrial activities. Airborne cyanide is generally far below levels that would cause concern. In air, cyanide is present mainly as gaseous hydrogen cyanide. A small amount of cyanide in air is present as fine dust particles. This dust eventually settles over land and water. Rain and snow help remove cyanide particles from air. The gaseous hydrogen cyanide is not easily removed from the air by settling, rain, or snow. The half-life (the time needed for half of the material to be removed) of hydrogen cyanide in the atmosphere is about 1–3 years. Most cyanide in surface water will form hydrogen cyanide and evaporate. However, the amount of hydrogen cyanide formed is generally not enough to be harmful to humans. Some cyanide in water will be transformed into less harmful chemicals by microorganisms (plants and animals of very small size), or will form a complex with metals, such as iron. The half-life of cyanide in water is not known. Cyanide in water does not build up in the bodies of fish.

Cyanides are fairly mobile in soil. Once in soils, cyanide can be removed through several processes. Some cyanide compounds in soil can form hydrogen cyanide and evaporate, whereas some cyanide compounds will be transformed into other chemical forms by microorganisms in soil. Consequently, cyanides usually do not seep into underground water. However, cyanide has been detected in underground waters of a few landfills and industrial waste disposal sites. At the

high concentrations found in some landfill leachates (water that seeps through landfill soil) and in the wastes stored in some disposal sites, cyanide becomes toxic to soil microorganisms. Because these microorganisms can no longer change cyanide to other chemical forms, cyanide is able to passes through soil into underground water. See Chapters 5 and 6 for more information about what happens to cyanide in the environment.

Less is known about what happens to thiocyanate when it enters the environment. In soil and water, thiocyanate is changed into other chemical forms by microorganisms. At near-normal temperatures (30 °C), evaporation or sorption (binding to soil) does not seem to be important for thiocyanate in soil. See Chapters 5 and 6 for more information about what happens to thiocyanate in the environment.

1.3 HOW MIGHT I BE EXPOSED TO CYANIDE?

You can be exposed to cyanides by breathing air and drinking water, touching soil or water containing cyanide, or eating foods that contain cyanide. Many plant materials, such as cassava roots, lima beans, and almonds, naturally contain low-to-moderate levels of cyanide. The concentration of hydrogen cyanide in unpolluted air is less than 0.2 parts of hydrogen cyanide per million (ppm; 1 ppm is equivalent to 1 part by volume of hydrogen cyanide in a million parts by volume of air). Cyanide concentration in drinking water ranges from 0.001 to 0.011 ppm (1 ppm is equivalent to 1 part by weight in 1 million parts by volume of water) in the United States and Canada. Cyanogen chloride, which can be formed in the process of water chlorination, has been found at concentrations ranging from 0.00045 to 0.0008 ppm in drinking water from 35 U.S. cities. We do not know how many people in the general population of the United States are exposed to significant amounts of cyanide from eating foods that naturally contain it. Smoking is probably one of the major sources of cyanide exposure for people who do not work in cyanide-related industries. Breathing smoke-filled air during fires also may be a major source of cyanide exposure. People who live near hazardous waste sites that contain cyanide may be exposed to higher amounts of cyanide than the general population.

Cyanide is used or produced in various occupational settings where activities include electroplating, some metal mining processes, metallurgy, metal cleaning, certain pesticide applications, tanning, photography and photoengraving, firefighting, and gas works operations. Cyanide also is used in some dye and pharmaceutical industries. The National Occupational Exposure Survey (NOES) has estimated the numbers of workers potentially exposed to the following cyanides: 4,005 to hydrogen cyanide; 66,493 to sodium cyanide; 64,244 to potassium cyanide; 3,215 to potassium silver cyanide; 3,606 to calcium cyanide; 22,339 to copper (I) cyanide; and 1,393 to cyanogen chloride. See Chapter 6 for more information about exposure to cyanide.

You can be exposed to thiocyanate in the same ways that you can be exposed to cyanide. Exposure to cyanide will expose you to thiocyanate because cyanide changes to thiocyanate in your body, which is considerably less toxic than cyanide. Many foods (plants, dairy products, meat) contain thiocyanate. People who work in cyanide-related industries, such as the manufacture of electronic computing equipment, commercial printing, photographic processes, hospitals, production of adhesives, and construction and furniture manufacture, may be exposed to thiocyanate. No information is available about the concentrations of thiocyanate in unpolluted air or drinking water. We do not know how many people in the general U.S. population are exposed to significant amounts of thiocyanate from eating foods that contain thiocyanate. People who smoke or breathe tobacco smoke in the environment, and fetuses of mothers exposed to environmental tobacco smoke, can be exposed to high levels of thiocyanate. People who live near hazardous waste sites that contain thiocyanate potentially can be exposed to higher amounts of thiocyanate compared with nonsmokers in the general population. The National Occupational Exposure Survey estimates that 90,599 workers potentially are exposed to ammonium thiocyanate.

1.4 HOW CAN CYANIDE ENTER AND LEAVE MY BODY?

Cyanide can enter your body if you breathe air, eat food, or drink water that contains it. Cyanide can enter your body through the skin, but this is common only for people who work in cyanide-related industries. You can be exposed to contaminated water, air, or soil at hazardous waste

sites. Once it is in your body, cyanide can quickly enter the bloodstream. Some of the cyanide is changed to thiocyanate, which is less harmful, and leaves the body in the urine. A small amount of cyanide is converted in the body to carbon dioxide, which leaves the body in the breath. At low levels of exposure to cyanide compounds, most of the cyanide and its products leave the body within the first 24 hours after exposure. The way cyanide enters and leaves the body is similar in people and animals. You can find more information about the movement of cyanide in the body in Chapter 3.

1.5 HOW CAN CYANIDE AFFECT MY HEALTH?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways to treat people who have been harmed.

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing can help identify health problems such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal-care guidelines because laws today protect the welfare of research animals.

Exposure to small amounts of cyanide can be deadly. The severity of the harmful effects depends in part on the form of cyanide, such as hydrogen cyanide gas or cyanide salts. Exposure to high levels of cyanide for a short time harms the brain and heart and can even cause coma and death. Cyanide produces toxic effects at levels at or greater than 0.05 milligrams of cyanide per deciliter of blood (mg/dL), and deaths have occurred at levels of 0.3 mg/dL and higher (a deciliter equals 100 milliliters). People who breathed 546 ppm of hydrogen cyanide have died after a 10-minute exposure; 110 ppm of hydrogen cyanide was life-threatening after a 1-hour exposure. People who eat small amounts of cyanide compounds in a short time may die unless they quickly receive antidote therapy.

Some of the first indications of cyanide poisoning are rapid, deep breathing and shortness of breath, followed by convulsions (seizures) and loss of consciousness. These symptoms can occur rapidly, depending on the amount eaten. The health effects of large amounts of cyanide are similar, whether you eat, drink, or breathe it; cyanide uptake into the body through the skin is slower than these other means of exposure. Skin contact with hydrogen cyanide or cyanide salts can irritate and produce sores. Workers who breathed in amounts of hydrogen cyanide as low as 6–10 ppm over a period of years had breathing difficulties, chest pain, vomiting, blood changes, headaches, and enlargement of the thyroid gland.

Use of cassava roots as a primary food source has led to high blood cyanide levels in some people in tropical countries. Some of them suffered harmful effects to the nervous system, including weakness of the fingers and toes, difficulty walking, dimness of vision, and deafness, but chemicals other than cyanide also could have contributed to these effects. Cyanide exposure from cassava was linked to decreased thyroid gland function and goiter development; this is because in the body, cyanide is converted to thiocyanate, which attacks the thyroid gland. These effects have not been seen at levels of cyanide exposure usually found in foods in the United States. Cyanide has not been reported to directly cause reproductive problems in people. Adverse effects on the reproductive system occurred in rats and mice that drank water containing sodium cyanide. Other cyanide effects in animal studies were similar to those observed in people. Cyanide has not been reported to cause cancer in people or animals. EPA has determined that cyanide is not classifiable as to its human carcinogenicity (ability to cause cancer in humans).

Vitamin B_{12}, a chemical substance containing cyanide, is beneficial to your body because it prevents anemia (iron-poor blood). The cyanide binds in vitamin B_{12} so that it does not serve as a source of cyanide exposure and cannot harm you. You can find more information about the harmful effects of cyanide in Chapter 3.

1.6 HOW CAN CYANIDE AFFECT CHILDREN?

This section discusses potential health problems in people from exposures conception to maturity (18 years of age).

Like adults, children can be exposed to cyanide by breathing air, drinking water, touching soil or water, or eating foods that contain cyanide, but the amounts are usually low. Breathing smoke is a more important source of cyanide exposure for children. Serious exposures can occur when children accidentally eat certain fruit pits, such as apricot kernals, containing a cyanide-releasing substance. A high blood level of thiocyanate is a sign of cyanide exposure in children, as well as adults. If a pregnant mother is exposed to cyanide, the fetus will be exposed to both cyanide and thiocyanate crossing the placenta. Animal studies show that cyanide and thiocyanate can be transferred into milk and pass to nursing baby animals.

Effects reported in exposed children are like those seen in exposed adults. Children who ate large quantities of apricot pits, which naturally contain cyanide as part of complex sugars, had rapid breathing, low blood pressure, headaches, and coma, and some died. Cyanide has not been reported to directly cause birth defects in people. However, among people in the tropics who eat cassava root, children have been born with thyroid disease because of the mothers' exposure to cyanide and thiocyanate during pregnancy. Birth defects occurred in rats that ate cassava root diets, and harmful effects on the reproductive system occurred in rats and mice that drank water containing sodium cyanide.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO CYANIDE?

If your doctor finds that you (or a family member) have been exposed to cyanide, ask whether your children also might have been exposed. Your doctor might need to ask your state health department to investigate.

Families can reduce their exposure to cyanide by not breathing in tobacco smoke, which is the most common source of cyanide exposure for the general population. In the event of a building

fire, families should evacuate the building immediately, because smoke from burning plastics contains cyanide (and carbon monoxide). Breathing this smoke can lead to unconsciousness or death. Cyanide in smoke can arise from the combustion of certain plastics (e.g., polyacryl-amines, polyacrylics, polyurethane, etc.).

Compounds that release cyanide are naturally present in plants. The amounts are usually low in the edible portion but are higher in cassava. Pits and seeds of common fruits, such as apricots, apples, and peaches, may have substantial amounts of cyanide-releasing chemicals, so people should avoid eating these pits and seeds to prevent accidental cyanide poisoning.

Studies have shown that the effects of cyanide are worse in humans and animals with poor nutrition. Diets containing adequate amounts of protein should improve recovery from cyanide exposure incidents.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO CYANIDE?

Blood and urine levels of cyanide and thiocyanate can be measured, and small amounts of these compounds are always detectable in blood and urine because of natural processes. After cyanide poisoning, increased blood levels of cyanide and thiocyanate are detectable. Harmful effects can occur when blood levels of cyanide are higher than 0.2 parts per billion (ppb), but some effects can occur at lower levels. Tissue levels of cyanide can be measured if cyanide poisoning is suspected. However, cyanide and thiocyanate are cleared rapidly from the body in urine or exhaled breath; therefore, blood measurements only can indicate evidence of recent exposure. A bitter, almond-like odor in the breath may alert a physician that a person was exposed to cyanide. In general, if cyanide exposure is suspected, treatment would be started immediately without waiting for the results of blood cyanide measurements. For more information about the health effects of cyanide and how it can be detected in the environment, see Chapters 3 and 7.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) are some federal agencies that develop regulations for toxic substances. Recommendations provide valuable guidelines to protect public health but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control and Prevention (CDC) are two federal organizations that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as "not-to-exceed" levels—in other words, levels of a toxic substance in air, water, soil, or food that do not exceed critical levels that are usually based on levels that affect animals; they are then adjusted to levels that will help protect people. Sometimes these not-to-exceed levels differ among federal agencies because these agencies use different exposure times (for example, an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are periodically updated as more information becomes available. For the most current information, check with the federal agency that provides it.

EPA sets regulations for the amount of cyanide allowed in drinking water. The highest amount allowed is 200 micrograms of cyanide per liter of water (µg/L or 0.2 ppm). EPA also sets limits for amounts of hydrogen cyanide in stored foods that have been treated with cyanide to control pests. The maximum amount allowed on citrus fruits is 50 ppm. EPA also requires industries to report spills of 1 pound or more of potassium silver cyanide and 10 pounds or more of hydrogen cyanide, potassium cyanide, sodium cyanide, calcium cyanide, or copper cyanide.

OSHA sets levels of cyanide that are allowable in workplace air. The permissible exposure limit for hydrogen cyanide (HCN) and most cyanide salts is 10 ppm or 11 milligrams of cyanide per cubic meter of air (mg/m^3) averaged over an 8-hour workday and 40-hour workweek. NIOSH sets guidelines (recommended exposure limits or RELs) for chemicals in workplace air. The short-term REL for hydrogen cyanide is 4.7 ppm or 5 mg/m^3, averaged over 15 minutes and not to be exceeded at any time in the workday. There is a 10-minute ceiling limit for most cyanide salts of 4.7 ppm or 5 mg/m^3. NIOSH also determines levels that are immediately dangerous to life and health (IDLH) if a worker is exposed for more than half an hour. IDLH levels are 50 ppm for hydrogen cyanide or 25 mg/m^3 for most cyanide salts.

For more information about regulations and advisories for cyanide in the environment or workplace, see Chapter 8.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below.

ATSDR can tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses that result from exposure to hazardous substances.

Toxicological profiles are available on-line at www.atsdr.cdc.gov and on CD-ROM. You may request a copy of the ATSDR ToxProfiles™ CD-ROM by calling the toll-free information and technical assistance number at 1-888-42ATSDR (1-888-422-8737), by e-mailing atsdric@cdc.gov, or by writing to:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE
Mailstop F-32
Atlanta, GA 30333
Fax: 1-770-488-4178

For-profit organizations may request copies of final Toxicological Profiles

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000
Web site: http://www.ntis.gov/