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## Final Report

# Mercury in King County

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Local Hazardous Waste Management Program in King County

This report was prepared by the Local Hazardous Waste Management Program in King County, Washington. The program seeks to reduce hazardous waste from households and small quantity generator businesses in King County by providing information and technical assistance to protect human health and the environment.

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# EXECUTIVE SUMMARY AND RECOMMENDATIONS

Mercury is a widely-used substance that also happens to be toxic to humans. Washington State identified mercury as one of nine 'priority pollutants' and is developing a state action plan for mercury before any of the other pollutants (Washington State Department of Ecology, 2002). The Local Hazardous Waste Management Program in King County (LHWMP) conducted a parallel effort in summer 2002 to prioritize and set forth steps for the management of mercury-containing products at the county level.

Mercury poses a threat to human health both nationally and in Washington State. This is especially significant because mercury is a *persistent* pollutant—once it is in the environment it never goes away. Water bodies in Washington and King County have been "listed" as contaminated due to mercury pollution, and there are fish advisories for fish and shellfish.

Mercury is widespread. It is found throughout the home—in consumer products such as wall thermostats, oven pilot lights, fluorescent lights, hearing aid batteries and thermometers—and it is used in electrical systems and manufacturing processes. It is part of the silvery material used to fill teeth. The list of products and processes that rely on mercury is huge.

According to studies, an estimated 3,000 pounds of mercury are released into the environment each year from human sources in Washington State (Washington State Department of Ecology, 2002). An estimated 1,000 pounds of this mercury comes from within King County (estimates actually range from 550 – 1,900 pounds). King County has no large point sources of mercury waste, such as chloralkali plants, incinerators, coal-burning power plants or operating gold mines. Rather, mercury emissions from King County are attributable to small, non-point sources—dental offices, households, crematoria, auto shredders, electric arc furnaces, etc.

Studies indicate that mercury entering the environment from King County comes from three main areas:

- Products containing mercury (600 lbs. estimated)
- Biosolids from publicly owned treatment works (146.8 lbs.)
- Manufacturing (62.7 lbs.)

In light of this situation, the Local Hazardous Waste Management Program can have a large impact on reducing mercury entering the environment by focusing on *products* that contain mercury—first, by promoting the replacement of mercury-containing products with non-mercury alternatives, and second, by requiring the capture and safe disposal of mercury-containing products.

**Table 1. Estimated Amount of Mercury in Products Discharged Annually in King County (lbs.)**

| | |
|---|---|
| dental amalgams | 260 – 900 |
| fluorescent lamps | 150 – 300 |
| wall thermostats | 70 – 178 |
| vehicle switches | 35 – 100 |
| thermometers | 4 – 100 |

In summer 2002 the Local Hazardous Waste Management Program in King County (LHWMP) conducted a study and review of mercury-related products and produced this report documenting quantities of mercury, discharge of mercury to the environment, health risks associated with products and alternatives to mercury use.

The planning process also led to the following recommendations for short-term (2002-2003) action by the LHWMP:

- **Fluorescent lamps:** Increase the recycling of mercury-containing lamps within King County from 20 percent (the estimated 2002 rate) to 40 percent.
- **Thermometers:** Obtain a Board of Health ban on the sale of mercury-containing thermometers; collect and dispose of 5 – 10 percent of the inventory of thermometers in King County (estimated at 15, 000 – 30,000); and support state efforts to ban sales of mercury-containing thermometers statewide.
- **Wall thermostats:** Initiate a program to promote alternative non-mercury wall thermostats and to collect/recycle mercury-containing thermostats.
- **Vehicle switches:** Initiate a program to collect/recycle mercury-containing vehicle switches and replace them with non-mercury switches. Collaborate with national groups working to ban mercury in cars.

While it's important to prioritize and take action at the county and state levels, addressing mercury pollution also requires collaboration at national (and international) levels. Mercury released to the environment in King County undoubtedly travels outside the county, and mercury impacting our fish and the health of our citizens may easily come from somewhere else. The nature of mercury as a persistent, bioaccumulative, widely traveled toxin means that mercury contamination must be addressed globally. The Local Hazardous Waste Management Program in King County will also support broader efforts to replace mercury in products, regulate emissions and reduce discharges.

# INTRODUCTION

Mercury is a priority pollutant nationally and internationally because it is highly toxic to humans and is pervasive in the environment.

Once exposed to mercury through the lungs, the gastrointestinal tract or the skin, the human body has few means to eliminate it—mercury simply stays in human tissue. It can also cross the placenta and has been found in breastmilk. Babies *in utero* and young children are more susceptible to mercury uptake—methylmercury levels in fetal brains can be twice those found in maternal brains (Clarkson, 1994).

Mercury is a naturally occurring element and is released to the environment naturally through volcanic activity, mineral deposits and forest fires. Human activities release mercury through burning of fossil fuels and product use. Human activities account for an estimated 50 – 75 percent of percent of mercury emissions (compared to natural sources) (USEPA, 1997a).

Mercury is widespread. It is found throughout the home—in wall thermostats, oven pilot lights, freezer lids, fluorescent lights, hearing aid batteries, thermometers, light switches (the silent ones). It's in cars—in trunk lights, antilock brake systems and navigational screens. Mercury is an ingredient in float switches and is found in the hundreds of places where fluids are controlled—septic systems, boilers, fuel dispensaries, boats, wastewater treatment plants, metal plating operations. It is part of the silvery material used to fill teeth. The list of products and processes that rely on mercury is huge.

Mercury-containing products and wastes that aren't captured and properly managed have the potential to release more mercury into the local—and global—reservoir, thus adding to the problem. The United States has pledged to reduce and control mercury emissions nationwide, and the Environmental Protection Agency is currently drafting a national mercury action plan. The State of Washington is doing the same. The purpose of this report is to look at the various mercury sources in King County as a basis for developing a county strategy to reduce future mercury discharges.

In a nutshell, here is a summary of the reasons that the Local Hazardous Waste Management Program in King County (LHWMP) should focus on mercury:

- Additional mercury is put into the environment—from natural sources and human activities—every year. Human activities account for an estimated 50 - 75 percent of this (USEPA, 1997) An estimated 3,000 pounds of mercury is released from human activities in Washington State annually (Washington State Department of Ecology, 2002). An estimated 1,000 lbs. of this is comes from within King County.

- Mercury in the environment threatens the health and well being of U.S. citizens. The level of risk and extent of exposure are the focus of active research by a number of organizations. According to the National Academy of Sciences, at least 60,000 U.S. children a year are born at risk of neurodevelopmental problems due to mercury exposure in the womb (National Research Council, 2000). The Centers for Disease

Control and Prevention (2001) found that one in ten U.S. women of childbearing age is exposed to levels of mercury potentially harmful to a developing fetus. This translates to about 390,000 children born annually. (Scaled to population, this would be an estimated 2,300 children in King County.)

- Fish consumption is the main pathway through which humans and wildlife are exposed to mercury, and fish advisories have been issued for fish and shellfish in Washington State and King County (Washington State Department of Health, 2000). Native Americans are particularly at risk (Washington State Department of Health, 2001).

- It is possible to capture and safely store mercury contained in the thousands of thermometers, thermostats, vehicle switches, appliance switches, electrical apparatus, fluorescent lamps, batteries and other products used by King County citizens and businesses. Unfortunately, this rarely happens because these products are typically disposed in our garbage cans or drains or into incinerators. Because mercury does not degrade, there is potential for release to the environment through this type of disposal.

- Many of the mercury-containing products—like thermometers and car trunk light switches—have cheap, available non-mercury alternatives. The agencies comprising the LHWMP—as purchasers of products, educators of the public, and political entities able to effect manufacturer change—can play a role in product substitution.

# THE NATURE OF MERCURY

Mercury naturally occurs in mineral deposits, soils and waters, and it can be mined from an ore called cinnabar. Once in the environment, mercury readily migrates between air, land and water.

Mercury is released to the environment naturally, through volcanic activity, mineral deposits and forest fires, and by human activities, including the burning of fossil fuels. As noted above, human activities account for an estimated 50 –75 percent of mercury emissions annually (compared to natural sources of mercury) (USEPA, 1997a).

## Persistence

Mercury is an 'element,' which means it's neither created nor destroyed. It can transform into various compounds, or remain as 'elemental' mercury, and it can change phases between solid, liquid and vapor. But it never stops being mercury. For that reason, it is *persistent.* Human activities—and some naturals ones, such as volcano eruptions—take mercury out of the earth, where it didn't disturb other forms of life, and disperse it through the air, water and topsoil. Mercury released to the air as a gas or particulate returns to earth in rain or other precipitation. Erosion and leaching can also transport mercury to waterbodies. Once deposited in streams, rivers, lakes and oceans, mercury either enters the aquatic food chain or volatilizes back into the atmosphere.

## Bioaccumulation

Mercury in the food chain bioaccumulates—that is, it accumulates in greater concentrations as it moves up the food chain. Fish at higher levels of the food chain have been observed to have mercury concentrations more than one million times that of surrounding water. Mercury further accumulates in mammals and birds that eat mercury-contaminated fish.

## Methylmercury

Not all forms of mercury pose the same risk to humans. Methylmercury compounds are extremely toxic and accumulate in the muscle, moving up through the aquatic food chain. (Methylmercury is formed by bacteria in soil or water sediments converting other forms of mercury to methylmercury.) Forms of mercury that are readily converted to methylmercury pose the greatest risk to humans. Incineration, for example, releases mercury in a form that is readily methylated. The amount of methylmercury taken up by organisms is influenced by factors such as organic carbon concentrations, pH, and sulfate levels (Driscoll, 1994).

# MERCURY IN THE FOOD CHAIN (KING COUNTY)

For humans and wildlife, the main threat to health comes from eating fish contaminated with methylmercury. Mercury accumulates in greater quantity in fish that are higher on the food chain. The Environmental Protection Agency (EPA) gives guidance about consuming non-commercial fish, and the Food and Drug Administration (FDA) gives guidance for commercial fish. These advisories were last updated in January (EPA) and March (FDA) of 2001 (Chapman, 2002).

## Commercial fish

The FDA's "action level" on mercury in fish is one part per million (1 ppm). In 2001, the FDA recommended that women of childbearing age *not eat* shark, swordfish, king mackerel or tilefish and eat no more than 12 ounces per week of other fish (US Food and Drug Administration, n.d.). In FDA tests, more than half the swordfish tissue had unsafe mercury levels, and a third of the shark tissue exceeded the action level for mercury (as did four percent of the tuna) (Motavalli, 2002).

## Non-commercial fish

The EPA recommends limiting adult consumption to 6 ounces of non-commercial fish per week (Chapman, 2002). In one report, the EPA tested a variety of fresh-water fish; high concentration predators were bass, walleye and brown trout. One largemouth bass had 9 ppm mercury.

## Washington State advisories

Individual states track wildlife in their own lakes, rivers and streams. Using their own standards, each state issues advisories, bans and warnings on fishing and fish consumption (New York Academy of Sciences, 2002). In Washington, fish and shellfish consumption advisories due to mercury contamination have been issued for the following marine fish: all shellfish, bottom fish and crab in Eagle Harbor on Bainbridge Island; for walleye, whitefish and sturgeon on Lake Roosevelt in Eastern Washington; and for all shellfish, bottom fish, and crab in Sinclair Inlet, Bremerton (Washington State Department of Health, 2000).

To date, there have been no assessments of mercury concentrations in fish found in Washington's 'sports fishing' lakes. Starting in summer 2002, the Statewide Mercury in Fish Tissue Project will look at the distribution and magnitude of mercury in edible fish tissue in 20 freshwater lakes around Washington. Bass is the target species for this project. In addition to monitoring mercury levels, the study will look at factors that might influence the uptake of mercury (Peele, 2002).

In April 2001 the Washington State Department of Health (DOH) issued a fish consumption advisory that added fresh tuna to the FDA list of "do not eat" fish. DOH recommends limiting canned tuna to 6 ounces per week for women of childbearing age (and average body weight) and recommends less than that for children under six (Washington State Department of Health, 2002). This guidance is based on the average canned tuna mercury concentration of 0.17 ppm.

## Fish-eating populations

Native Americans and Asian and Pacific Islanders in Washington may be at increased risk for mercury exposure due to their reliance on fish as a source of protein.

## Fish and shellfish monitoring

In Washington, the Toxics Monitoring Program investigates the occurrence and concentrations of toxic contaminants in edible fish tissue and surface waters from freshwater lakes, rivers and streams. The Puget Sound Ambient Monitoring Program monitors levels of mercury in the edible muscle tissue, liver or whole bodies of fish and crabs. The King County Water Quality Assessment for the Duwamish River and Elliott Bay monitored mercury in the tissue of sole, perch, salmon, mussels, and crab for in the Duwamish River and Elliott Bay (King County Department of Natural Resources, 1999; Simmonds, 2002).

## Mussel Watch

The National Oceanic and Atmospheric Administration's Mussel Watch Project monitored mercury concentrations in mussels and oysters at more than 240 coastal and estuarine sites in the U.S. The study found median mercury concentrations highest in the Pacific, North Atlantic, and Eastern Gulf coasts (compared to those in the Middle and South Atlantic and Western Gulf coasts). The highest total mercury concentrations (>1.0 ppm dry weight) were found in mussels along the Pacific coast and the Western Gulf coast compared to the Atlantic and the Eastern Gulf coast sites (Connor and Beliaeff, 1995).

# HEALTH IMPACTS OF MERCURY

Mercury is a potent neurotoxin. The effects of exposure depend in part on the form of mercury involved.

## Inhaling mercury vapors

Elemental mercury (found in thermometers, blood pressure devices and other equipment) is a problem when inhaled. Such exposure can happen if, for example, a thermometer is broken. A recent study of middle school students exposed to high levels of elemental mercury from a science lab reported a range of long-lasting symptoms, including high blood pressure, insomnia, impotence, severe muscle pains, skin rashes, tremors and memory loss (Tominack et al., 2002). Even at low levels, mercury exposure can cause damage to the brain and central nervous system (Clarkson, 1992). Inorganic mercury salts and mercury vapor tend to affect the kidneys more than other types of mercury (New York Academy of Sciences, 2002).

## Ingesting methylmercury

For humans and wildlife, the significant threat to health comes from eating fish contaminated with methylmercury, a more toxic form of mercury originating from bacterial action on elemental mercury.

Methylmercury ingested in food is almost completely absorbed into the blood and distributed to all tissues, including the brain. It readily passes through the placenta to the fetus and the fetal brain (USEPA, 1997a). The nervous systems of babies in utero and young children are more susceptible to mercury uptake than adult brains: methylmercury levels in fetal brains can be twice those found in maternal brains (Clarkson, 1994). Infants exposed to chronic levels of mercury at critical times can show delayed walking and speech development. Higher exposures can result in cerebral palsy or mental retardation (Mahaffey, 2000). Effects of exposure to methylmercury are primarily neurotoxic and include fatigue, vision and hearing loss, tremor and, potentially, coma and death (New York Academy of Science, 2002).

## Effects on health

Long term exposure to mercury can permanently damage the brain and kidneys, and such exposure can be harmful to the lungs, heart, blood, immune system and reproductive system (US EPA, n.d.). Mercury can also damage the stomach and large intestine and raise blood pressure and heart rate (US EPA, n.d.; National Academy of Sciences, 2000).

## Exposure levels and rates of exposure

What level of mercury exposure is 'safe' is a subject of continuing discussion. The current 'reference dose' (RfD) for methylmercury (that is, the amount of methylmercury which can be ingested over a lifetime without adverse health effects) set by the US EPA is 0.1 µg methylmercury per kilogram bodyweight per day (US EPA, 1997a). This may change as data on fish-eating populations in the Faroe and Seychelle Islands are better analyzed.

The Mercury Report to Congress concluded that "The typical U.S. consumer eating fish from restaurants and grocery stores is not in danger of consuming harmful levels of methylmercury from fish and is not advised to limit fish consumption" (USEPA, 1997a) The report went on to note that certain people may be at risk by eating fish—those who eat large quantities of contaminated fish and women of childbearing age. Less than 3 percent of women age 15 – 44 years were thought to be at risk from eating fish (USEPA, 1997, p. 0-3).

New data suggest different exposure rates. A 1999 survey of mercury levels in the hair and blood of U.S. women of childbearing age found that one in ten is exposed to levels of mercury potentially harmful to a developing fetus. This translates to about 390,000 children born annually in the United States (Centers for Disease Control and Prevention, 2001).

## Exposure in King County

Data on exposure of King County residents indicate that mercury may be a problem, at least for those who consume significant amounts of fish:

- Native Americans in King County may be particularly at risk. Dose estimates for members of the Suquamish Tribe consuming salmon from the Lower Duwamish River were calculated to be 1.9 times higher than the oral reference dose (e.g., 'safe' dose) for methylmercury (Washington State Department of Health, n.d.). The Department of Health study found relatively high mercury levels in Puget Sound quillback rockfish and elevated levels in red rock and Dungeness crab.

- A second Washington State Department of Health (2001) analysis of fish consumption rates found that some Native Americans are likely to exceed DOH's tolerable daily intake (TDI) for methylmercury and concluded that such overexposure needs to be reduced below the TDI by consuming a variety of salmon species. (Chinook contain the highest levels of methylmercury of all the salmon species analyzed) (Washington State Dept. of Health, 2001).

# PERSISTENT CHEMICALS AND POLICY-MAKING

In 1997 the Environmental Protection Agency submitted a Report to Congress called the "Mercury Study" (USEPA, 1997a) which quantified sources of mercury emissions in the U.S. and assessed the health and environmental implications of those emissions. In addition to setting forth a snapshot of the state-of-science about mercury, the Report clarified what is *not* known—those areas of uncertainty within which planners and policymakers must operate. For example, while U.S. annual emissions of mercury total an estimated 158 tons (for 1994-95), only a third of that is deposited in the U.S. The remainder enters the global reservoir of mercury from which it will be deposited on land and water bodies and may enter the food chain.

> *Given the current scientific understanding of the environmental fate and transport of this element, it is not possible to quantify how much of the methylmercury in fish consumed by the U.S. population is contributed by U.S. emissions relative to other sources of mercury . . . As a result, it cannot be assumed that a change in total mercury emissions will be linearly related to any resulting change in methylmercury in fish, nor over what time period these changes would occur. This is an area of ongoing study. (USEPA, 1997a, p. 0-2)*

The difficulty in proving a correlation between reductions in mercury emissions and lower levels of methylmercury in fish at the national level applies to King County as well. Mercury released from King County undoubtedly travels outside the county. And mercury impacting our fish and the health of our citizens may easily come from somewhere else.

The nature of mercury as a persistent, bioaccumulative, widely traveled-toxin implies changes in the traditional way of looking at the issue. Mercury really is a global problem. A local mercury emission has the potential to harm people who live far away—as well as those nearby. In addition, since mercury never degrades—in fact, it accumulates in fish and animals over time—the effects of mercury aren't temporally limited either. Mercury can harm people in the next generation.

# THE POTENTIAL FOR MERCURY RELEASES IN KING COUNTY

Because mercury emitted to the air may travel, the amount of mercury deposited in King County (and Washington State) is not necessarily correlated to local emissions. In order to better understand mercury depositions in Washington, the state maintains two monitoring stations as part of the National Atmospheric Deposition Program for Mercury (aka the Mercury Deposition Network). The Seattle station is operated by Frontier Geosciences, Inc. The Deposition Network has a database of weekly concentrations of mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition. It will be used to better understand spatial and seasonal trends in mercury deposition.

## Quantities released in Washington and King County

Conservative estimates put the amount of mercury released to the environment each year in Washington State from human sources at more than 3,000 pounds (Washington State Department of Ecology, 2002). Most of the point source mercury dischargers (e.g., coal-fired power plant – 436 lbs; gold mine – 777 lbs; municipal waste combustors – 146 lbs; medical waste incinerators and autoclaves –106.3 lbs; and sewage sludge incinerators –79 lbs) are not located in King County (Washington State Department of Ecology, 2002).

Identified sources of mercury from within King County are:

- products containing mercury – 600 lbs., to sewer and solid waste disposal systems.[1]
- biosolids from publicly owned treatment works - 146.8 lbs., to land (Washington State Department of Ecology, 2002); and
- manufacturing - 62.7 lbs., to air.

These estimates omit large sources of mercury due to lack of data. These include batteries and electronic waste, switches and gauges, historical mercury accumulations in sewerage pipes, and emissions from burning fuels—oil, gasoline, wood, etc.

[1] 1800 lbs. of mercury comes from products in Washington (Washington State Department of Ecology, 2002.) An estimated 30 percent of this, or an estimated 600 lbs., comes from within King County

# MERCURY CONTAMINATION IN KING COUNTY

## Waters and sediments

- Thirty sections of a total of ten water bodies in Washington State exceed water quality standards for mercury and have been placed on the 303(d) List of Impaired and Threatened Water Bodies (Washington State Department of Ecology, 1998). Those located in King County are: Elliott Bay, the Duwamish Waterway and River (5 sections), Central Puget Sound, the Green River (3 sections) and Mill Creek. Mercury-contaminated water and/or sediments are found in other parts of Puget Sound, including Commencement Bay, Port Gardner and inner Everett Harbor, Inner Budd Inlet, Commencement Bay, Eagle Harbor, Sinclair Inlet, and Bellingham Bay.
- A 1998 U.S. Geological Survey study found mercury to be much higher in sediments and sculpin (a bottomfish) in urban streams than in other streams in western Washington (Washington Toxics Coalition, 2000).
- Washington is the only state to adopt standards for marine sediment quality—the 1991 Sediment Management Standards. More than fifteen sites in King County have sediments that are considered "Mercury Above Cleanup Levels" sites. Sediments in these waters are contaminated with mercury above the cut-off for cleanup (Washington State Department of Ecology, 2002b.)

## Homes

Preliminary data from a chemical analysis of 7 vacuum bags from King County homes found mercury detected in 5 of these. In one sample, the mercury was twice the limit set by the Model Toxics Control Act (Moran, 2002).

## Contaminated sites

The 1989 Model Toxics Control Act resulted in Ecology's Toxics Cleanup Program. The program investigates and ranks potential sites and works to arrange site clean ups, often in coordination with the EPA. Until recently, Ecology had not tracked mercury as a specific contaminant at clean up sites (it was considered a 'metal'). This is changing. 475 sites in King County are potentially contaminated with mercury according to the Integrated Site Information System (Peele, 2002).

## Landfills

If products containing mercury are disposed in landfills, mercury may be released through air emissions or landfill leachate. A Florida study found that methylmercury was emitted with landfill gas (Lindberg et al., 2001). While there are no data for mercury

emissions from landfills in Washington, the Department of Ecology plans a study to look at this issue (Peele, 2002 b).

# USE AND DISPOSAL OF MERCURY IN KING COUNTY

Elemental mercury's unique attributes—including temperature sensitivity, conductivity, ready amalgamation with other metals and catalytic properties—make the metal useful in a wide variety of products and manufacturing processes. Elemental mercury conducts electricity and is used in electrical switches, gauges, sensors and other applications; these, in turn, are found in hundreds of products. Elemental mercury amalgamates to other metals, and large amounts are used in gold mining operations (panning for gold) and to create dental restoratives. Since elemental mercury is a liquid at room temperature and vaporizes easily, it is used in tilt switches, pressure gauges, temperature-measuring devices, etc. and again, these are found in thousands of products, from cars to pizza ovens to clothes dryers. Because mercury and mercury compounds form reactions with key chemicals, they are widely used in laboratory analysis, chloralkali plants and other chemical manufacturing processes. And the very toxicity of mercury compounds makes these compounds useful as pesticides and preservatives in pharmaceuticals.

Mercury is naturally found in gold ore, coal, oil and other resources: when these are heated, mercury is volatilized and released to the air. Gold mines, for example, release mercury as a by-product of the smelting process, and coal-burning power plants are the largest source of mercury released in the United States.

King County has no existing large point sources of mercury waste and/or emissions such as chloralkali plants, medical waste or municipal waste incinerators, coal-burning power plants or operating gold mines (Washington State Department of Ecology, 2002). Rather, mercury emissions within King County are attributable to small, non-point sources like dental offices, households, crematoria, auto shredders, and electric arc furnaces. Mercury from these sources may be recycled, sent to hazardous waste landfills, disposed at municipal landfills and sewerage systems, or released to air.

Estimates of mercury contained in products and discharged annually within King County are presented below. The appendices following this report discuss each of these mercury sources in detail. For each mercury source, or product, there are estimates of the quantities of mercury contained in the product, quantities of mercury disposed as waste, human exposure to mercury from the product, alternatives to using mercury and the tools available for managing mercury in the product (regulations, policy, education, etc.) The purpose of this report is to provide information useful in prioritizing the action steps that the LHWMP should take to reduce and manage mercury.

## Table 2. Estimates of Mercury in Products, 2002

**Note: See Appendices A-J for computations and sources.**

| Product | Number of items | Amount of mercury (lbs) | Mercury released annually (lbs) | Mercury recycled annually (est. lbs) |
|---|---|---|---|---|
| Wall thermostats | 861,859 | Hm 1782 – 4409<br>Biz 1025<br>Institutions 250 | 70-178 | None |
| Thermometers, fever | 305,000 | 336-780 | 4 – 95 (broken thermo.) | < 1 |
| Amalgam – dental offices | -- | Unk | 262-899 | Unk |
| Amalgam – crematoria | -- | -- | 17 | None |
| P-traps and plumbing | -- | Unk | Unk | None |
| Batteries | -- | Unk | 25- 275 | 3 - 34 [2] |
| Fluorescent lamps | 14,400,000 | 624 - 736 | 145– 321 | 29 – 64 |
| Vehicle switches | 495,900-1,222,450 | 873-2156 | 35 – 108 | None |
| Electronics | Unk | Unk | Unk | Unk |

Little is known about many of the areas in which mercury is used. This report reflects these gaps. For example, while the report provides information about quantities of mercury used in wall thermostats, nothing has been mentioned about other temperature-controlling devices containing mercury—residential heat pumps, flame sensors (found in ovens, clothes dryers, water heaters, space heaters and central heating systems), commercial heating and cooling equipment.

Another omission is mercury used in switches, including silent wall switches, tilt switches in appliances (like freezers), flow meters, and float meters. Mercury use in manufacturing processes, such as tungsten bar sintering or the production of high purity copper foil (used in printed circuit boards), is also not addressed, to name just two.

While mercury use as a whole in the U.S. declined between 1995 (baseline) and 1999, mercury use for wiring devices and switches reportedly grew during this period, from 92 tons in 1995 to 110 tons in 1999 and is now almost as high as it was in 1980 (Cain, 2000). (Another estimate puts mercury use for switches and relays at 36-63 tons per year.

[2] New York Academy of Sciences, 2002, p. 68. (Estimate of battery recycling rates.)

(Leopold, 2002)). The reservoir of mercury in existing switches and relays is estimated at 630 tons (Leopold, 2002).

Reportedly, the largest single use of mercury in this category is for mercury relays, followed by thermostats, float switches and light switches—most of which are not addressed in this report. Furthermore, because little is known of these products, little use reduction effort has been devoted to mercury relays (Cain, 2000).

King County may be a location for businesses that manufacture mercury-containing electrical and measuring devices. The 1997 Economic Census lists 103 King County businesses that manufacture electrical equipment and appliances and more than 200 that make HVAC equipment, electronic components, navigational and measuring instruments, and other measurement and control devices (US Census Bureau, 1997).

Mercury-using firms and mercury-containing electrical and measurement applications remain unexplored in this report. Accessible data do not exist.

# GOVERNMENT AND PRIVATE SECTOR EFFORTS TO MANAGE MERCURY

## State

The Washington State Department of Ecology identified mercury as the first of nine persistent, bioaccumulative toxins ("PBTs") targeted for reduction and/or elimination. Ecology and the Department of Health have convened a stakeholder group to help develop a Mercury Chemical Action Plan for Washington (Washington State Department of Ecology, 2002). Updates to this process are at http://www.ecy.wa.gov/programs/eap/pbt/pbtfaq.html .

## King County

The Local Hazardous Waste Management Program in King County (LHWMP) has worked with the dental sector on mercury issues since 1994 and King County's Industrial Waste Program now includes dentists in its discharge limits with a full compliance deadline of July 1, 2003. King County is the first jurisdiction in the country to require dentists to meet local discharge limits for mercury, typically by installing amalgam separation equipment (see http://dnr.metrokc.gov/wlr/indwaste/dentists.htm .) The LHWMP has promoted commercial fluorescent lamp recycling since 1999, providing outreach, a Web site with information about recycling firms, and cash incentives. A pilot office-based thermometer exchange was conducted in summer 2002 and the LHWMP mercury planning process and report were completed in October 2002. Mercury-containing devices are accepted by all household hazardous waste collection services in King County.

## Other counties and cities

Numerous other jurisdictions in Washington are also working to manage or reduce mercury.

- The Seattle City Council is considering an initiative to inventory all PBT-containing products purchased by the city and to redirect purchasing to non-PBT products.
- Washington State Department of Ecology Coordinated Prevention Grants for 2002 were awarded for a number of mercury-related projects, including thermometer exchanges.
- Snohomish, Kitsap, Kittitas, King and Pierce Counties and the City of Vancouver have implemented or plan to implement thermometer exchanges.
- Kitsap, Snohomish, and King Counties and the Cities of Vancouver and Seattle are considering vehicle switch replacement in agency fleets.

## Other states

Many jurisdictions have banned the sale of mercury thermometers and other mercury products. These include the cities of Chicago, Boston, and San Francisco and the states of Oregon, Minnesota, New Hampshire, Rhode Island, Maine, Maryland, and Indiana. There are currently seven state laws and 15 local ordinances that ban or restrict the sale of mercury fever thermometers.

## Private sector and Non-governmental organizations (NGO's)

- Fifteen retailers and manufacturers—Albertson's, Brooks Pharmacy, CVS, drugstore.com, Kinney Drugs, Kmart Corporation, Longs Drug Stores, Meijer's Supermarkets, Rite Aid, Safety 1st, Target, The First Years, Toys 'R Us/Babies 'R Us, Walgreen, and Wal-Mar-- pledged to not sell mercury fever thermometers, offering non-mercury alternative thermometers instead.
- The American Academy of Pediatrics supports the elimination of mercury containing thermometers in a 2001 technical report.
- In June 2001 the American Hospital Association and the U.S. Environmental Protection Agency reaffirmed their commitment to and began the next phase of their "Hospitals for a Healthy Environment" program. The goal of the program is to eliminate the use of mercury in health care settings and to reduce overall waste generation.

# APPENDIX A

# BATTERIES

Mercury is used to prevent gas formation in batteries and has been historically used in alkaline and mercuric oxide batteries. *Alkaline batteries* are the most commonly recognized batteries ('AA', 'AAA') and are used in flashlights, radios, etc. (Wisconsin Mercury Sourcebook, 1997) Until the mid-90's, mercury was used to control the zinc reaction in these batteries, but since then the industry has virtually eliminated mercury in alkaline batteries.

*Mercuric oxide* batteries—also known as mercury zinc batteries—can be button-shaped (marked with a '+' and used in hearing aids, watches and items requiring a small battery) or larger (look like 9-volt or fat 'AA' batteries). The larger mercuric oxide batteries are used by the military and in hospitals. Other button-shaped batteries that may contain small amounts of mercury to control gassing are *zinc air batteries*, used in hearing aids, and *silver oxide batteries*, used in watches, calculators, toys, etc. (Wisconsin Mercury Sourcebook, 1997)

## Quantity of mercury

Recent federal and state regulations restrict or ban the sale of mercury-bearing batteries and have resulted in reduced mercury content in most batteries.

The battery industry has virtually eliminated mercury in alkaline batteries (it is declining by 50 percent every two years), and mercuric-oxide batteries aren't being manufactured for general use as they are being replaced with lower-mercury *zinc air* and *silver oxide* button batteries. (Gilkeson, 2001) The federal Mercury-Containing and Rechargeable Battery Management Act restricts the amount of mercury in such batteries to 25 milligrams or less (USEPA, 1997 b). Between 1981 and 1994, the amount of mercury in batteries decreased by 71 percent (USEPA, 1997 b).

Direct data on the number of mercury-containing batteries either purchased or in use in Washington State (or King County) are not available. However, mercury contained in batteries in King County may be estimated as set forth below.

*Estimate #1:*

| | |
|---|---|
| 2,000 kg | estimated mercury in all batteries (domestic and imported) sold in US in 2000 (Barr Engineering, 2001) |
| x .006 | % of US population in King County |
| **12 kg** | **estimated mercury in batteries sold in King County in 2000** |
| **26.4 lbs** | |

*Estimate #2:*

| | |
|---|---|
| 454 kg | estimated mercury used by US battery industry in 1995 (doesn't include imported batteries) (US Bureau of Mines, n.d.) |
| x 4 | 75% of US batteries are imported (New York Academy of Sciences, 2002) |
| 1816 kg | estimated total mercury in US batteries (domestic and imported),1995 |
| x.006 | % of US population in King County |
| **11 kg** | **estimated mercury in King County batteries in 1995** |
| **24.2 lbs** | |

*Estimate #3*

| | |
|---|---|
| 1818 kg | estimated mercury contained in *button* batteries sold in the US (Erdheim, 2001) |
| x.006 | % of US population in King County |
| **11 kg** | **estimated mercury in King County *button* batteries (no year)** |
| **24.2 lbs** | |

While the above three estimates are close, another source reports that 176 flasks (or 13,200 pounds, or 6.6 metric tons) of mercury are used by the battery industry nationally each year (Wisconsin Mercury Sourcebook, 1997). (This is based on 1995 estimates and does not include imported batteries.) Reliance on this source would lead to a significantly higher estimate for King County batteries.[3]

Per these estimates, the amount of mercury in batteries entering markets in King County each year is about 25 pounds, contained primarily in button cell batteries**.** (The amount of mercury in batteries discarded in King County each year may be higher—see discussion below—since older batteries could contain more mercury.)

*Mercuric oxide batteries:* As noted above, the Federal Battery Act and many state laws led to the reformulation of most batteries containing mercury. Some of these laws call for a ban on mercuric-oxide batteries. Alexander Technologies, Inc. is the only source of mercuric-oxide batteries in the United States, manufacturing them for medical and specialty markets (Gilkeson, 2001). (While both Rayovac and Energizer list mercuric-oxide batteries in their products list, Energizer states that their mercuric-oxide batteries are not for sale in the United States.)

*Alkaline batteries*: The industry is eliminating mercury in alkaline batteries. As noted above, the amount of mercury is reportedly declining by 50 percent every two years. Between 1989 and 1994, the average mercury content of a "D" alkaline battery dropped from 65 to 27 grams (USEPA, 1997 b).

[3] And another source reports: "There are no reliable industry estimates of the total amount of mercury in button cells manufactured and/or sold in the US, but some believe that it is between ½ and 2 tons per year" (Gilkeson, 2001).

*Button-cell batteries:* Button cell batteries, used for electronic toys, watches, hearing aids, calculators, thermometers, etc., still contain small amounts of mercury, up to 25 milligrams. Zinc-air and silver-oxide batteries contain about one percent mercury by weight, or an average 3.5 to 9 milligrams mercury (Erheim, 2001). Both battery types are used to replace button batteries that historically had higher mercury content.

## Mercury waste

Data on the actual number of mercuric oxide and other mercury-containing batteries discarded in King County (or Washington State) each year are not available. The decrease in mercury content of batteries described in the preceding section means that the amount of mercury contained in batteries is decreasing—unless more mercury-containing batteries are being purchased and used.

*Estimate #1:*

| | |
|---|---|
| 25,455 kg | estimated mercury from batteries put in US waste stream each year (Oregon Mercury Source Report, 2001) |
| x.006 | % of US population in King County |
| 153 kg | estimated mercury from batteries disposed in solid waste disposal systems in King County each year |
| x .10 | recycling rate (New York Academy of Sciences, 2002) |
| 15.3 kg | estimated mercury recycled |
| **137.7 kg, 275 lbs** | **estimated non-recycled mercury disposed in solid waste disposal systems in King County each year** |

*Estimate #2:*

| | |
|---|---|
| 25 lbs | estimated mercury in batteries sold in King Co each year (see above computations) |
| x.10 | recycling rate (New York Academy of Sciences, 2002) |
| 2.5 lbs | estimated mercury recycled |
| **22.5 lbs** | **estimated non-recycled mercury disposed in solid waste disposal systems in King County each year** [4] |

Any discrepancies between the quantities of mercury used to make batteries and the quantities of mercury in batteries disposed each year could be due to the fact that some old mercury-containing alkaline batteries that are being disposed are no longer being manufactured. In fact, it is unclear how much mercury is contained in batteries currently being discarded. The National Electrical Manufacturers Association (NEMA) estimates that 25 tons of mercury from alkaline batteries and 3 tons of mercury from button cell

[4] This estimate assumes that batteries are purchased to replace those disposed and that all batteries currently disposed are button batteries (not alkaline). Since alkaline batteries weren't manufactured after 1996 and they have a life of 5 years, no more are being disposed (New York Academy of Sciences, 2002).

batteries go to the U.S. solid waste stream each year (Oregon Mercury Source Report, 2001). On the other hand, the New York Academy of Sciences (2002) assumes that alkaline batteries only have a 5-year life expectancy and most are no longer around.

The decrease in mercury content of batteries and the requirements to recycle batteries has led to a presumed decrease in batteries disposed in landfills during the 1990's. Annual battery sorts conducted in Minnesota, New Jersey and Florida by the National Electrical Manufacturers Association document a decline in mercury content in alkaline and carbon-zinc batteries in the waste stream (Price, 2001).

The City of Seattle hazardous waste facilities accept household batteries and separate them into the following categories: alkaline; nickel/cadmium; nickel-metal hydride; sealed lead-acid; lithium ion; unknown sealed batteries; car/motorcycle batteries (lead acid). Alkaline batteries are sent to hazardous waste landfills in either Idaho or Oregon. The Wastemobile and the Factoria Household Hazardous Waste Collection service do not accept household batteries.

### *Recycling Requirements*

The 1996 Mercury-containing and Rechargeable Battery Management Act required manufacturers of mercuric-oxide batteries to identify collection sites for used batteries and telephone numbers for battery recycling facilities (USEPA, 1997 b). Mercuric oxide batteries are banned from landfill disposal. Both Rayovac and Alexander Technologies offer recycling options.

The Washington State Department of Ecology requires that most commercial batteries be managed as Universal Wastes (see *Regulations* section below), since most batteries (mercury and non-mercury) designate as hazardous waste.

Households are exempt from the Universal Waste Rule and homeowners may dispose of batteries in the garbage. However, the LHWMP encourages recycling of batteries by households. Households can also dispose of batteries at the City of Seattle permanent hazardous waste facilities. These facilities collect all types of household batteries (see *Disposal* above).

### *Mercuric-oxide batteries*

Mercuric-oxide batteries have a shelf life of up to ten years. Although hospital and medical equipment has been designed to use zinc-air batteries instead of mercuric-oxide batteries since the early 1990's, hospitals still stock mercuric-oxide batteries for use with older equipment (Lowell Center for Sustainable Production, 1998).

The United States Military still purchases mercuric-oxide batteries for use in equipment and continues to be a significant generator of spent mercuric-oxide batteries.

Prior to the passage of the Mercury-Containing and Rechargeable Battery Management Act in 1996, few battery recycling options were available, and the majority of mercury-containing batteries were probably disposed to landfills (Smith, n.d.), as noted above.

## Alternatives

Zinc air and silver oxide batteries may be substituted for higher mercury content button batteries for many applications requiring small batteries. Many toys and novelty items (including several from overseas) come pre-packaged with mercury-bearing button batteries. These products are more challenging when it comes to alternatives.

## Human exposure

Mercury exposure from batteries is not common, as batteries are hermetically sealed. Water and soil contamination from batteries breaking down in solid waste landfills is an unknown threat.

In the case of exposure to the contents of a mercury battery (through fire, a broken casing, or ingestion), acute and chronic effects include chemical burns, abdominal pain, impairment to the central nervous system, inflammation of the kidney, chest pains, diarrhea, and liver damage (USEPA, 1997 b).

## Tools

### *Regulations*

The 1996 Mercury-Containing and Rechargeable Battery Management Act requires the phase-out of batteries containing mercury (USEPA, 1997 b). Title II specifically prohibits the sale of alkaline-manganese batteries (except for button cell batteries containing up to 25 mg of mercury) and zinc-carbon batteries containing mercury (except in incidental amounts not intentionally introduced into the product.) Other mercuric-oxide batteries are prohibited from sale unless manufacturers meet certain provisions, including identifying collection sites for used batteries and providing telephone numbers for recycling facilities.

In 1998 the Washington State Department of Ecology concluded that most batteries (including several that do not contain mercury) designate as federal or state-only Dangerous Wastes and can be managed as "Universal Waste" (except for lead-acid, or automotive, batteries.)

For businesses, this means that batteries can be managed under less stringent requirements than other hazardous wastes—provided they go to a treatment, storage, disposal or recycling facility.

### *Policy*

The LHWMP's guidance for businesses is that "Most, if not all, batteries have hazardous properties and should be recycled or sent to a hazardous waste treatment, storage or disposal facility."

The City of Seattle hazardous waste facilities accept batteries from households, and household batteries can be put in the garbage outside Seattle. The LHWMP also recommends that consumers contact retailers to find out about the location of rechargeable battery collection sites. The Rechargeable Battery Recycling Corporation Web site is **www.rbrc.org** . Several private companies accept nickel cadmium, nickel metal hydride, lithium, ion and small sealed lead batteries for recycling.

# APPENDIX B

# CREMATORIA

Mercury from dental amalgam is released to the air when human remains are cremated. (Mercury is contained in the silvery material used to fill teeth.) In the United States, crematoria aren't regulated for air emissions and don't have air pollution controls.

## Mercury waste

Along with Hawaii, Washington State has the highest percentage of cremations in the U.S.—59 percent of deaths are cremated.

*Estimate of mercury released:*

| | |
|---|---|
| 7615 | number of cremations in King County, 2000 (www.cremation.org/ ) |
| x 1 gm | estimated mercury released during one cremation (Reindl, 2002b) [5] |
| **7615 gm** | **estimated mercury released during cremations in King County, 2000** |
| **7.6 kg or 16.7 lbs** | |

Mercury emissions from crematoria *having emissions controls* are found to average 0.46 grams per cremation (Cremation Association of North America, 1999).

The number of cremations in the U.S. have been increasing at the rate of ten percent a year and at this rate will double every seven years (Reindl, 2002b). However, since fewer amalgams are placed each year, over time the number of amalgams incinerated during cremation will be reduced.

Not all mercury is emitted to the air during cremation. Some stays on the walls of the furnace and elsewhere in the crematoria. (Reindl, 2002b).

## Alternatives

Since the average life of an amalgam filling is 8 – 20 years, cessation of mercury fillings would decrease mercury in cremations by 50 percent in 5 - 10 years and virtually eliminate it in 10 – 20 years (Reindl, 2002b). Norwegian environmental groups recommended pulling teeth prior to cremation, but 53 percent of the public surveyed didn't feel this was right.

## Human Exposure

There are no data on the percent of mercury emissions in Washington State attributable to crematoria and where these are deposited.

[5] Estimates of the amount of mercury released during a cremation vary greatly—from less than 1 gm to more than 5 gm.

A British study found that people working at crematoria are at increased risk of mercury poisoning, with almost twice as much mercury in their hair as a control group (The Lancet, 1998).

## Tools

Crematoria in the United States aren't currently regulated for emissions and don't have controls. This is also true for most European countries. Norway has proposed a standard to go into effect in January 2003 (Reindl, 2002b) and two German states have local standards.

# APPENDIX C

# DENTAL AMALGAMS (DENTAL OFFICE)

Dental amalgam is the silvery metal material used to fill cavities in teeth. Used by U.S. dentists for over 150 years, amalgams are 42 - 50 percent mercury and about 25 percent silver; the remainder is copper, tin and zinc. Mercury is a critical ingredient because it causes the metals to 'amalgamate' into a hard, durable material. A 'spill' is a measure of amalgam size, with 300 - 400 milligrams mercury per spill. A tooth filling contains one to three spills. Amalgam remnants, dust and removed fillings are wastes in dental settings. In addition, amalgams used to fill teeth leach mercury into human waste and produce mercury emissions at crematoria.

## Quantity of mercury

*Estimate #1:*

| | |
|---|---|
| 40,000 kg | estimated mercury used by US dentists, 2001 (Lawrence, 2001) |
| x. 006 | % of US population in King County |
| **240 kg** | **estimated mercury used by King County dentists, 2001** |
| **528 lbs.** | |

*Estimate #2:*

| | | | |
|---|---|---|---|
| 0.10 gm | to | 0.15 gm | estimate of per person mercury use in US for dental restoratives (mid-'90's) (Reindl, 2001b) |
| x 1.737 | | x 1.737 | population of King County (millions) |
| **174 kg** | **to** | **61 kg** | **estimated mercury used in King County for dental restoratives** |
| **383 lbs** | **to** | **574 lbs** | |

*Estimate #3:*

| | | | |
|---|---|---|---|
| 71 | to | 100 | estimated number of amalgam fillings placed in US annually (millions) (American Dental Assn, 2002; Water Environmental Fed., 1999) |
| x .006 | | x .006 | % of US population in King County |
| 426,000 | | 600,000 | estimated number of amalgam fillings placed in King County annually |
| x.0005 kg | | x.0005 | estimated mercury in average filling |
| **213 kg** | **to** | **300 kg** | **estimated mercury in fillings placed in King County annually** |
| **467 lbs** | **to** | **660 lbs** | |

## Mercury waste

*Estimate #1:*

| | | | |
|---|---|---|---|
| 426,000 | to | 600,000 | estimated number of amalgam fillings placed in King County each year (see above) |
| x .70 | | x .70 | estimated % of fillings that are replacements |
| 298,000 | to | 420,000 | estimated number of fillings replaced in King County each year |
| x.0004 kg | | x .0005 | estimated mercury released during filling removal (per filling) (New York Academy of Sciences, 2002) |
| **119 kg** | **to** | **210 kg** | **estimated mercury released during filling replacement in King Co.** |
| **262 lbs** | **to** | **462 lbs.** | **annually** |

*Estimate #2:*

| | | | |
|---|---|---|---|
| 14 | to | 17 | estimated number of fillings removed each week per dentist (Water Environmental Federation, 1999) |
| x48 | | x48 | number of weeks worked each year |
| 672 | | 816 | estimated number of fillings removed each year per dentist |
| x 1000 | | x 1000 | estimated number of King County dentists that remove amalgam (Metro, 1991) |
| 672,000 | | 816,000 | estimated number of fillings removed each year in King County |
| x .0005 kg | | x .0005 | estimated mercury released during removal of one filling |
| **336 kg** | **to** | **408 kg** | **estimated mercury released in King County during filling removal** |
| **739 lbs** | **to** | **899 lbs** | |

Given these estimates of the quantity of mercury in dental amalgams and the amount of mercury waste from dental offices, dentists in King County appear to generate between 262 and 900 pounds of mercury waste from placing and removing amalgam fillings each year.

### *Waste disposal-general*

An estimated 108 – 170 pounds of mercury waste per year go to the sewer and an estimated 100 pounds are disposed with biomedical waste from dental offices in King County (Local Hazardous Waste Management Program, 2000; Magnuson, 2002). (Note: this latter estimate may be low. See section on *Biomedical waste* below). In addition, an unknown amount of mercury-bearing waste is undoubtedly put in the garbage, handled as hazardous waste, or emitted to air.

Finally, some amalgam is left over from placing fillings—in 'empty' capsules, on instruments and collected as waste scrap. Quantities of leftover amalgam are unknown.

Of wastes produced in dental offices, some goes to sewer, some to a hazardous waste facility, some to air, and some is improperly disposed to the landfill and biomedical waste (Local Hazardous Waste Management Program in King County, 2000). Amalgam wastes may designate as dangerous waste. Unless they are tested and shown to pass TCLP,

amalgam wastes should go to a hazardous waste landfill or to a facility that reclaims mercury and silver. Amalgam waste should not go into an infectious (biomedical) waste container because biomedical waste is often heat-treated.

### *Wastewater*

Untreated wastewater containing amalgam particles does not typically meet King County local discharge limits for mercury (0.2 ppm). In addition, wastewater containing mercury in concentrations greater than 0.2 ppm designates as dangerous waste under Washington State Dangerous Waste regulations and cannot be discharged to wastewater treatment facilities without an exemption or permit. In most cases, treatment is required before amalgam-bearing wastewater can be legally discharged to the sewer.

Estimates of mercury discharged by dental offices to wastewater treatment systems range from 120 mg –200 mg/dentist/operating day (Water Environment Federation, 1999). Studies conducted in King County found that 50 - 78 kg per year, or 108 -171 lbs., of mercury from dental offices are discharged to the sanitary sewer system in King County annually. (Calculations using estimates of mercury discharged by dental offices in other localities find that dentists contribute 176 lbs per year.) This is 30 – 60 percent of the total mercury detected at the wastewater treatment plants in King County (Balogh, 2002; Magnuson, 2002).

An evaluation of seven municipal wastewater treatment plants by the Association of Metropolitan Sewerage Agencies found that dental uses were “by far” the greatest contributors of mercury to the sewer system. On average, dental offices accounted for 40 percent of the load—more than three times the next largest source (Association of Metropolitan Sewerage Agencies, 2002). A recent Minnesota study found dentists accounted for 29 percent of mercury entering the wastewater system in one community and 44 percent in another (Anderson, 2001).

While estimates of the percentage of mercury entering the sewer system are fairly consistent from place to place, estimates of the national tonnage of dental mercury vary greatly per year, from 2.6 tons in 2002 (Association of Metropolitan Sewerage Agencies, 2002) to 24.7 tons in 2001 (Mercury Policy Project, 2002).

Mercury discharged to the sewer system ends up in the drainage pipes (both at the dental office and throughout the wastewater collection system), in treatment plant grit, in effluent from the treatment plant and in the biosolids produced by the wastewater treatment process. Measures of mercury in these endpoints may be spotty. There is some evidence that conditions in the wastewater treatment system may promote the methylation of mercury within wastewater or sludge (Mercury Policy Project, 2002).

### *Wastewater drainage pipes*

See Appendix F for a discussion of P-traps and drainage pipes.

### *Treatment plant grit*

Mercury amalgam particles may drop out in the grit chamber (the initial coarse settling chamber at the front end of a treatment plant). This grit is most commonly placed in landfills along with other settled material (Mercury Policy Project, 2002).

### *Effluent from treatment plant*

An estimated 12 – 20 percent of mercury coming into a treatment plant is discharged in the effluent (Huffert, 2002).

### *Biosolids*

Treatment plant residuals, known as biosolids, produced by wastewater treatment plants in King County are land-applied. Because mercury and other substances in biosolids limit their beneficial reuses, it's in the interest of the wastewater treatment plants to keep the amount of any pollutant to a minimum. Biosolids produced by wastewater treatment plants in King County meet all standards for land application. In fact, measures of mercury in King County biosolids are well below national standards; estimated quantities are 135 pounds per year (Sifford, 2002). Regulations for land application of biosolids in the U.S. are far less restrictive for mercury and other metals than many other countries (Harrions, et al, 1997).

### *Septic systems*

Amalgam-bearing wastewater may be discharged to septic systems in areas not served by municipal wastewater treatment systems. The potential for methylation of mercury exists in the anoxic environment of a septic tank, which can lead to the production and discharge of methylmercury at private disposal fields (Mercury Policy Project, 2002). Significant levels of mercury contamination have been detected both within septic tanks and in disposal fields receiving wastewater from dental clinics (Capital Regional District, 2001).

### *Hazardous waste facilities*

Unfortunately, no information is available regarding measures of amalgam going to hazardous waste facilities from dental offices.

### *Biomedical waste*

An estimated 53 lbs. of mercury in 'scrap' amalgam from dentists in King County is improperly disposed with biomedical waste each year (Local Hazardous Waste Management Program, 2000). There is probably an equal amount of mercury waste from chairside traps and pump filters. A conservative estimate of mercury disposed to the biomedical waste system by dentists is 106 lbs per year.

Biomedical waste from dentists in King County is either autoclaved or microwaved in one of two Stericycle facilities (Morton in Lewis County and Ferndale in Whatcom County). At the time that this report was compiled, the extent of emissions control, mercury vapor release and effluent discharge from these facilities during sterilization

were unknown. Mercury-bearing residuals are reportedly placed in landfills (Tomasello, 2001; Healthcare Without Harm, 2002).

### *Air*

The extent of releases into the air from dental offices presents a critical data gap (Minnesota Pollution Control Agency, 2001). Mercury is expected to be released during drilling due to the heat of friction and as mercury vapor from waste amalgam, especially in air/water separators (Rubin and Yu, 1996).

### *Reclamation*

A small but increasing number of dentists are collecting their mercury amalgam waste for reclamation. Where collection systems are in place, about 60 percent of mercury-bearing amalgam is captured in coarse chairside filters (Mercury Policy Project, 2002), and 95 percent or more of amalgam is captured when an amalgam separator is added to the system.

## Alternatives

Alternatives to amalgam include resins (fortified with powdered glass, quartz, silica or ceramic), gold, glass ionomers (ground-up glass mixed with polyacrylic acid, used for cavities below gumline), and porcelain compounds. According to a survey by the ADA Health Policy Resources Center, these non-amalgam materials have surpassed amalgam fillings for single-tooth restorations (Amercian Dental Association, 2002).

Until recently, amalgam was the most widely-used restorative, with 92 percent of dentists listing it as the material of choice in 1990 (Minnesota Pollution Control Agency, 2001). In 1990, 99 million amalgam fillings were placed in the U.S., compared to 48 million composites. By 1999, however, the situation was reversed: 86 million composite resin fillings were placed in the U.S., compared with 71 million amalgam restorations (American Dental Association, 2002). The same trend is true in Canada: From 1992 to 1996 amalgam use in Ontario declined from 50 percent of all fillings to about 40 percent (Environment Canada, 2000). This was corroborated by a 23 percent decline in amalgams imported into Canada between 1994 and 1999.

This is corroborated by data from Strategic Dental Marketing, a marketing consultant. According to their data, in 2001 sales of composites outpaced amalgams by a three-to-one ratio. In the U.S., composite resins accounted for almost $119 million in sales (up 13 percent from the previous year), compared to $39 million for amalgams (up less than 1 percent).

In a survey of dental practitioners in December 2001, Clinical Research Associates, a Utah-based nonprofit that evaluates dental materials and techniques, found that 27 percent weren't using mercury amalgam, up from 3 percent in 1985 and 9 percent in 1995 (Allen, 2002).

Current projections are that dental mercury use is expected to gradually decrease in coming years from the current rate of 44 metric tons/year (U.S.) (Lawrence, 2000).

Reasons for increase in composite use have been attributed to esthetics, patient preference and advances in materials science, rather than to concerns about safety (American Dental Association, 2002). While the properties of resins and composites have improved (they are less technique-sensitive), dentists have also become better trained in placing composite resins.

Amalgams may still have a role in treating severe root caries, certain systemic conditions and after radiation therapy (American Dental Association, 2002). Even if amalgam placement stopped today, mercury-bearing amalgam would continue to be removed and put into the waste stream for the next 20-30 years.

Currently, most dental insurance plans do not provide equal rates of reimbursement for amalgam and composite restoratives—amalgam fillings are typically reimbursed at a higher rate. In addition, amalgam fillings cost less to place. However, some dental insurance plans reimburse alternative materials at similar rates as amalgam (Larsen, 2002).

## Tools

### *Regulations*

The King County Industrial Waste Program requires dental offices that place or remove amalgam fillings to meet local wastewater discharge limits for mercury (King County Code--Title 28 and Public Rule PUT 8-13). For most dental offices, this will require implementing best management practices and installing amalgam separation equipment. Enforcement of these regulations is possible because appropriate and reasonably priced technology is now on the market. (See http://dnr.metrokc.gov/wlr/indwaste/dentists.htm.)

Regulations governing the disposal of dangerous waste by small quantity generator businesses apply to dental offices provided that their solid waste (chairside trap amalgam waste and pump filter waste) designate as dangerous waste under Washington State code.

### *Policy*

See above section on regulations.

It appears that most dental insurance plans don't provide equal rates of reimbursement for amalgam and composite restoratives—amalgam fillings are typically reimbursed at a higher rate. This policy promotes the choice of amalgam fillings by some consumers for economic reasons. However, some dental insurance plans reimburse alternative materials at similar rates as amalgam (Larson, 2002).

# APPENDIX D

# ELECTRONIC PRODUCTS

## Quantity of mercury

Numerous electronic products contain mercury, typically for energy efficient lighting in lamps and displays (Electronic Industries Alliance, n.d.). These are listed below:

**Table 3. Electronic Products Containing Mercury**

| Product | Estimated amount of mercury in product (mg) |
|---|---|
| Multi-media monitor | 50-100 |
| LCD projector TV | 50-100 |
| LCOS TV | 10-50 |
| Flat panel display monitors (including TV) | 0-5; 5-10; 10-50 |
| Multi-function devices (i.e.: fax, copy, print) and fax machines | 0-5; 10-50 |
| Scanners | 0-5; 10-50 |
| Photocopiers | 0-5; 5-10 |
| Laptops/notebook computers | 0-5 ; 10-50 |
| Camcorders & cameras | 0-5 |
| Audio equipment | 0-5 |
| Telephones | 0-5 |
| DVD Players | 0-5 |
| WEB Appliances | 0-5 |
| Document processing equipment | 0-5 |
| Products with LCD display | 0-5 |
| Palm top PC's; E-book | 0-5 |
| Measurement devices | 0-5 |
| Medical devices | 0-5 |
| Digital sender | 0-5 |
| VHS duplicator | 0-5 |
| Digital picture frame | 0-5 |

## Mercury waste

Discarded electronic equipment (especially computers) is one of the fastest growing waste streams in the industrialized world. This is due to increased sales coupled with rapid obsolescence (Silicon Valley Toxics Coalition, 2001).

An Oregon study comparing the percentage of computers and "brown goods" (TVs, radios, cell phones, microwaves, etc.) in the state's solid waste stream in 1998 and 2000 found that the volume of computers almost tripled (from 0.25% of the waste stream to

0.68%). The volume of "brown goods" more than doubled (from 0.44% of the waste stream to 0.98%) (Oregon Department of Environmental Quality, 2001).

A survey of households in King County in January 2002 found that 29 percent have computers they are no longer using—up from 21 percent in 2000. Eighteen percent have a TV they are no longer using (King County Solid Waste Division, 2002).

The City of Seattle and King and Snohomish Counties are working together on an innovative project to recruit businesses to collect and recycle electronics for a fee from residents and other businesses. (See http://dnr.metrokc.gov/swd/default.shtml .)

## Alternatives

Since mercury in electronics is found in the lamps used to backlight digital displays, no known alternatives are currently available.

The City of Seattle and the King County Solid Waste Division have developed a Guide to Environmentally Preferable Computer Equipment to aid large-quantity buyers in selecting more environmentally-friendly computer systems.

## Human exposure

Electronic equipment contains lead, mercury, cadmium and brominated flame retardants. Lead is found in the cathode ray tube (CRT) of computer monitors and televisions. Mercury is contained in computer printed wiring boards, switches, relays, lamps and batteries. Electronic equipment wasn't designed to be taken apart, and components aren't easy to recycle. Disassembly is labor intensive and costly. Electronic equipment should be recycled. Environmentally responsible recycling of electronics is available from selected vendors.

## Tools

### *Policy*

A national effort is underway to share responsibility for managing used electronic equipment. Known as 'product stewardship,' the approach distributes management costs for used electronic equipment among those benefiting from the products. The goal of the National Electronic Product Stewardship Initiative (NEPSI) is to develop a national collection and recycling infrastructure funded with fees collected at the time the product is purchased. These funds would be used to cover the costs of collecting and processing this equipment. The NEPSI Web site is http://eerc.ra.utk.edu/clean/nepsi/.

### *Regulations*

Mercury-bearing electronic products may designate as hazardous waste. Many electronic products contain other potentially hazardous constituents (such as lead in cathode ray

tubes in TVs) that can also cause them to designate as a hazardous waste. Under state and federal regulation, businesses that dispose of electronics such as computers, TVs, or VCRs are responsible for determining if the products designate as hazardous waste prior to disposal.

The Washington State Department of Ecology has issued an Interim Enforcement Policy that excludes Cathode Ray Tubes (CRTs) from the Dangerous Waste Regulations if they are properly recycled. This policy outlines the provisions that must be met by generators of CRTs, transporters, and operators of facilities that handle computer-related equipment.

Nation-wide, industry representatives indicate that they need national legislation in order to establish a voluntary, industry-managed program. Electronics legislation has been introduced in six states in 2002.

# APPENDIX E

# LAMPS

Mercury-containing lamps include fluorescent tubes (such as T8s and T12s), compact fluorescent lamps, high-intensity discharge lamps (HID) and neon lamps.

While mercury content in lamps has steadily decreased during the last twenty years, a certain amount of mercury is reportedly still required to ensure that the lamp operates properly (National Electrical Manufacturer's Association, 2001). A typical fluorescent lamp has a phosphor-coated glass tube with electrodes at either end. The tube contains mercury, a small amount of it in vapor form. When voltage is applied, the electrodes energize the mercury vapor, causing it to emit ultraviolet (UV) energy. The phosphor coating absorbs the UV energy, causing the phosphor to fluoresce and emit visible light (National Electrical Manufacturer's Association, 2001). Fluorescent lamps contain both insoluble elemental mercury and soluble ionic mercury (Sustainable Conservation, 2000).

Fluorescent tubes and compact fluorescent lamps are found in businesses and homes. HIDs include high pressure sodium, metal halide and mercury vapor lamps used in street lighting, outdoor security lighting, industrial settings, farmyards, parking lots, warehouses, stadiums and in some cases (metal halide), homes and offices (Wisconsin Recycling Markets Directory). Neon lamps are typically used in advertising. Those in colors other than red are likely to contain mercury (Chapman, 2001).

Philips, Osram-Sylvania (Siemens) and GE reportedly control 85 percent of sales in the U.S. and dominate global lamp markets (Sustainable Conservation, 2000). Many small lamp producers target specific commercial and industrial niche markets.

## Quantity of mercury

The quantity of mercury found in a lamp varies with the type of lamp.

**Table 4. Estimated Quantity of Mercury, by Lamp**

| Lamp type | Estimated Hg | Life of lamp |
|---|---|---|
| Fluorescent tubes | 10-40 mg (average 22.8 mg) | 20,000 hrs. |
| Compact fluorescent lamps | 5-10 mg | 10,000 hrs. |
| HID lamps | 20 – 250 mg | 10,000 – 24,000 hrs. |

(USEPA, 1994; Katayama, 2002).

Roughly 650 million fluorescent lamps are sold in the U.S. market each year. The majority (600 million) are fluorescent tubes and the remaining 50 million are compact fluorescent lamps (Reindl, 2000). The US commercial market for fluorescent lamps continues to grow as commercial floor space increases (currently growth is 2.4 %/year). Energy conservation drives an increase in residential use of compact fluorescent lamps, in particular.

Estimates of the mercury found in fluorescent lights in King County are as follows:

*Estimate #1:*

| | |
|---|---|
| 600 mill | estimated number of lamps sold in the US annually (Reindl, 2000) |
| x.006 | % of US population in King County |
| 3.6 mill | estimated number of lamps sold in King County annually |
| x.000023 kg | estimated mercury in one lamp |
| 82 kg | estimated mercury in lamps sold in King County annually |
| 180 lbs | |
| x 4 yrs | average life of a lamp. (Number of lamps sold each year is ¼ of total lamp inventory.) |
| **722 lbs** | **estimated mercury in lamps in King County** |

*Estimate #2:*

| | |
|---|---|
| 13 tons | reported mercury used annually by lighting industry in US (National Electrical Manufacturers Assoc.-NEMA-2001)[6] |
| x .006 | % of US population in King County |
| .078 tons | estimated mercury used annually by lighting industry in King County |
| 156 lbs | |
| x 4 yrs | average life of lamp (number of lamps sold each year is ¼ of total inventory.) |
| **624 lbs** | **estimated mercury in all lamps in King County** |

*Estimate #3:*

| | |
|---|---|
| 70 tons | estimated mercury in lamps in the US (Leopold, 2002) |
| x.006 | % of US population in King County |
| **840 lbs** | **estimated mercury in lamps in King County** |

Household use of compact fluorescent lamps (CFLs) is growing. Local power utilities in King County distributed more than 300,000 CFLs to residents in 200l to promote energy conservation, and many retail stores stock a large selection of energy-efficient, mercury-bearing CFLs.

## Mercury waste

Mercury-containing lamps burn out every three to six years.

[6] The above estimates do not account for large numbers of high intensity discharge lamps used in street lighting, outdoor security lighting, industrial settings, farmyards, parking lots, warehouses and stadiums in King County.

The quantity of mercury in waste lamps has been computed using several methods:

*Estimate #1:*

| | |
|---|---|
| 2.2 | estimated number of lamps per person disposed annually in U.S. (Abernathy, n.d.) |
| x 1.7 million | population of King County |
| 3.7 million | estimated lamps disposed annually in King County |
| x .000023 kg[7] | |
| **84 kg or 185 lbs** | **estimated mercury in lamps disposed annually in King County** |

| | |
|---|---|
| 3.7 million | |
| x .000018 kg | |
| **66 kg or 145 lbs** | **estimated mercury in lamps disposed annually in King County** |

185 lbs x .20 = 37 lbs estimated mercury in lamps recycled in King County (2002) (Abernathy, 2001)

145 lbs x .20 = 29 lbs estimated mercury in lamps recycled in King County (2002) (Abernathy, 2001)

**116 – 148 lbs** **estimated mercury in non-recycled lamps disposed in solid waste disposal systems annually in King County**

*Estimate #2:*

| | |
|---|---|
| 26.8 tons | estimated mercury from lamps in US solid waste annually[8] (USEPA, 1992) |
| x .006 | % of US population in King County |
| **321 lbs** | **estimated mercury in lamps disposed in solid waste disposal systems annually in King County** |
| x .20 | % of lamps recycled in King County (Abernathy, 2001) |
| 64 lbs | estimated mercury in recycled lamps in King County |
| **257 lbs** | **estimated mercury in non-recycled lamps disposed in solid waste disposal systems annually in King County** |

[7] Since the amount of mercury in lamps change (decrease) from year to year, two estimates are used here. They are based on the assumption that lamps disposed of now were made several years ago (and thus had higher mercury content.)

[8] Based on 1989 estimates of composition of solid waste.

*Estimate #3:*

| | |
|---|---|
| 20,000 kg | estimated mercury disposed in lamps in US (New York Academy of Sciences, 2002) |
| x .006 | % of US population in King County |
| 120 kg or 264 lbs | estimated mercury in lamps disposed annually in King County |
| x .20 | estimated % of lamps recycled in King County (Abernathy, 2001) |
| **211 lbs** | **estimated mercury in non-recycled lamps disposed in solid waste disposal systems annually in King County** |

*Estimate #4:*

| | |
|---|---|
| 180 lbs | estimated mercury in lamps sold in King County annually (see estimated mercury in lamps disposed in King County annually (New York Academy of Sciences, 2002) |
| x .2 | estimated % of lamps recycled in King County (Abernathy, 2001) |
| **144 lbs** | **estimated mercury in non-recycled lamps disposed in solid waste disposal systems annually in King County** |

*Estimate #5:*

| | |
|---|---|
| 11 tons | estimated mercury in lamps disposed in solid waste disposal systems annually in US (Leopold, 2002) |
| x.006 | % of US population in King County |
| **132 lbs** | **estimated mercury disposed in solid waste disposal systems annually in King County** |

Given the various methods of estimating mercury lamp waste, the number of lamps generated in King County that are disposed each year ranges from 3.6 – 6.5 million, and the amount of mercury in these lamps ranges from 132 – 321 lbs. Again, this includes home and building lamps only and does not account for street lighting, outdoor security lighting, industrial settings and warehouses, and other outdoor applications.

### *Recycling*

Lamp recyclers separate fluorescent tubes into component materials – glass, metal, phosphor powder and mercury – so that these can be recycled or reused. Recycling facilities typically charge by linear foot (e.g., $0.08/foot for a 4-foot tube) and accept HID, neon, CFLs and other mercury lamps.

In 1996, the EPA estimated two percent of fluorescent lamps were recycled (USEPA, 1998). At that time, the industry estimated a 12.5 percent recycling rate (USEPA, 1998). More recent estimates range from 10 - 20 percent as the new lamp recycling rule is being implemented. For example, the Association of Lighting Recyclers now estimates a 20 percent recycling rate for lamps (Abernathy, 2001).

LHWMP tracked recycling of lamps generated in King County (including Seattle) for the years 2001 and 2002 through two major lamp recyclers (McDonald, 2002a). In 2001, the two recyclers handled 1.1 million lamps generated in King County. Given the estimated range of total lamps disposed in King County annually (3.6 – 6. 4 million) (McDonald,

2002b), the recycling rate would be between 17% – 30% for those two recyclers alone. Based on these data, a recycling rate of 20 percent for all lamps recycled in King County is not unreasonable. Recycling at this rate would amount to between 37 and 65 lbs of mercury recycled annually from lamps in King County.

Resistance to recycling lamps comes from consumers who aren't used to paying for lamp disposal and who lack storage space. The biggest barrier is that "many consumers (this includes individuals and businesses) don't know that fluorescent lamps contain mercury and that mercury is an environmental problem" (Sustainable Conservation, 2000). Those entities most likely to recycle lamps are companies that handle large volumes and are clearly regulated.

### *Dumpsters and landfills*

An estimated 37 – 65 lbs of mercury in lamps generated in King County (including Seattle) are recycled. The lamps that are not recycled (containing an estimated 147-262 lbs of mercury) are, unfortunately, likely sent to solid waste disposal systems or released into the air during breakage.

When sent to solid waste landfills, spent lamps are likely to break. As of July 2000, the King County Solid Waste Division discontinued acceptance of fluorescent lamps from commercial customers (King County Solid Waste Division, Solid Waste Acceptance Policy, 2000). See *Tools: Policy* section below for more on this.

Lamps broken during handling and transport—especially when crushed in office compactors—can release mercury into the air, posing a health threat to workers. This may be especially true at transfer stations, where large quantities of lamps are dumped from trucks into containers. The USEPA estimates that 8 – 10 percent of lamps are broken during handling and transport.

One study found that 20 – 80 percent of mercury from a broken lamp is volatilized within 8 days (Lindberg et al, 1998.) This contrasts with studies by the National Electrical Manufacturers Association that show one percent of mercury is volatilized (National Electronic Manufacturers Association, n.d.) The US EPA uses a 1 – 7 percent volatilization rate in its analysis for the Universal Waste Rule (Sustainable Conservation, 2000).

### *Crushing*

Lamp crushers are used by businesses to reduce lamp volume and facilitate transport. If a business opts to crush dangerous waste lamps, it must recycle the crushed lamps, dispose of them as hazardous waste, or demonstrate through testing that the debris is not hazardous. Some recycling firms accept crushed lamps for recycling. Companies that crush must follow all OSHA/WISHA requirements to protect staff. Crusher filters must be handled as hazardous waste.

The LHWMP does not endorse crushers due to concerns about exposure (IRAC White Paper, 2000). Some crusher models may not consistently capture mercury, creating a

possibility of worker exposure and environmental release. Also, proper maintenance and personnel training can be complicated (IRAC Fluorescents Work Group, 2000)

### *HHW collection*

The City of Seattle's household hazardous waste facilities and the Wastemobile operated by King County accept mercury-bearing lamps from residents. In spring 2001, the LHWMP Household Hazards Line reported one to two calls per day regarding fluorescent lamps (Shallow, 2000).

The increasing use of compact fluorescent lamps noted above may result in a growing number of CFLs entering the solid waste stream and the household hazardous waste collection centers (McDonald, 2002c).

### *"Low mercury" lamp disposal*

Low-mercury lamps that don't designate as dangerous waste can be put in a landfill. In King County a waste clearance is required. Less than ten clearances for low-mercury lamps were issued in the past year (Burke, 2002). Lamp waste that has received a clearance is placed in the 'asbestos' area of the Cedar Hill Landfill to protect from breakage.

As with all mercury-bearing lamps, the best management practice for low mercury lamps is recycling. Because of the waste clearance requirement, recycling frequently turns out to be simpler and less costly as well.

## Alternatives

Three major lamp manufacturers offer some low-mercury tubes, typically distinguished by a green end cap or green writing on the tube itself. Light output is the same as standard models. Some low-mercury models don't designate as dangerous waste lamps for mercury: they are able to pass the TCLP test due to slightly lower mercury levels and because of an additive that binds with the mercury to reduce the chance of leaching (Smith, 2002; EPPNet, 2002).

The likelihood that fluorescent lamps will soon be replaced with mercury-free lamps is low. The commercial building marketplace is particularly slow in accepting new lighting products and technologies. In addition, the rate of technological development and product innovation is slow in the lighting industry (Sustainable Conservation, 2000).

The U.S. Department of Energy, the lighting industry, and NGOs developed a Lighting Technology Roadmap called *Vision 2020* to establish priorities for the lighting industry for the next 20 years. This includes a 3 – 10 year plan to develop "toxic-free" lamps and replace mercury with xenon in metal halide lamps. The Department of Energy envisions mercury-free fluorescent lamps by 2020 (US Department of Energy, 1999).

## Tools

### *Regulations*

Prior to 1999, fluorescent lamps weren't regulated and could be disposed as solid waste. In July 1999, the U.S. EPA added spent fluorescent lamps to the federal list of Universal Wastes (effective Jan. 2000). Under the rule, businesses are required to recycle most types of fluorescent lamps or to dispose of them at a hazardous waste facility. Generators that manage lamps as Universal Waste may apply simpler standards for storage, labeling and shipping. The EPA goal is a 60-80 percent recycling rate (Sustainable Conservation, 2000).

In May 2000, the Washington State Department of Ecology published a similar rule adding spent fluorescent lamps to the state list of Universal Wastes. Mercury-containing lamps from businesses must be recycled under Universal Waste rules, or disposed of as hazardous waste. This includes all lamps listed in the first paragraph of this section (IRAC Fluorescent Work Group, 2000). Household lamps are exempt.

Mercury-containing lamps are often excluded from mercury ban legislation due to a desire for energy conservation, lack of an alternative and strong lobbying by lamp manufacturers. Lamps and other mercury products now require labels when sold in Vermont (the law was recently upheld in a legal challenge by the National Electrical Manufacturer's Association). The mercury content of lamps must be listed on the invoice in both Rhode Island and Minnesota (NEWMOA, New England Waste Management Officials Association, n.d.).

### *Policy*

In 2000 a LHWMP interagency workgroup published a white paper clarifying application of the Universal Waste Rule in King County (IRAC Fluorescent Work Group, 2000).

During 2000-2001, Seattle City Light and the LHWMP rewrote technical specifications for lighting retrofit contracts for the utility's small and large business ratepayers to include waste lamp recycling.

As stated previously, in July 2000 the King County Solid Waste Division discontinued accepting fluorescent lamps from commercial sources (Neely, 2000). King County solid waste screeners reported only ten sightings of fluorescent tubes at the landfill in 2001 out of 6000 - 7000 loads screened (Badger, 2001). According to landfill representatives, these numbers may be low because lamps are difficult to find: "They are usually broken by the time we see them at a transfer station or landfill" (Badger, 2001).

The spokesperson for one waste hauler noted that small quantities of tubes may not be visible in dumpsters (Gordy, 2001). She added that when tubes are observed, the driver does not pick up the problem waste. This is something that happens "regularly but not frequently."

### *Product stewardship*

*Vision 2020*, a Lighting Technology Roadmap setting priorities for the lighting industry for the next 20 years, was developed by the US Department of Energy, representatives of the lighting industry, other agency representatives and NGOs concerned with energy efficiency. According to the *Vision 2020* document, the lighting industry proposed a product take-back for complete recycling by 2010. Osram Sylvania has discussed making a high mercury, long-lived tube that explicitly requires recycling (Sustainable Conservation, 2000).

### *Outreach/Education*

Since early 2000, LHWMP outreach has focused on overcoming barriers to recycling fluorescent lamps, including lack of public knowledge, mixed messages from government agencies and haulers, habit, cost, and confusion about vendors.

Outreach has focused on audiences that generate or have control over lamp waste: property managers, small businesses undergoing lamp retrofits, lighting contractors and electric utilities sponsoring retrofits. Efforts have included a partnership with Seattle City Light and voucher incentives to help with lamp recycling costs.

# APPENDIX F

# P-TRAPS, PIPES AND PLUMBING

If elemental mercury—with a density about 8 times that of water—enters the plumbing system (e.g., if a broken thermometer is put down the drain), it will tend to pool in low areas such as P-traps and joints between pipes.

Mercury can amalgamate to metal piping, such as copper, high silicon cast iron and stainless steel pipes (Stone et al, 2000; MASCO, 1999). The US Naval Dental Research Institute looked at five copper waste lines serving dental facilities and found mercury ranging from 606 to 1603 mg/kg, with an average of 1097 mg/kg (Stone et al, 2000).

Mercury may be found in plumbing pipes during demolition of old buildings and when re- plumbing dental clinics, labs, medical/vet clinics, hospitals and other facilities where mercury was used. The form can be elemental mercury, amalgam particulate and in some cases—where biological material is present—mercury-laden biomass. Certain biological wastes may provide media for a biomass with an affinity for mercury. Methylated mercury has been found in this biomass, some of which had 1000 mg/L mercury (Massachusetts Water Resources Authority, 2000).

Plumbing in dental offices can become significantly laden with dental amalgam and can provide a continuing source of dissolved mercury to wastewater over time (Mercury Policy Project, 2002). A recent Environment Canada study found that slow dissolution of mercury amalgam in dental office plumbing and in the municipal sewer system serves as a long-term source of mercury to the receiving facility (Environment Canada, 2001). As part of a series of studies on dental amalgam and the environment, Goodfellow Airforce Base looked at the settling of dental amalgam in wastewater sewage pipes (Binovi, 1989).

## Quantity of mercury

Wherever mercury-containing devices are used, mercury from spills can collect in the plumbing. Data on quantities are anecdotal.

### *Dental*

- Fifteen pounds of mercury was found in 33 feet of pipe outside a dental clinic in Sweden (Purdue, n.d.). No further information was available. This is probably an unusually high amount.
- Minnesota estimates that 35 pounds of mercury are stored in that state's dental office pipes (Minnesota Pollution Control Agency, 2001).
- The Western Lake Superior Sanitary Sewer District experienced high concentrations of mercury amalgam when the sewage pipes below a major medical/dental building were cleaned. The particles were re-suspended, and some of them reached the sewage treatment plant. Others re-settled before reaching the plant (Westman and Tuominen, 2000).

### *Hospitals*

Massachusetts General Hospital continued to experience elevated concentrations of mercury in wastewater even after no more mercury was discharged to the sewer system. Eventually the hospital removed 300 feet of drainage pipe and mercury discharges stopped (American Society for Healthcare Engineering, 2001).

Massachusetts found that 1 – 2 percent of mercury in the wastewater treatment system was from hospitals. Palo Alto calculated about four percent from clinics and hospitals. In addition to elemental mercury, these figures include sources of mercury that are not resident in the pipes (such as reagents or other dissolved forms of mercury) as well as biomass in the "special waste" pipes that may dislodge (Massachusetts Water Resources Authority, 2000). (In Washington State, management of "special waste" is different from Massachusetts, so we may not see the same kind of biomass formation.)

### *Schools labs and industry*

University of Michigan found elemental mercury in 10 percent (40) of the p-traps in their dental research laboratories. Quantities ranged from a few droplets to 5 mL (~ 40 mg). None was found in the sink traps of the dental clinic. (University of Michigan, n.d.)

### *Other*

The Danish Environmental Protection Agency investigated sewer catchment areas with high mercury concentrations in sludge that had accumulated in the pipes. Mercury had leaked into the sewer pipes from upstream domestic heating stations fitted with special pressure-holding devices (each of these had several kilograms of mercury) and sludge downstream in the pipes was contaminated (Danish Environmental Protection Agency, 2001).

### *King County*

Given the lack of data, it's not feasible to calculate quantities of mercury in p-traps and pipes in King County.

## Mercury waste

The main issues are demolition and removal of old plumbing in dental facilities and other areas containing mercury. Demolition workers should protect themselves from possible mercury (vapor) exposure. Testing waste before disposal would protect the landfill.

Disposing of mercury by emptying p-traps and other accessible plumbing will protect the sewer system. Pipe cleaning, or flushing, can increase mercury levels in the sewage treatment system a hundred fold (Western Lake Superior Sanitary Sewer District, n.d.).

Disposal of mercury-containing sludge in p-traps and plumping pipes should be sent to a RCRA-permitted treatment, storage, disposal or recycling facility.

## Alternatives

Source control is the best alternative: keep all elemental mercury out of sink and floor drains. Dental offices can capture amalgam particles in wastewater and remove them with amalgam separation equipment. Sink p-traps in situations where elemental mercury may spill should be carefully cleaned.

## Human exposure

Plumbers and demolition personnel are directly impacted. Others are affected through landfill, treatment plant or biosolids application.

# APPENDIX G

# SWITCHES, FLOAT

A float switch is a particular type of tilt switch (a tilt switch is a capsule of elemental mercury with wiring at one end.) In a float switch, this assembly is mounted on a float and the wiring travels to a control box. As the fluid level rises and falls, the position of the 'floating' capsule changes and the elemental mercury flows from one end of the capsule to the other, completing the electrical circuit. This starts the equipment (pump, turn-off valve, etc.) In the opposite position, the circuit is broken and the equipment stops.

Float switches may be found in places where liquids are controlled—these include chemical manufacturing, refineries, sewage treatment plants, metal finishing or electroplating tanks, fuel storage or distribution centers, boats, sumps, bilges, septic systems (other than gravity drain), and drinking water systems. The float switch often controls pumps or activates alarm systems. Government facilities, commercial businesses and residents all use mercury float switches.

Examples of float switch use include the New England Air Force Base, where mercury float switches were found in buildings with individual oil-fired boilers. At the Missoula Wastewater Treatment Plant, approximately 400 faulty mercury float switches were disposed at the city landfill, and in Antarctica, the sewage treatment plant used several mercury float switches to automatically pump out tanks. A Web site called www.heatinghelp.com has a section on boilers and reports that a pump controller has two mercury switches, one that responds to normal water levels in the boiler and one that serves as a 'low boiler water level cutoff' or alarm switch.

## Quantity of mercury

There are no estimates of the number of float switches in King County (or anywhere.) An estimated 630 tons of mercury are in "Switches and relays" in the United States (Leopold, 2002), but these include all switches—lights, cars, electrical relays, etc.

The amount of mercury per float switch varies. Florida reports one gram in a boat bilge pump float switch. Larger switches, if similar to tilt switches found in thermostats, may have at least 3 grams mercury.

## Human exposure

The rate of switch breakage is unknown.

Anecdotal reports tell about drinking water systems and electroplating solutions becoming contaminated with mercury from broken float switches. In systems such as drinking water, sewage or septic systems, breakage could result in an immediate release of high risk. Breakage into fuel systems would result in eventual release of mercury to the air during combustion.

# APPENDIX H

# SWITCHES, VEHICLE

Mercury switches are used to regulate lighting in automobile trunks and hoods. (Mercury can also be found in antilock brake systems (ABSs), navigational lights, high intensity discharge headlights and vehicle entertainment systems (Scrap Magazine, 2001)). This summary is limited to trunk and hood switches.

Automobile switches are position-sensitive, or tilt, switches. When the hood or trunk reaches a certain angle, mercury in the switch makes contact with the electrical points, creating a circuit and turning on the light (Great Lakes United, 2001).

When taken out of service, about 90 percent of all automobiles are dismantled to remove reusable parts (Maine Land and Water Resources Council, 1999). The hulk is shredded and crushed for metal recovery.

## Quantity of mercury

*Estimate #1*

| | | |
|---|---|---|
| 1,341,000 | | licensed vehicles in King County (Wash State Dept of Licensing, 2000) |
| x. 86 | | estimated % of vehicles with mercury switches [9] |
| 1,152,260 | 1,152,260 | estimated vehicles in King County with mercury switches |
| x .43 | x 1.08 | number of switches per car (Recycling Council of Ontario, 2000; Great Lakes United, 2001) |
| 495,902 | 1,244,441 | estimated number of mercury switches in King County |
| x .0008 kg | x .0008 kg | estimated mercury in one switch (Great Lakes United, 2001) |
| **397 kg** | **996 kg** | **estimated mercury in car switches in King County** |
| **873 lbs** | **2190 lbs** | |

Vehicles in King County contain an estimated 873 to 2200 pounds of mercury in switches. This underestimates the total amount of mercury contained in King County cars because it doesn't account for antilock braking systems (3 gm each) and Ride Control systems (2 gm). One report estimates that new cars with these features average 1 gram/mercury per car (Recycling Council of Ontario, 2000).

## Mercury waste

Mercury may be released to the environment if the vehicle is damaged and the switch broken, when scrap autos are crushed and shredded, or when the scrap steel is melted to produce new steel. There are an estimated 40 auto recyclers in King County (and no

[9] Not all cars have mercury switches. International vehicle manufacturers phased out mercury switches during 1992-93.

shredders. Cars in the county are crushed) (Chapman, 2002). Most switches aren't removed from vehicles prior to disposal.

An estimated five percent of vehicles are scrapped each year (Great Lakes United, 2001). This means that there are 24,800 – 57,700 mercury switches in Washington State scrapped each year—or a total of 94 – 102 pounds of mercury from switches. In King County, there's an estimated 35 – 108 lbs. of mercury from switches in scrapped cars. (There may be mercury from other sources, such as ABS.)

## Alternatives

Mercury-free switches are inexpensive and readily available. Many automobile manufacturers have committed to phasing out the use of mercury switches.

## Human Exposure

Mercury releases from retired vehicles are due primarily to melting contaminated scrap steel in electric arc furnaces. Some mercury is also released at auto shredding facilities as air emissions or as a contaminant in waste. Auto scrap yards are also a problem (Great Lakes United, 2001).

## Tools

*Regulations:* Oregon will prohibit the sale of new vehicles with mercury switches in 2006. Upcoming legislation may prohibit the sale of new cars containing mercury switches in Washington as well.

*Product stewardship:* Vehicle manufacturers may be willing to take responsibility for collecting and retiring switches from existing vehicles. The Alliance of Automotive Manufacturers has prepared educational materials regarding mercury switch removal for automotive dismantlers and is willing to do informational programs.

*Outreach:* The LHWMP could replace switches in internal fleet vehicles used by various agencies and commit to purchasing cars without mercury. A private sector partner should be recruited to assist with the replacement program. The City of Seattle is planning to replace all vehicle switches in its fleet.

# APPENDIX I

# THERMOMETERS, FEVER

Fever thermometers contain 0.5 - 1 grams of elemental mercury (Maine Land & Water Resources Council, 1999; Busshart, 2001) and are typically used in health care settings (including veterinary clinics), schools and private homes to measure body temperature.

## Quantity of mercury

A 2001 survey of King County residents found that 59 percent of households that have fever thermometers have mercury fever thermometers. (This is 46 percent of all households.) The elderly and families with young children are more likely to own a mercury thermometer.

*Estimate #1:*

| | |
|---|---|
| 710,916 | estimated number of households in King County (US Census Bureau, 2000) |
| x .43 | estimated % of households that have mercury thermometers in King County (Local Hazardous Waste Management Program, 2001) |
| 305,694 | estimated number of mercury fever thermometers in households in King County[10] |
| x .0005 kg | estimated mercury in one thermometer (Maine Land & Water Resources, 1999) |
| **153 kg** | **estimated mercury in thermometers in households in King** |
| **336 lbs** | **County** |

*Estimate #2:*

| | |
|---|---|
| 65 tons | estimated mercury in thermometers in US (Leopold, 2002) [11] |
| x .006 | % of US population in King County |
| .39 tons | estimated mercury in thermometers in King County |
| **780 lbs** | **estimated mercury in thermometers in King County** |

*Estimate #3*

| | |
|---|---|
| 0.24 | estimated number of thermometers sold per household per year (Barr Engineering Co., 2001) |
| x 710,916 | households in King County (US Census Bureau, 2000) |
| 170,620 | estimated number of thermometers sold per year in King County |
| x .0005 kg | estimated mercury in one thermometer (Maine Land & Water Resources, 1999) |
| **85 kg** | **estimated mercury in thermometers *sold* annually in King County** **187 lbs** |

[10] This assumes one mercury thermometer per household that reports having a mercury thermometer. Some may have more than one.

[11] Estimate #2 may be greater that Estimate #1 because it includes *all* thermometers—hospitals, clinics, labs, etc.—not just household thermometers.

## Mercury waste

*Estimate #1:*

| | |
|---|---|
| **3.5 lbs** | **Estimated mercury in household thermometers broken in King County in one year** (Local Hazardous Waste Management Program, 2001) |

*Estimate #2:*

| | |
|---|---|
| 170,916 | estimated number of thermometers sold in King County annually (see above) |
| x .50 | % of thermometers sold that replace broken thermometers (Barr Engineering, 2001) |
| 85,458 | estimated number of thermometers broken each year in King County |
| x .0005 | estimated mercury in one thermometer (Maine Land & Water, 1999) |
| **43 kg** | **estimated mercury in thermometers broken annually in King County** |
| **95 lbs** | |

According to anecdotal reports from the Wastemobile, few mercury fever thermometers are disposed through the Wastemobile (Cole, 2002). The City of Seattle household hazardous waste facilities collect 4 – 10 thermometers a week, or an estimated 200 – 500 thermometers a year. (This is less than a pound of mercury.) Most thermometers probably go to the garbage. When broken, mercury recovered likely goes into the sewer or septic systems or solid waste systems.

The Association for Metropolitan Sewerage Agencies (AMSA) estimates that for every million households, 654 grams (or 1 –1/2 pounds) of mercury goes to the sewer system each year (Cain, 2001). This translates into an estimated 1 –1/2 to 2 pounds of mercury disposed to the sewer from thermometers each year in King County.

## Alternatives

Non- or low-mercury alternative thermometers are readily available at comparable cost. Digital thermometers containing button batteries with up to 25 mg mercury (Gilkeson, 2001) cost somewhat more than mercury thermometers. A new 'card' thermometer with heat-sensitive cells (manufactured by Medical Indicators) contains no mercury and is comparable in cost to mercury thermometers.

## Human Exposure

People are directly exposed to mercury when fever thermometers break. Some mercury volatilizes and may be inhaled. People may also be exposed through skin contact. In a 2001 survey of households in King County, one percent of households with mercury thermometers reported breaking a thermometer during the preceding year. Extrapolating this data to the population of King County means a release and potential human exposure to 3-1/2 pounds of mercury (Local Hazardous Waste Management Program, 2001). Other

sources show higher breakage rates (5 percent, USEPA, 1992; and 50 percent, Barr Engineering Co., 2001.)

## Tools

### *Regulations*

Seven states and fifteen local jurisdictions have banned or restricted the sale and manufacture of mercury fever thermometers (Cain, 2001). A planned proposal to be presented to the Seattle-King County Board of Health would ban the sale of mercury fever thermometers in King County.

### *Policy*

Nationally, eleven retail pharmacies have voluntarily agreed to discontinue the sale of mercury fever thermometers. The American Hospital Association has signed a memorandum of agreement with the EPA to virtually eliminate the use of mercury in hospital settings.

# APPENDIX J

# THERMOSTATS, WALL

Thermostats respond to changes in temperature and send signals that control heating or cooling devices. Temperature control is needed in residential and commercial heating, ventilation and air conditioning (HVAC) systems. Since the 1950's, mercury tilt switches have been common components of wall thermostats (Wisconsin Mercury Sourcebook, 1997).

The tilt switch is a glass ampoule containing elemental mercury, readily visible once the thermostat cover has been lifted. (See http://www.howstuffworks.com/home-thermostat3.htm for a photo.) The tilt switch turns the HVAC equipment on and off.

A bimetallic spring (a two-layered metal 'sandwich', often coiled) in the thermostat moves in response to changes in temperature and is attached to the tilt switch. When changes in temperature cause the spring to move, these movements change the angle of the tilt switch, causing liquid mercury in the switch to flow back and forth. The mercury completes the circuit by touching the electrical contacts and wires attached to one end of the tilt switch.

For example, at low temperatures, the coil moves the tilt switch and mercury flows over the contacts, completing the electrical circuit and starting the furnace. Multiple tilt switches may be used in one thermostat to control more complex systems—e.g., one switch may control heating and another may control cooling.

Wall thermostats for electric baseboard heaters (also called electric strip heaters) have slightly different switching requirements and typically do not use mercury.

## Quantity of mercury

Tilt switch thermostats may be one of the top three contributors of mercury into the solid waste stream (NEWMOA, n.d.). Each switch contains approximately 3 grams of mercury in a sealed glass ampoule, and a thermostat may have from one to six ampoules, or from 3 to 18 grams of mercury. There are an estimated 50 - 65 million mercury-switch thermostats in homes across the United States (National Electrical Manufacturer's Assoc., n.d.). Other estimates put this higher (70 million) (USEPA, 1994).

An estimated 10 to 15 metric tons of mercury are used annually in the United States to manufacture thermostats, primarily for home heating and cooling, and an estimated 90 percent of the thermostats in residential use in the United States use mercury (USEPA, 1994).

Based on estimates described below, existing King County homes, businesses and institutions contain an estimated 2700 to 5,700 pounds of mercury in thermostats. An estimated 50 – 300 pounds of mercury are added to this inventory annually.

*Estimate #1 – Residential thermostats*

| | | |
|---|---|---|
| 50 | 65 | estimated number of thermostats in US (millions) (National Electrical Manufacturers Assoc., n.d.) |
| x .006 | x .006 | % of US population in King County |
| 300,000 | 390,000 | estimated number of thermostats in King County homes |
| x .90 | x .90 | estimated % of thermostats that contain mercury (USEPA, 1994) |
| 270,000 | 351,000 | estimated number of mercury thermostats in King County homes |
| x .003 | x .003 | estimated mercury per thermostat (range 3 – 18 gm/thermo.) (www.nema.org) |
| **810 kg** | **1053 kg** | **estimated mercury in thermostats in King County homes** |
| **1782 lbs** | **2316 lbs** | |

*Estimate #2 – Residential thermostats*

| | |
|---|---|
| 742,237 | estimated number of housing units in King County (US Census, 2000) |
| x .90 | estimated % of homes that contain mercury thermostats (USEPA, 1994) |
| 668,013 | estimated number of mercury thermostats in King County homes |
| x .003 kg | estimated mercury per thermostat |
| **2,004 kg** | **estimated mercury in thermostats in King County homes** |
| **4,409 lbs** | |

*Estimate #3 – All thermostats*

| | |
|---|---|
| 230 tons | estimated mercury contained in thermostats in the US (Leopold, 2002) |
| x.006 | % of US population in King County |
| **1,38 tons** | **estimated mercury contained in thermostats in King County** |
| **2760 lbs** | |

*Businesses:* In King County (including Seattle), estimates of mercury in thermostats in business establishments are based on a total of 172,308 businesses.[12] Assuming each establishment has one thermostat and 90 percent contain 3 grams of mercury, businesses in King County would contain 1,025 pounds mercury in thermostats.

*Institutions:* Estimates of mercury in institutional settings in King County, such as schools and government buildings, is unknown. For the purpose of this report, it is estimated to be one-quarter the amount of mercury in business establishments, or 250 pounds.

[12] This is based on 59,335 total employers (U.S. Census, 2000; see http://www.census.gov/epcd/cbp/map/99data/53/033.txt) and 112,973 non-employers (U.S. Census, 2000; see http://www.census.gov/epcd/nonemployer/1998/wa/WA033.htm )

**New construction:** *New construction and home remodeling means that new thermostats are added to the existing inventory of thermostats.*

*Estimate #1 – New thermostats*

| | | |
|---|---|---|
| 9489 | 14,695 | estimated new housing units annually in King County (US Census, 2000; King Co Annual Growth Report) |
| x .90 | x.90 | estimated % of thermostats that contain mercury (USEPA, 1994) |
| 8540 | 13,226 | estimated mercury thermostats in new housing units annually in King County |
| x .003kg | x .003 | estimated mercury in one thermostat |
| **26 kg** | **40 kg** | **estimated mercury in thermostats in new housing units in King County** |
| **57 lbs** | **88 lbs** | |

*Estimate # 2 – New thermostats*

| | | |
|---|---|---|
| 5 to | 8 | estimated number of mercury thermostats sold annually in US (in millions) (New York Academy of Sciences, 2002) |
| x.006 | x. 006 | % of US population in King County |
| 30,000 | 48,000 | estimated number of mercury thermostats sold annually in King County |
| x.003 kg | x.003 | estimated mercury in one thermostat |
| **90 kg** | **144 kg** | **estimated mercury in thermostats sold annually in King County** |
| **198 lbs** | **317 lbs** | |

## Mercury waste

Thermostats last an estimated 20 to 50 or more years (USEPA, 1992; USEPA, 1994). Estimates of the amount of mercury contained in thermostats discarded each year in King County are as follows:

*Estimate #1:*

| | | |
|---|---|---|
| 7 | 10.3 | estimated mercury from thermostats disposed annually in US (in tons) (Leopold, 2002; USEPA, 1992) |
| x .006 | x.006 | % of US population in King County |
| .042 tons | .06 tons | |
| **84 lbs** | **120 lbs** | **estimated mercury in thermostats disposed to solid waste disposal systems annually in King County** |

*Estimate #2:*

| | | |
|---|---|---|
| 2 | to 5 | estimated number of thermostats disposed annually in U.S. (in millions) (USEPA, 1994; New York Academy of Sciences, 2002) |
| x .006 | x .006 | % of US population in King County |
| 12,000 | 30,000 | estimated number of thermostats disposed to solid waste disposal systems annually in King County |
| x .90 | x .90 | % of thermostats that contain mercury (USEPA, 1994) |
| 10,800 | 27,000 | estimated number of mercury thermostats disposed annually in King County |
| x .003 k | x.003 | estimated mercury in one thermostat |
| **32 kg** | **81 kg** | **estimated mercury in thermostats disposed to solid waste disposal systems** |
| **70 lbs** | **178 lbs** | **annually in King County** |

Creating a range out of these various estimates, an estimated 70-178 pounds of mercury are discarded in thermostats in King County each year.

## Thermostat disposal

Although services for proper disposal and recycling of thermostats are available, many businesses and residents are not aware that thermostats contain mercury. Disposal of mercury thermostats into the garbage is probably common. According to the New England Waste Management Officials Association, mercury-switch thermostats were one of the top three contributors of mercury to the solid waste streams (NEWMOA, n.d.). Improper disposal onto the ground or into sewer or storm drains is unlikely.

### *Businesses*

Mercury-containing thermostats from businesses may be managed under the state Universal Waste rules if they are recycled (see *Tools* section, below); otherwise they are fully regulated hazardous waste.

### *Recycling*

The Thermostat Recycling Corporation (TRC) provides wholesalers with containers to collect thermostats. Heating, ventilation and air conditioning (HVAC) contractors may drop thermostats off at no cost. Under the TRC program, thermostats are shipped to a processing center where the mercury ampoules are removed for recovery (National Electrical Manufacturers' Assoc., n.d.).

The TRC program was first offered in Washington State in April 2001 and there are currently only two or three collection sites. Other mercury recycling services may charge a fee. The quantity of thermostats managed through TRC or other mercury recycling services is not known.

### *Households*

Residential thermostats may go to the Wastemobile or fixed household hazardous waste collection sites.

The two fixed sites receive 4 – 16 thermostats total per week, or an estimated 200 – 832 thermostats per year (Westgard, 2002). This amounts to between 1 and 5 pounds of mercury (assuming each thermostat contains 3 grams; some contain more) taken to the collection sites each year.

## Alternatives

Non-mercury thermostats entered the U.S. market in 1985 with about 5 percent of the market, gaining an estimated one percent a year through 2000. They reportedly will not begin to impact disposal of mercury thermostats until after 2000 (USEPA, 1992).

Mercury-free thermostats are readily available at comparable cost. A digital thermostat has the added benefit of energy savings from improved performance. However, mercury-containing thermostats are still available. In a new step away from mercury, Honeywell plans to phase out mercury in its popular T87 residential model by 2006 (http://twincities.bizjournals.com ).

## Human Exposure

The risk of human exposure to mercury from an operating thermostat is low because the mercury is sealed. The greatest risk of breakage is probably when a thermostat is replaced or transported to a recycling center. The thermostat should be delivered intact; the mercury ampoule should not be removed from the rest of the thermostat.

When broken, however, thermostats have potential to cause widespread contamination. For example, a situation in which a 13-year-old boy heated up mercury from an apartment thermostat caused the evacuation of 20 people from the building. Dangerous levels of mercury were found in twelve units (Washington Post, 2002). In Connecticut, the Department of Environmental Protection responded to a mercury spill involving a few ounces of mercury spilled onto the floor of a high school classroom from a broken thermostat (Department of Environmental Protection, CT, 2001).

## Tools

### *Regulations*

The Washington State Universal Waste Regulations provide that mercury-containing thermostats from businesses may be managed as Universal Waste if they are recycled. If not recycled, they are fully regulated hazardous waste.

### *Outreach/Education*

The three major United States manufacturers of thermostats—Honeywell, General Electric, and White-Rogers—established the Thermostat Recycling Corporation (TRC) in January 1998. In spring 2001 TRC expanded to include services in Washington State.

TRC provides web marketing of the service through the National Electrical Equipment Manufacturer's web site at http://www.nema.org/trc.

The Northeast Waste Management Officials' Association (NEWMOA) has a Mercury Thermostats Hub Topic, with multiple links to useful thermostat information at http://www.newmoa.org/.

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