NEW HAMPSHIRE DEPARTMENT OF Environmental Services

THE NEW HAMPSHIRE DIOXIN REDUCTION STRATEGY

February 2001

New Hampshire Department of Environmental Services

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NEW HAMPSHIRE
DIOXIN REDUCTION STRATEGY

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DEPARTMENT OF
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Services

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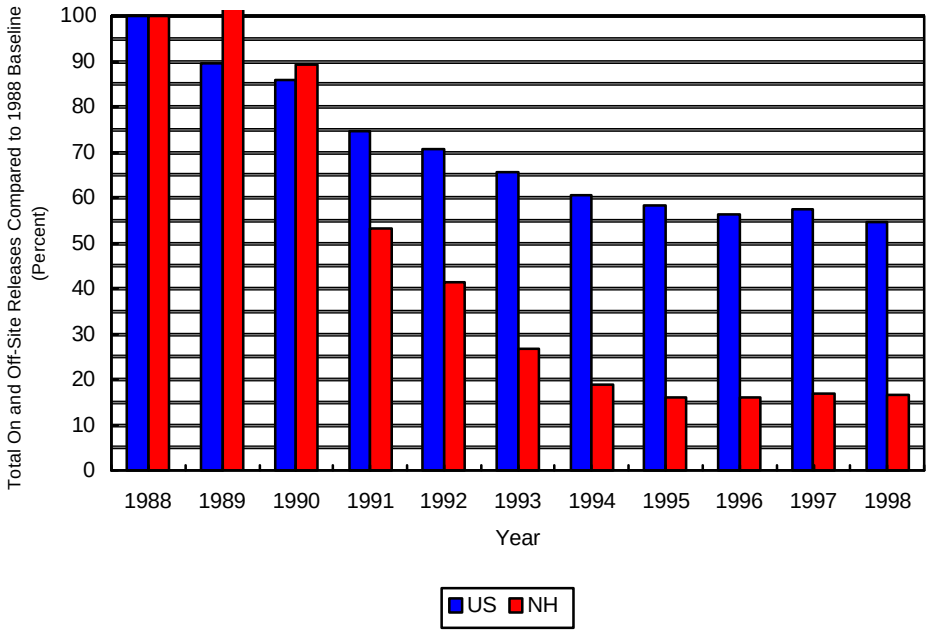
1.0 INTRODUCTION

The New Hampshire Department of Environmental Services (DES) has long recognized the risks posed by toxic pollutants to human health and the environment, and has been a national leader in reducing our exposure to these pollutants. DES has instituted a multi-media approach in addressing the environmental burden of toxic pollutants through programs that include pollution prevention, waste minimization, resource recovery, and pollution control. For example, in efforts to remove toxic substances from the waste stream, New Hampshire has enacted legislation that requires manufacturers to phase out the presence of lead, cadmium, mercury and hexavalent chromium in packaging (New Hampshire Toxics in Packaging Law), and bans the disposal of lead acid batteries in landfills and incinerators. In addition, DES enforces strict surface water and drinking water standards for toxic contaminants. DES adopted the New Hampshire Air Toxics Control Program in 1987, three years before the U.S. EPA began regulating hazardous air pollutants under the 1990 Clean Air Act Amendments; and in 1991 DES established the New Hampshire Pollution Prevention Program to assist NH industries in adopting practices that avoid the generation of waste and minimize the transfer of pollutants from one medium (air, water or land) to another. According to U.S. EPA's Toxic Release Inventory (TRI) data, these efforts have all helped to reduce toxic releases from NH manufacturers by over 85% since 1987, far outpacing the nation as a whole. **See Figure 1-1**.

Figure 1-1. Reduction in Toxic Chemical Releases from Manufacturing Facilities, USA and NH 1988-1998 (Source: US EPA 1998 Toxic Release Inventory)



In a continuation of these toxics reduction efforts, DES has been focusing on a group of chemicals with serious environmental and health effects known as persistent bioaccumulative toxics, or PBTs. PBTs are chemicals that are generally emitted into the environment at very

low or even non-detectable levels, but they share the following characteristics that make them significant environmental threats:

- They break down very slowly allowing their concentrations to build up in the environment over time;
- They accumulate in the bodies of animals when ingested, and increase in concentration as they move up the food chain;
- They are linked to toxic effects to the nervous, immune and reproductive systems, developmental problems, cancer and endocrine disruption in fish, wildlife and humans;
- They can be transported long distances from where they are emitted by wind, precipitation and water currents.

PBTs include a variety of chemicals such as mercury, dioxins, and a number of pesticides and other chemicals. New Hampshire has already had success in pollution reduction efforts for mercury that include eliminating mercury in alkaline batteries, restrictions on the sale of some mercury-containing products and novelty items; and banning the use of mercury in K-12 public schools. In addition, New Hampshire is the first state in the nation to pass legislation prohibiting the sale of mercury containing thermometers. DES also recently instituted strict requirements for mercury emissions from sources such as hospital/medical/infectious waste incinerators (HMIWIs) and large municipal waste combustors (MWCs) that are far more stringent than federal requirements. In the first two years since these reduction efforts were initiated, the state has seen more than a 37% reduction in mercury emissions to the environment.

As one of many continuing efforts to identify and reduce environmental toxins, DES has targeted dioxin as a significant public health threat requiring immediate attention. The term "dioxin" refers to a family of chemical compounds that share certain similar chemical characteristics, and common mechanisms of toxicity. Many individual dioxin-like compounds exist, but all are members of a group of chemicals known as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs). The most toxic and well-studied individual dioxin compound is known as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

Dioxin is produced both naturally (from sources such as volcanoes and forest fires) and as a by-product of a number of human activities including combustion processes. Although dioxin is released into the environment in very minute quantities, it builds up in soils, sediments and plants, bioaccumulates in animal and fish tissue, and is then passed up the food chain to people. Dioxin is considered to be a very potent toxicant that has the potential to produce a number of adverse effects in humans including reproductive and developmental disorders, suppression of the immune system and cancer.

Environmental dioxin contamination is considered a significant public health and environmental problem. Over the last 10-20 years, federal and state governments, as well as the private sector, have taken many steps to reduce releases of dioxin mainly through restrictions on emissions from large industrial sources. As a result of these efforts, the amount of dioxin released to the environment has declined significantly. For example, EPA estimates that dioxin emissions from waste incineration processes in the United States has

decreased by about 80% between 1987 and 1995, primarily due to federally required reductions in air emissions from these sources. New Hampshire also has taken action and adopted key legislation, rules, and policies that have reduced dioxin releases to the environment. **See Appendix 1.**

Despite these efforts however, dioxin is still being released and deposited in quantities significant enough to threaten public health and environmental quality. Once emitted into the air, dioxin can travel great distances due to prevailing winds and upper air currents. Much of it is then washed out of the air by precipitation and deposited onto land and vegetation and into water bodies. This transported airborne dioxin, combined with sources of dioxin within New Hampshire, results in increased levels in local vegetation, crops, farm animals, fish and wildlife. New Hampshire needs to take a strong leadership role in reducing dioxin emissions from in-state sources in order to reduce local environmental and public health impacts, as well as dioxin transport to areas further downwind. By addressing sources within the state, New Hampshire will also enhance its ability to seek reductions from upwind sources outside of the state. Due to its persistence, dioxin takes many years, even decades, to break down into safer components. Thus, reduction efforts in New Hampshire are necessary now in order to reduce dioxin exposure for our children and grandchildren.

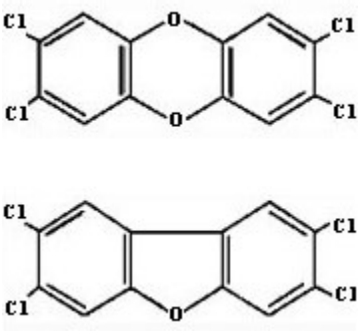
The goal of this Strategy is to identify the major sources of dioxin and recommend actions to substantially reduce dioxin exposure in New Hampshire. This report describes and details steps that New Hampshire intends to take in order to reduce dioxin pollution in the State. It provides a summary of the impacts of dioxin contamination, lists sources and pathways by which dioxin enters the environment, and recommends actions that should be taken to reduce the amount of anthropogenic (man-made) dioxin emitted into the environment. ***The actions recommended in The New Hampshire Dioxin Reduction Strategy are expected to achieve at least a 50% reduction in dioxin releases from New Hampshire sources by 2003.*** Although all dioxin in the environment cannot be totally eliminated, DES, in conjunction with other agencies and organizations, is committed to pursuing all feasible actions to reduce releases of dioxin to the greatest extent possible, providing a safer and healthier environment for future generations in New Hampshire.

2.0 DEFINITION, ORIGINS, TRANSPORT AND FATE OF DIOXIN

2.1 What is Dioxin?

As stated earlier, dioxin refers to a category of pollutants that have similar chemical structure, similar physical-chemical properties, and common toxic responses and effects. For this strategy, dioxins have been defined as a group of 17 toxic compounds from two closely related families: polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). There are a total of 75 individual PCDD compounds and 135 individual PCDF compounds. These individual compounds are technically referred to as *congeners*. Although 210 different congeners exist, only 17 are considered toxic, all of which have chlorine atoms at the 2,3,7,and 8 positions of the carbon-oxygen molecular framework **See Figure 2-1**.

Figure 2-1. Structure of 2,3,7,8-TCDD (top) and 2,3,7,8-TCDF (bottom) (EPA-NCEA)



Each of the 17 congeners differs in its individual toxicity. As a result, international teams of scientists have developed Toxicity Equivalency Factors (TEFs) for each individual congener based on its relative toxicity to the most toxic congener, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). 2,3,7,8-TCDD is assigned a TEF of 1.0. Each of the other 16 congeners is given a value between 0 and 1 indicating its toxicity relative to 2,3,7,8-TCDD. Given these factors, the toxicity of a mixture can be expressed in terms of its Toxicity Equivalents (TEQ) with respect to 2,3,7,8-TCDD, by multiplying the concentration of each congener by its corresponding TEF, and then summing their products. The TEQ approach is the most widely accepted method of evaluating the complex mixtures of dioxins found in the environment, and has been used in this Strategy as well as in the recent U.S. EPA *Draft* Dioxin Reassessment. **Table 2-1** lists the TEFs used for each of the 17 dioxin congeners.

2.2 Origins of Dioxin

Unlike many other toxic environmental contaminants, dioxin is formed as an unintended byproduct of both natural events (volcanoes, forest fires, etc) and “anthropogenic” or man-made processes such as combustion of fuels, wastes and other manufacturing processes.

Although tests have found dioxin contamination in lake sediments and human tissue from ancient times as well as in minerals dating as far back as pre-historic periods, levels in the environment have increased dramatically since industrial expansion began in the 1920s, and it is estimated that only a trace amount of the dioxin found in the world today is a result of natural sources.

Table 2-1 International Toxic Equivalency Factors (TEFs) for PCDD and PCDF Congeners (Source: U.S. EPA 1989)

Congener	**TEF**
2,3,7,8-TCDD	1.0
1,2,3,7,8-PeCDD	0.5
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
1,2,3,4,6,7,8,9-OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
1,2,3,4,6,7,8,9-OCDF	0.001

Dioxin belongs to a family of chemicals known as *organochlorines*. Dioxin is not created intentionally, but is a byproduct of the inadvertent reaction of chlorine and organic molecules in a process. Fuel combustion, waste combustion, chemical manufacturing, pesticide manufacturing, wastewater disinfection, polyvinyl chloride (PVC) manufacturing, and chlorine pulp and paper bleaching can all unintentionally create small quantities of dioxin.

Non-combustion sources of dioxin include operations such as chemical and pesticide manufacturing processes, wastewater treatment operations (including land application of biosolids/sludge), metal smelting and refining, elemental chlorine pulp and paper bleaching, and pressure treated wood manufacturing. In these processes, chlorine and organic compounds in the process react to form small quantities of dioxin. Dioxin emitted into the environment from these non-combustion sources occur mainly as direct discharges to land and surface water. With the exception of wastewater treatment operations, very few of these sources exist in New Hampshire, and as discussed in detail in Chapter 4 of this document, they account for only about 2% of all dioxin emissions in the state.

Most dioxins are emitted into the environment as a result of the combustion of materials containing dioxin or dioxin precursors (chlorine and organics). Dioxins can be emitted from combustion sources through one or more of the following mechanisms:

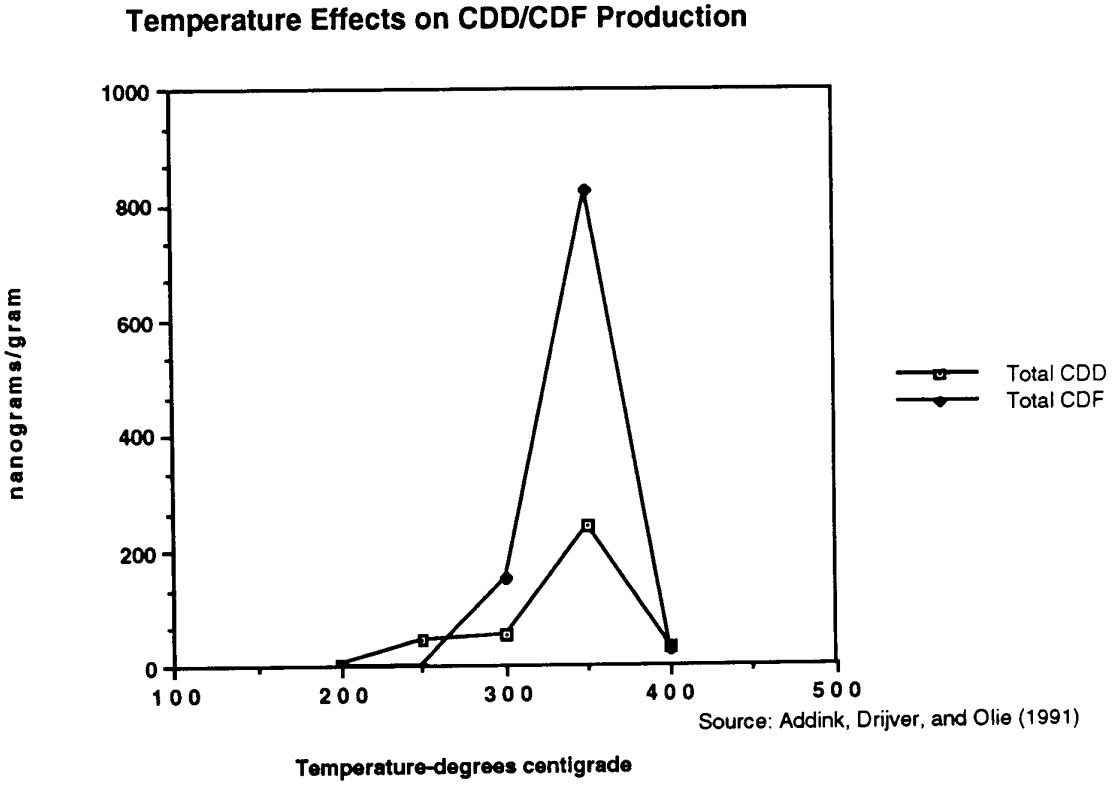
- incomplete combustion of dioxin present in the fuel;

- in-furnace generation; and
- "de novo" formation.

Incomplete combustion refers to the release of dioxin contained in the fuel that passes through the combustion chamber intact, and is subsequently released into the environment. Most fuels contain at least small quantities of dioxin as contaminants. During the combustion process, not all of the dioxin present is destroyed, and some of this dioxin is emitted into the air. This may be especially true during the combustion of fuels and substances known to contain higher quantities of dioxin such as certain municipal wastes, sewage sludge, plastics, bleached paper and certain types of treated wood; especially when burned at relatively low temperatures. It should be noted that where combustion temperatures are high (greater than 800°C) and combustion is well controlled, over 99.95% of the dioxin originally present in the fuel is destroyed.

In-furnace generation is the formation of dioxin from the thermal breakdown and re-arrangement of chlorine and organic precursor molecules in the combustion chamber. Dioxin forms when the precursor molecules attach themselves onto the surface of fly ash particles and react with one another to form dioxin, especially when certain metals that act as catalysts are present in the fly ash. In-furnace generation of dioxin is highly dependent on temperature, retention time, and availability of catalytic metals and fly ash particles. As shown in **Figure 2-2**, combustion gas temperatures in the range of 200 to 400°C produce the highest levels of in-furnace dioxin formation.

Figure 2-2. Temperature Dependence on Dioxin Formation During Combustion



The third mechanism, “de novo” formation, is the creation of dioxin “downstream” of high temperature combustion zones, when combustion gases have cooled to temperatures favorable for dioxin formation chemistry. This mechanism is similar to in-furnace generation described above, but results from the reaction of chlorine and carbon in the fly ash downstream of the combustion chamber, rather than directly from chlorine and organic precursors formed in the furnace. Carbon reacts with chlorine and oxygen in the presence of catalytic metals in the fly ash to form both dioxins and dioxin precursors. The precursors are then also transformed into dioxin through the same mechanism described above for in-furnace generation. In well designed and operated combustion systems, de novo dioxin synthesis is believed to be the dominant pathway for dioxin formation. De novo synthesis can be minimized, however, by rapidly reducing the temperature of the combustion gases through the critical temperature range.

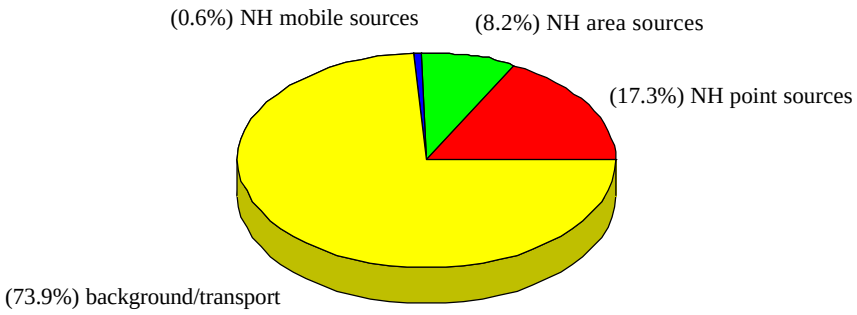
2.3 Atmospheric Transport and Fate of Dioxin

Dioxins are semivolatile organic compounds and as such can be emitted into the air both in the vapor phase and as a component of particulate matter. The two key parameters controlling the phase in which an individual congener is found are the congener's vapor pressure and the atmospheric temperature. Congeners with higher vapor pressures (i.e., the less chlorinated congeners) are found to a greater extent in the gas phase. For a given congener, the fraction in the vapor phase increases with increasing temperature and decreases with increasing particulate concentration.

Once in the atmosphere, dioxin can travel thousands of miles before being deposited on the earth’s surface. Deposition can occur in two ways. Wet deposition occurs as a result of rain or snow washing dioxin in suspended particulate matter from the atmosphere. Dry deposition is a result of atmospheric turbulence and gravity causing both vapor-phase and particulate-related dioxin to be deposited. Studies have concluded that the transfer of nearly all non-hepta- and non-octa-chlorinated dioxins compounds to leafy vegetation is dominated by vapor-phase dry deposition that involves the movement of vapor-phase dioxin from ambient air directly into leafy vegetation (Welsch-Pausch *et al*, 1995).

The distance dioxin travels from its source is dependent on many factors, such as release height (stack height), wind speed, meteorological conditions, dioxin form (vapor or particle phase), and the size of the particles to which the dioxin might adhere. Because of long-range transport, much of the dioxin deposited in New Hampshire most likely comes from other regions, and some of the dioxin emitted from New Hampshire sources is deposited outside of the state. Several recent studies have been conducted to examine long-range transport of dioxin. A study by the Center for the Biology of Natural Systems, Queens College, CUNY, reported that dioxin deposited in the Great Lakes, while primarily from regional sources, came from sources as far away as Southern Florida and Colorado, and estimated that only 1-10% of dioxin emitted is deposited within 30 miles of its source (Commoner *et al*, 1996). Recent U.S. EPA studies including the 1998 Cumulative Exposure Project (that estimated 1990 ambient concentrations of air toxics) suggest that over 70% of dioxin found in New Hampshire’s air is not attributable to New Hampshire sources, but is a result of long-range transport, re-suspension of historical emissions, and non-anthropogenic sources (background). The estimated sources of dioxin in New Hampshire are shown in **Figure 2-3**.

Figure 2-3. Sources of Dioxin in New Hampshire - 1990



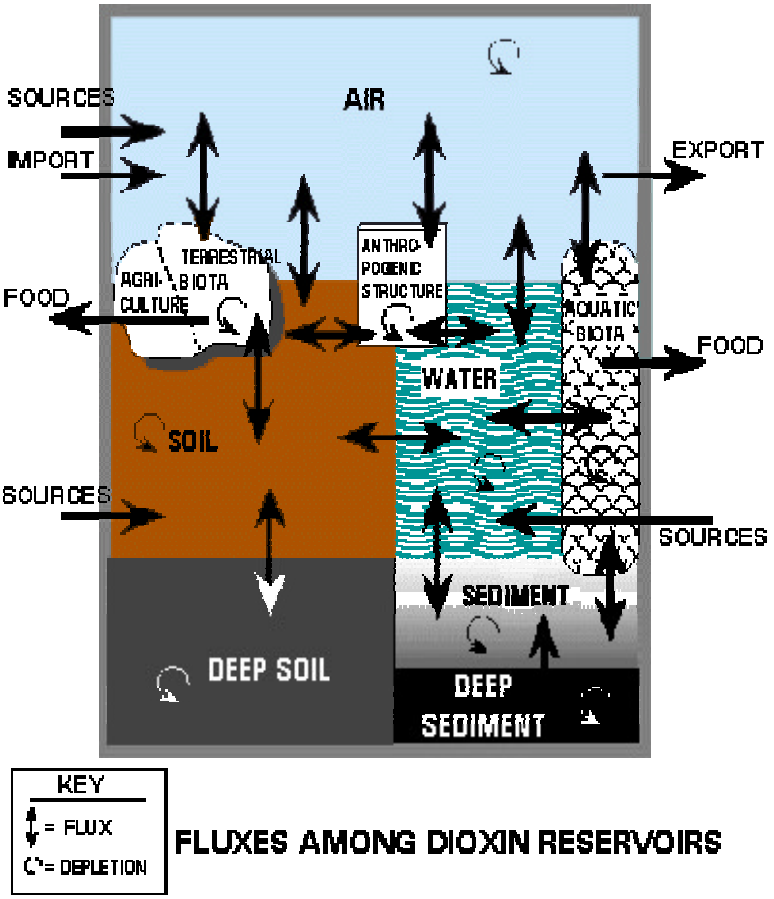
(Source: US EPA Cumulative Exposure Project)

Another study, *Long-range Transport of Dioxin from North American Sources to Ecologically Vulnerable Receptors in Nunavut, Arctic Canada* (Commoner *et al,* 2000), was commissioned by the North American Commission for Environmental Cooperation (NACEC), and has linked dioxin deposition in Canada's Arctic to sources in Canada, Mexico and the United States (NACEC is a Montreal-based organization established under the environmental side accord to the North American Free Trade Agreement). Elevated levels of dioxin were observed in mother's milk in the native Inuit population of Arctic Canada. Although there is some debate over the significance of local dioxin sources as well as the dietary habits of the Inuit population, the potential contributions of distant sources of dioxin to these elevated mother's milk levels were evaluated. Using a sophisticated air transport model developed by the US National Oceanographic and Atmospheric Administration (NOAA), the research team modeled, on a continental scale, the rates of deposition of airborne dioxin in the Canadian Arctic, and identified the possible major contributing North American sources.

Based on 1996-1997 emissions data, the results indicated that a number of specific sources including waste combustors (municipal and medical), cement kilns, metal processing facilities, and backyard trash burning may be in part responsible for dioxin reaching Arctic Canada. Although many experts question the appropriateness of this model for the purpose of attributing dioxin contributions from specific sources, and many of these sources have significantly reduced or eliminated dioxin emissions since the 1996-1997 time period, the study still provides valuable information about the significance of long-range atmospheric transport as an important factor in dioxin deposition. For example, the results suggest that sources 600 to 2,500 miles away may be responsible for the majority of dioxin deposition in the region, and even sources in Mexico, more than 3,700 miles away, could be significant contributors. Although the results of this study are specific to the effects of North American dioxin sources on the Canadian Arctic, they help confirm that dioxin emissions are a large-scale problem that will require continental and even global solutions.

An illustration of the cycling of dioxin through the environment is shown in **Figure 2-4**. Dioxins are deposited on plants, water, soil and sediments in the environment and are broken down very slowly. They are *bioaccumulative* and undergo *biomagnification*, that is, they

Figure 2-4. Cycle of Dioxin in the Environment



(Source: The US EPA Dioxin Exposure Initiative, 1994)

collect in plants, water, soil and sediments and are taken up by animals and aquatic organisms where they tend to accumulate and become concentrated in the food chain. Because dioxins are hydrophobic[1], they accumulate in fats stored in the body. Very few methods of elimination exist, and the half-lives[2] of most dioxin species are relatively long, 7-10 years according to EPA's most recent assessment. Dioxin levels in the environment have been declining for the last 30 years due to reductions in man-made sources, but dioxins break down so slowly that some of the dioxins from past releases will still be in the environment many years from now. The only substantial removal of dioxin from the environment is through food and export. The dioxin removed through food goes into our bodies. Dioxin removed through export is simply passed on to others downwind.

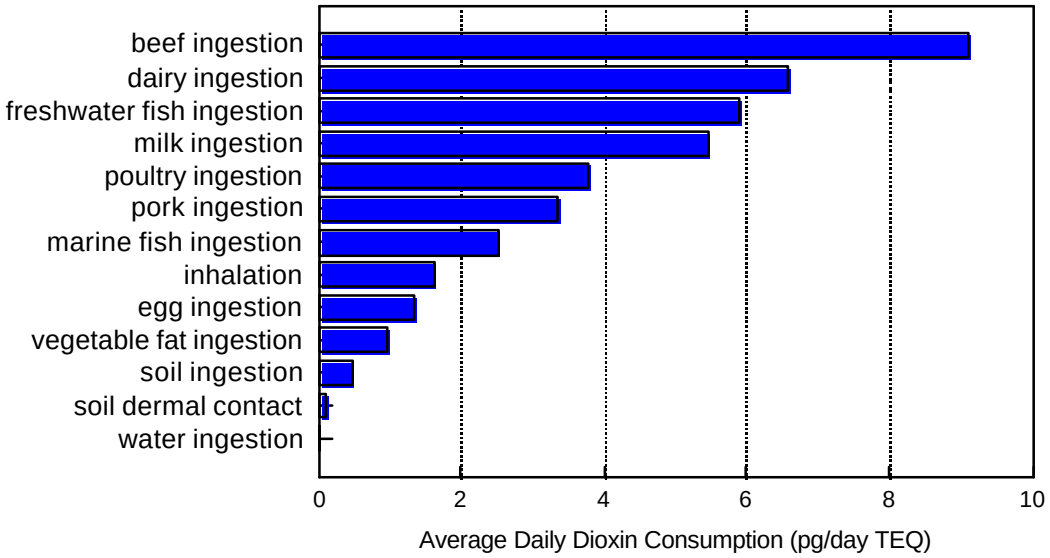
[1] Hydrophobic molecules can dissolve in fats, oils, and other lipids, but not in water.
[2] The half-life of a chemical is the amount of time it takes for half the original amount of chemical to degrade.

3.0 IMPACTS ON PUBLIC HEALTH AND THE ENVIRONMENT

3.1 Human Exposure and Health Effects

As discussed earlier, dioxins are emitted into the atmosphere and are deposited on plants, water and soil. They accumulate in plants, including livestock feed, and are then taken up by animals and aquatic organisms where they accumulate and become concentrated in the food chain. As a result, it is estimated that, for most people, exposure occurs mainly through the diet, with more than 95% coming through dietary intake of animal fats. Lesser human exposures occur from breathing air and drinking water containing trace amounts of dioxins, from inadvertent ingestion of soil containing dioxins, and from absorption through the skin contacting air, soil, or water containing very minute levels of dioxin. The average adult daily intake of dioxin from various sources in the United States is depicted in **Figure 3-1**.

Figure 3-1. Estimated U.S. Daily Adult Dioxin Exposure by Pathway



(Source: US EPA Dioxin Re-Assessment, Sept. 2000)

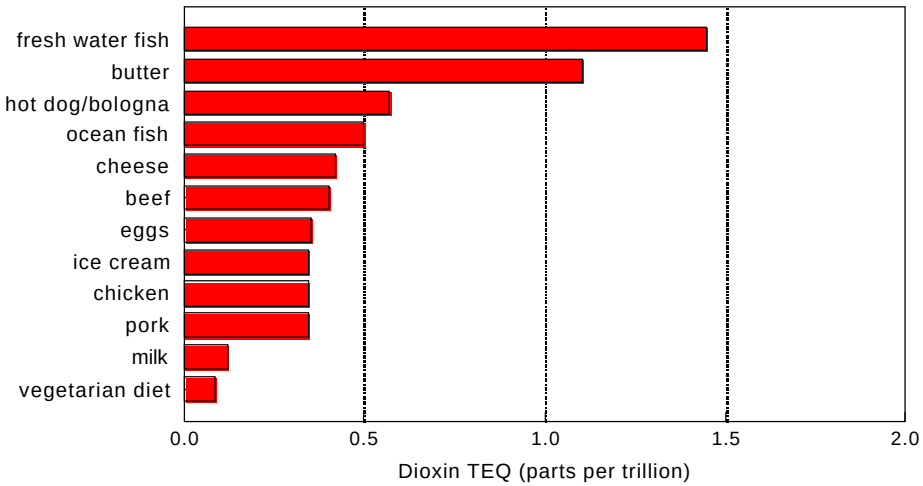
There are certain groups of people that may have higher exposures to dioxins than the general population. These groups may include people who smoke, those that consume unusually large quantities of fish, meat, or dairy products, those who may have experienced elevated exposure to dioxin as a result of a food contamination incident, and people that may have been exposed in the workplace or through industrial accidents.

Dioxin exposure in humans can lead to a variety of negative health effects. Some of these negative health effects include various types of cancers; chloracne (a severe acne-like condition that sometimes persists for many years); learning disorders and behavioral problems; adverse effects on reproduction and development; diabetes; weight loss; effects on the immune, endocrine, nervous, and gastrointestinal systems; and sometimes death. The wide range of these health problems is due to differing exposure levels, exposure times and sensitivities.

The US EPA has been conducting a reassessment of dioxin exposure and human health effects since 1991. On November 2, 2000, EPA's Science Advisory Board (SAB) approved the science supporting the findings of the reassessment, that dioxin is a potent animal toxicant with the potential to produce a broad range of adverse effects in humans including reproductive effects, developmental effects, suppression of the immune system and cancer. The report also concludes that the amount of dioxin found in the bodies of members of the general population (body burden) closely approaches the levels at which adverse effects are expected to occur (EPA, 2000). In addition, on January 19, 2001, the U.S. Dept. of Health and Human Services, National Toxicology Program listed 2,3,7,8-TCDD as a known human carcinogen. Thus, as we reduce, and where possible eliminate, dioxin production at the source, all foods will be safer and healthier, reducing dioxin body burden and the potential for adverse health effects.

As mentioned above, 95% of human exposure to dioxins is through food consumption, particularly animal fat. Most people's exposure to dioxin is through the consumption of meat and dairy products, although the highest concentrations of dioxin are found in fresh water fish. **Figure 3-2** shows various food products with approximate dioxin concentrations. The consumption of all food products has associated benefits and risks that must be taken into consideration. By cutting the amount of dioxin that is released into the environment and by better educating our citizens about the foods that they eat, we can reduce the risks and enhance the overall nutritional benefits of these foods.

Figure 3-2. Dioxin Concentrations in Typical American Foods

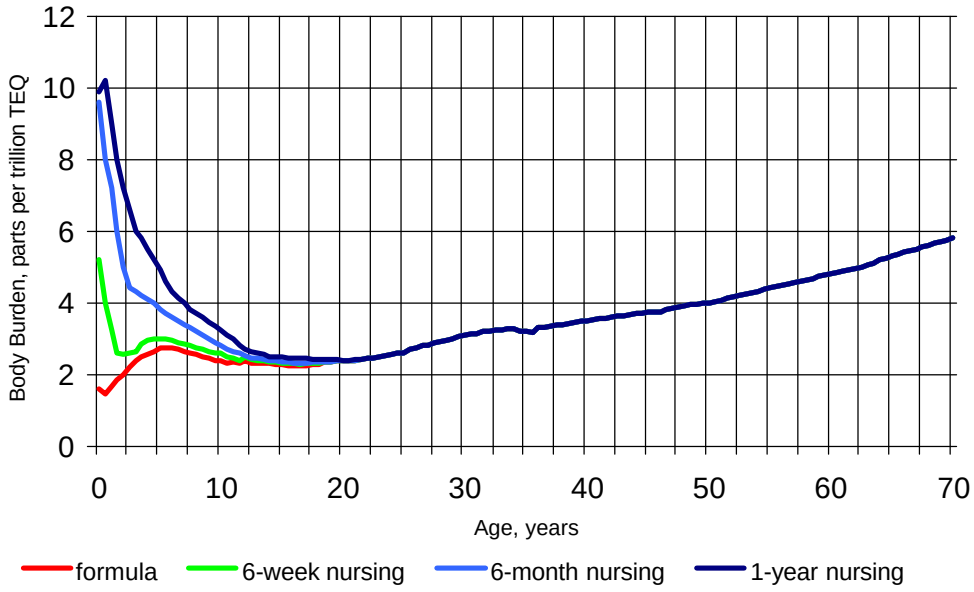


(Source: Schecter *et al*, Chemosphere, 1997)

Food consumption changes with age and stage of development, and therefore the daily intake and body burden of dioxin also varies with age. Fetuses and breast-fed infants are the maximum exposed age group. They may receive high levels in the uterus, as well as high levels from breast milk, depending on the diet of the mother. Chronic high-level exposures of fetuses to dioxins have been shown to cause low birth weights in children born to exposed mothers, as well as evidence of learning disorders, behavioral problems, hyper pigmented skin, and swollen gums and eyelids (Schettler, 2000). **Figure 3-3** shows the estimated dioxin body burden from birth to age 70 under four nursing scenarios: formula only, and 6-week, 6-

month and 1-year nursing. As indicated, breast-feeding has a significant impact on dioxin body burden for newborns and infants. **It should be noted, however, that the World Health Organization (WHO) and other experts believe that nutritional and other benefits of breastfeeding far outweigh any potential long-term harmful effects from typical dioxin exposures.** Thus, we must accelerate our efforts to reduce the sources of dioxin in our environment such that the nutritional benefits of breastfeeding can be maximized without adding unnecessary risks to infants and young children.

Figure 3-3 Estimated Dioxin Body Burden Concentrations from Birth to Age 70 Under Different Nursing Scenarios



(Source: U.S. EPA Dioxin Re-Assessment, Sept. 2000)

3.1.1 Fish Consumption Advisories

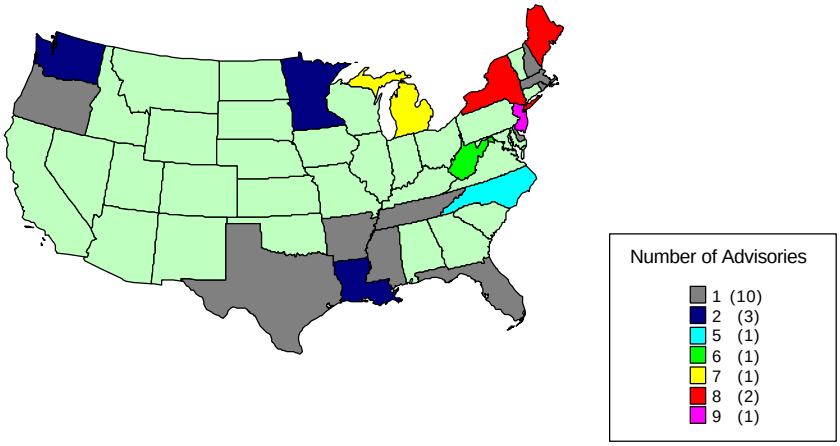
Dioxin builds up in surface water and sediments and is ingested by organisms, allowing it to bioaccumulate in the aquatic food chain. This leads to concentrations of dioxin in fish and other aquatic species that are hundreds to thousands of times greater than that of the water bodies in which they live. In December 1998, nine states issued 59 fish consumption advisories dealing with dioxins. 65% of these were administered by five states: Maine (8), New York (8), New Jersey (9), West Virginia (6), and North Carolina (5) (EPA, Sept 1999). The advisories inform the public that fish have been tested and found to have dioxin levels of concern. A map depicting those states with dioxin fish advisories is presented in **Figure 3-4**.

There are five major types of advisories. These include a no-consumption for the general public (NCGP) and no-consumption for sensitive subpopulations (NCSP). When contamination is less severe, a restriction for the general population (RGP) or a restriction for subpopulations (RSP) is issued. The fifth ban is a commercial fishing ban (CFB). Currently, one dioxin advisory has been issued in New Hampshire that includes a RGP and a NCSP for all types of fish in a 14-mile section of the Androscoggin River from Berlin to the Maine border. This advisory was issued in 1989 based on elevated dioxin levels found in the tissue of fish in the river downstream of the Berlin pulp and paper manufacturing facility. However, it should be noted that the mill changed its manufacturing process, and since 1994 no longer

discharges detectable concentrations of dioxins and furans. In 1997, the State of Maine enacted a law requiring all of its kraft pulp mills to reduce their 2,3,7,8-TCDD discharges to surface waters to non-detectible levels by July 1998. This law established the most stringent dioxin-control standards in the country. While the pulp mill in Berlin, NH is not subject to this regulation, its wastewater discharges comply with the standard. In addition, although the advisory is still in effect, fish (brown bullhead) tissue sampling downstream of the mill shows a decrease in 2,3,7,8-TCDD/TCDF concentration of more than 90% since 1990.

Although New Hampshire has been highly successful in cleaning up our rivers and lakes, the state also has a general, statewide fish consumption advisory based on freshwater mercury contamination (primarily due to mercury emissions from out-of-state and in-state sources that build up in bottom sediments over time and move up the food chain). It was issued by the New Hampshire Department of Health and Human Services, and applies to all fresh water fish species collected from all inland waters. In addition, on January 12, 2001 the U.S. Food and Drug Administration announced an advisory for pregnant women, nursing women and young children on the health hazards of mercury from consuming certain types of saltwater fish. Although the basis of these advisories is mercury contamination, observance of the advisories also serves to limit the consumption of dioxin for those whose diet includes fish.

Figure 3-4 State-Issued Fish Advisories for Dioxins (parentheses indicate number of states with the specified number of advisories). ME and NY Also Have Statewide Coastal Marine Advisories.



3.1.2 Reducing Human Exposure to Dioxin

All people have some level of dioxin in their bodies, and there currently are no effective treatments to remove dioxin that may be built up in the human body. Dioxin is metabolized very slowly, and even if exposure is sufficiently reduced, it may take years to see a decrease in dioxin body burden. It will take many years for the actions recommended in this Strategy to achieve significantly lower dioxin exposures for the general population. However, people have control over the foods that they eat. Thus, the fastest and easiest way for people to reduce their exposure to dioxin is to become educated about the foods that they eat and make dietary adjustments as necessary. For most people, reducing fat intake, eating a balanced diet,

and adhering to the State fish consumption advisories are key to reducing dioxin exposure. In addition, assuring healthy and safe workplaces, protecting the food supply from contamination and promoting healthy lifestyle habits will help reduce dioxin exposures while the reduction strategies recommended in this report are implemented and achieve the desired benefits over time. **Section 5.6** of this report lists several recommendations that can help New Hampshire citizens take immediate steps to reduce their daily exposure to dioxin.

3.2 Environmental Effects

Dioxin exposure is not just a concern for humans. It has also been shown to adversely affect populations of birds, mammals and fish, especially those at the top of the food chain. Dioxin released into the atmosphere and deposited on land is collected in vegetation including shrubs, grasses, lichens and mosses where it is ingested by insects, amphibians, birds and mammals and passed up the food chain. Recent studies of arctic wildlife (Jensen *et al*, 1997) show that dioxin enters the major terrestrial (caribou) food chain mostly through lichen, mosses and shrubs. Since these routes of entry into the food chain cannot be protected from airborne pollutants, corrective measures must be directed toward reducing dioxin emissions at the source.

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Dioxin deposited in water is taken up and collected in algae, which is also passed up the food chain and concentrated in fish and marine mammals. Dioxin exposure has been associated with reduced fertility and low hatch rates in fish and birds, as well as low birth weight and developmental problems in certain mammals and other wildlife.

Most studies of the effects of dioxin and dioxin-like compounds have been conducted on populations of wildlife including mink, trout, eagles, cormorants, osprey and herring gulls in the Great Lakes area where past environmental dioxin contamination is extensive. For example, lake trout populations in the Great Lakes underwent a very rapid and unexplained decline in the 1940's and 1950's. It is now believed that dioxin and dioxin-like compounds played a key role in this decline. Scientists have now determined that dioxin concentrations of 60 parts per trillion in water result in a 50% mortality rate for lake trout fry. Based on calculations of former concentrations of these chemicals in Lake Ontario in the 1950's, it is estimated that lake trout embryos would have been exposed to up to 300 parts per trillion of dioxin; over 2.5 times the level that would cause 100% mortality (Guiney, *et al*, 1996). Other studies show strong evidence of a link between low reproduction rates for eagle and osprey populations along Wisconsin's Lake Superior shore and high levels of dioxins in the fish that they eat (Karasov *et al*, 1998), as well as links between dioxin contamination and wood duck reproductive failure in Arkansas (White *et al*, 1995). Based on these data it is reasonable to assume that New Hampshire's predatory species like eagle, osprey, herons, loons, otters, martins, fishers and coyotes are also at risk for health effects of elevated levels of dioxin.

Although levels of dioxin in the environment have been decreasing in recent years, the relationship between low-level dioxin contamination and its effects on wildlife are still being studied. Evidence suggests that even at low contamination levels, dioxins may play a role in abnormal brain development, altered sexual development, behavioral abnormalities and abnormal or impaired growth in amphibians, reptiles, birds and mammals exposed throughout the food chain. Thus, despite significant reductions in dioxin emissions over the past several years, much more needs to be done to ensure that we have a clean, healthy and sustainable environment in New Hampshire.

4.0 REDUCING DIOXIN IN NEW HAMPSHIRE

4.1 Introduction

In order to identify major dioxin source categories where reduction strategies can be focused, DES assembled a comprehensive "emissions inventory" of dioxin emitting sources in New Hampshire. The inventory was based on 1999 emissions data using emission factors developed by the U.S. EPA. However, as discussed in Chapter 2, the actual amount of dioxin that the people of New Hampshire are exposed to is much greater than that produced within the state due to both long range transport, and exposure though consumption of foods produced in and out of state. Nevertheless, the results of this emissions inventory show that an estimated 5,244 mg of dioxin are emitted annually from known sources in New Hampshire. Over 98% of this dioxin is emitted into the air as a by-product of combustion, while the remaining 2% is a result of activities such as land application of biosolids from wastewater treatment and pesticide use.

Based on this emissions inventory, the largest dioxin emitters in New Hampshire in many cases differ from those historically associated with dioxin emissions nationally. For example, dioxin emissions to the air are typically associated with sources such as hazardous waste incinerators, cement kilns, large metal smelters, municipal solid waste combustors and pulp and paper mills. However, these sources are responsible for a smaller relative percentage of dioxin emissions in New Hampshire due to the fact that no hazardous waste incinerators, cement kilns or large smelters exist in New Hampshire; and emissions from New Hampshire's municipal solid waste combustors have been reduced substantially due to strict emissions regulations already in place for the large combustors, and the recent closure of several small municipal waste combustors. In addition, although the pulp and paper industry has historically been associated with dioxin emissions to surface water, recent operational changes in the bleaching process at New Hampshire's largest mill have dramatically reduced dioxin emissions to the Androscoggin River **(*see sidebar*)**.

Dioxin Reductions at the Burgess Pulp Mill - Berlin, NH

The Burgess pulp mill has been producing pulp for paper manufacturing in Berlin, NH for many years. The mill has had a number of different owners prior to being purchased by Pulp and Paper of America (PPA) in 1999. In the late 1980s dioxin emitted into surface waters from pulp and paper mill effluent became a major concern across the U.S., and a task force was established at the Berlin mill for the purpose of identifying and reducing dioxin in wastewater. Three main factors were identified that contributed to dioxin at the mill:

1. the use of elemental chlorine for pulp bleaching;
2. the use of defoamers that contained dioxin precursors; and
3. the use of foul condensates in pulp washing and screening.

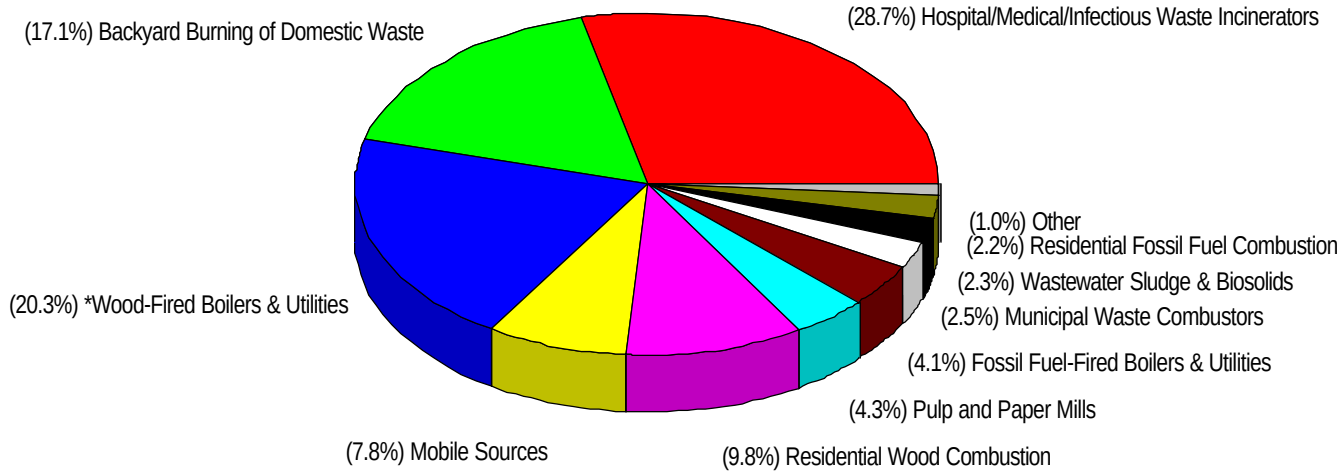
During the late 1980s and early 1990s a number of steps were taken to reduce dioxin at the mill. Chlorine use was reduced through alternative bleaching aids, new defoamers were introduced that contained lower amounts of dioxin precursors, and less foul hot water was used for pulp washing and screening. Further steps were taken to eliminate the use of elemental chlorine in the bleaching process, and by 1994 a complete substitution of elemental chlorine was completed. Recent tests now show that levels of dioxin in the mill wastewater are below the limits of detection. New EPA regulations will require all pulp mills to eliminate elemental chlorine bleaching by April 2001. The Berlin mill completed this effort seven years before these new requirements are scheduled to go into effect.

Based on 1999 dioxin emissions inventory estimates, the major categories of sources that contribute to dioxin contamination in New Hampshire are shown in **Figure 4-1**. The five largest source categories identified in 1999 include:

1) hospital/medical/infectious waste incinerators,
2) wood-fired boilers and utilities,
3) backyard burning of domestic waste,
4) residential wood combustion, and
5) mobile source fuel combustion.

In total, these five categories account for an estimated 80% of the state's dioxin emissions. The remaining 20% comes mainly from the combined emissions of about 15 other source categories, of which no single category amounts to more than 5% of the total. However, in order to achieve the goal of substantially reducing and ultimately eliminating all dioxin emissions to the environment where feasible, we must focus on **all** sources of dioxin regardless of the proportion of their dioxin contribution. In addition, in evaluating reductions from each source category, we must ask the question: "is there a viable alternative?". If viable, less polluting and cost effective alternatives exist then reduction efforts should be focused in these areas.

Figure 4-1 Estimated Sources of Dioxin Emitted in New Hampshire By Source Category, 1999



* Note: Actual percent contribution to be determined through future emissions testing at New Hampshire facilities.

(Source: New Hampshire Dept. of Environmental Services, 1999 Dioxin Emissions Inventory)

The major categories of sources that contribute dioxins in New Hampshire's environment, and strategies for reducing these contributions, are discussed in detail in the following sections. **Appendix 2** provides a comprehensive list of known New Hampshire dioxin emission sources, and **Appendix 3** contains a detailed comparison of state and national sources of dioxin, by category.

In order to put New Hampshire's estimated annual dioxin emissions of 5,244 mg into perspective, it should be noted that, using the World Health Organization's Tolerable Daily Intake (TDI) for dioxin of 1 - 4 pg/kg of body weight, this amount of dioxin would be enough to exceed the TDI for between 50 and 200 million people if equally distributed to these individuals. Of course, New Hampshire's dioxin emissions are not distributed only to people, but rather are distributed geographically without regard to human population. In addition, although it appears from the data in **Appendix 3** that New Hampshire's statewide annual dioxin emissions are only a small fraction of national dioxin emissions, it must be noted that New Hampshire represents only about one two hundredth (0.50%) of the U.S. population and only about one four hundredth (0.25%) of the U.S. land area. Additionally, the national dioxin emissions estimates are based on older (1995 rather than 1999) data. EPA estimates that since 1995, regulatory actions have resulted in dramatic reductions in dioxin emissions from some major source categories such as municipal waste combustors nationwide. As a result, it is clear that New Hampshire's contributions to U.S. dioxin emissions are in proportion to those from the rest of the nation as a whole.

4.2 Hospital/Medical/Infectious Waste Incinerators

Hospital/Medical/Infectious Waste Incinerators (HMIWIs) are used in New Hampshire by hospitals and health care facilities to dispose of hospital waste and medical/infectious waste. When burned, hospital and medical/infectious wastes emit a number of toxic air pollutants, including hydrochloric acid, dioxin, lead, cadmium, and mercury. The 1998 ***New Hampshire Mercury Reduction Strategy*** identified HMIWIs as major contributors to mercury emissions in the state, and as a result, led to the implementation of strict new state and federal regulations. In 1998 New Hampshire had thirteen operating HMIWIs. Since that time, however, several have chosen to shut down their incinerators rather than comply with the new emissions limitation requirements. As of October 2000, there were eight operating HMIWIs remaining in New Hampshire. Of these eight, four are expected to shut down by April 2001 as the new HMIWI rules take effect. Those that remain open will be required to comply with strict new emissions limitations no later than September 15, 2002.

Medical waste burned in HMIWIs consists of housekeeping, infectious, and non-infectious wastes produced on-site or transported from other facilities that do not have an on-site incinerator. HMIWIs produce relatively large amounts of dioxins in the incineration process primarily because of the high chlorine content of plastics in the incinerated waste. Medical waste typically consists of about 55% paper, 30% plastics, and 10% water (EPA, May 1997). Many of the plastics used in hospitals, particularly intravenous bags and tubing, contain polyvinyl chloride (PVC), which is a known precursor of dioxin formation in medical waste incinerators due to its high chlorine content. Most older HMIWIs are relatively small units and were rarely equipped with air pollution control devices designed to reduce dioxin formation and emissions.

To date, only one dioxin stack test has been conducted at a New Hampshire HMIWI (Weeks Memorial Hospital, Lancaster, NH, March 1996). As a result, emission factors used to calculate New Hampshire HMIWI dioxin emissions were taken from U.S. EPA's Draft *Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States* (EPA, April 1998). Using these emission factors, DES estimates that the eight HMIWIs still operating in New Hampshire produce almost 29% of the State's total dioxin

emissions. By contrast, HMIWIs were estimated to produce 11.5% of the nation's total dioxin emissions in 1995.

Dioxin emissions from HMIWIs in New Hampshire are subject to new state regulations. New Hampshire's State Plan for controlling air emissions from existing HMIWIs, which became effective April 10, 2000, makes New Hampshire the first and only state in EPA Region 1 to obtain final approval for its plan as of January 1, 2001. The New Hampshire Code of Administrative Rules, Env-A 3500, which is part of the approved State Plan, regulates a variety of pollutants, including dioxin, from all HMIWIs that began construction on or before June 20, 1996. Under the rule, HMIWIs are categorized according to size, capacity and geographical location. All *small* (maximum design capacity of less than or equal to 200 lb/hr of waste), *medium* (maximum design capacity of less than or equal to 500 lb/hr of waste), and *large* (maximum design capacity of greater then 500 lb/hr of waste) HMIWIs, will have a dioxin emissions limitation of 2.3 nanograms per dry standard cubic meter (ng/dscm) TEQ. *Small/remote* HMIWIs (located more than 50 miles from the boundary of the nearest Standard Metropolitan Statistical Area and burn less than 2000 lbs/week of waste) will have a dioxin emissions limitation of 15ng/dscm TEQ.

Owners or operators of HMIWIs were required to decide by September 1, 2000 to either shut down their incinerators or comply with the rule. Those choosing to shut down were required to file a closure agreement with DES by October 10, 2000 that demonstrates that the HMWI will close no later than April 10, 2001, and that approved alternate methods of disposal will be in place. HMIWIs that will remain open were required to submit a Title V operating permit application to DES by September 1, 2000 and must be in compliance with the applicable emissions limits by April 10, 2001 unless an extension is requested and granted. All HMIWIs, including those that are granted an extension, must be in compliance no later than September 15, 2002. HMIWIs that remain open will have the option of complying with the rule by installing air pollution control equipment, implementing a program of source reduction, seeking alternative methods of disposal, or a combination of these options.

Four HMIWIs have submitted closure plans and are expected to shut down by April 10, 2001. Concord Hospital, which owns and operates New Hampshire's largest HMIWI has already begun the closure process and that alone will result in the elimination of over 25% of all dioxin emissions from HMIWIs in the state. Once the HMIWI rules are fully implemented, it is expected that overall dioxin emissions from HMIWIs in New Hampshire will be reduced by over 90% between 1998 and 2002.

Hospitals and health care providers have several options for dealing with medical/infectious waste short of incineration. These options include source separation (segregating ordinary household waste and recyclables from medical/infectious waste), source reduction, (eliminating dioxin precursors from the waste stream) and, alternative disposal techniques. All of these options are effective in reducing overall hospital waste generation and minimizing the formation of dioxin and other pollutants by eliminating the combustion of dioxin precursor materials.

Waste separation is crucial to reducing the volume and toxicity of the medical/infectious waste stream. Many materials disposed of at hospitals and other medical facilities can be handled as ordinary household waste and need not be disposed of as "red bag" or infectious

waste. In addition, many materials, such as paper, cardboard, glass, metals and many plastics can be recycled rather than discarded. Hospitals that encourage employees to segregate these materials will not only save resources and eliminate pollution, but will also save money in disposal costs.

Source reduction includes eliminating the purchase and use of chlorine-containing materials that create dioxin. PVC plastic is a major source of chlorine in the medical waste stream and can lead directly to increased dioxin emissions from the incineration process. PVC plastics can contain up to 57% chlorine by weight. In healthcare, commonly used PVC items include intravenous bags and tubing, blood bags, endotracheal tubes, oxygen tents, mattress covers, patient I.D. bracelets, packaging and office supplies. Chlorine-free alternatives exist for many of these products. Soft plastic tubing, bags and containers made of chlorine-free polyethylene and polyolefin are readily available. Rigid PVC products have alternatives made of metal and non-chlorinated polypropylene or polycarbonate plastics. *Health Care Without Harm*, a national coalition of healthcare organizations and professionals working toward eliminating pollution in health care practices, has issued an alert on PVC I.V. bags and is working with hospitals and health care professionals to encourage the use and development of new PVC alternatives.

Alternate treatment technologies must meet the treatment standards for infectious waste set forth in the New Hampshire Code of Administrative Rules, Env-WM 2604. Examples include autoclaving, chemical treatment, plasma arc, microwave, low frequency radiowave and gamma irradiation, as well as combinations of these technologies. More and more hospitals and other medical waste generators have selected this alternative technology for their facility after carefully evaluating and comparing capital and treatment costs, worker safety, ease of operation and maintenance, confidence in the technology, and consideration of the public health benefits associated with the elimination of medical waste incineration.

There are many examples in the northeast where there has been a dramatic shift from medical waste incineration to autoclaving and other similar approaches. Both New York City and the State of New Jersey have opted to rely on autoclaving as a replacement alternative for incineration of medical and infectious wastes. Steam autoclaving offers one of the most convenient and cost-effective methods for processing these wastes. It requires only a small space adjacent to the waste handling area, and operates using readily available utilities such as steam, electrical power and water. Once processed, the treated waste may be disposed of in landfills in the same manner as general hospital waste, thus eliminating the formation of dioxin in the combustion process. In New Hampshire, Dartmouth Hitchcock Medical Center in Lebanon went through the process of examining its criteria and priorities for replacing its incinerator, and in 1996 chose to install and operate autoclave units as an alternative treatment technology. These units have proven to be a reliable and cost-effective waste treatment method for handling their medical and infectious wastes. Other New Hampshire HMIWIs that have chosen to shut down by April 10, 2001 will have their medical and infectious wastes shipped out-of-state for treatment and disposal until all alternative treatment technologies have been examined.

4.2.1 Recommended Actions Regarding Hospital /Medical /Infectious Waste Incinerators

R-1 Reduce dioxin emissions from HMIWIs by assuring that all facilities are either closed by April 10, 2001, or are in compliance with applicable dioxin emission requirements of the HMIWI rule by September 15, 2002.

R-2 Assure that the dioxin emissions testing is conducted and completed within 6 months of the applicable compliance date as required under Env-A 3500 in order to assure that dioxin emission reduction objectives are being met.

R-3 Work with the workgroup on Pollution Prevention in the Healthcare Industry (established under the October, 1998 *New Hampshire Mercury Reduction Strategy*) to facilitate the goal of virtual elimination of all PVC-containing products from the medical waste stream by January 1, 2005. The workgroup will conduct outreach and education to encourage proper waste management practices including source separation, purchase of alternative materials and recycling.

R-4 Work with the workgroup on Pollution Prevention in the Healthcare Industry (established under the October, 1998 *New Hampshire Mercury Reduction Strategy*) to facilitate the goal of reducing the volume of waste incinerated at all remaining medical waste incinerators in the state by encouraging alternative medical waste handling/disposal methods including waste minimization, recycling, source separation and sterilization.

R-5 Draft legislation by November 1, 2001 (with an effective date of July 1, 2005) to prohibit the disposal of PVC-containing products and materials in medical waste incinerators. This legislation will serve as a backstop to ensure that the pollution prevention objectives are achieved.

R-6 Support and promote the DES Solid Waste Operator Training Program for all HMIWI operators. This program, approved by EPA through New Hampshire's HMIWI rule, provides education, outreach and training on waste handling, source reduction, proper incinerator operation and ash management.

R-7 Draft legislation by November 1, 2001 (with an effective date of July 1, 2002) to:

a) ban the construction of medical waste incinerators in New Hampshire, and
b) phase out the operation of all existing HMIWIs in the state by 2010.

R-8 Work to revise DES Solid Waste Rules to require that all infectious medical wastes treated using alternate treatment technologies be required to be disposed of directly in approved landfills rather than incinerated at municipal waste combustors.

4.3 Wood Fired Boilers and Utilities

Although wood-fired boilers and utilities do not currently represent a large source category for dioxin emissions nationally, they are estimated to be the second largest source category in New Hampshire. New Hampshire currently has at least 24 permitted wood-fired boilers. Six of these boilers are larger units used to generate steam for electric power generation. These six wood-fired power plants generate a total of approximately 90 megawatts, providing the state with approximately 4% of its electric power generating capacity. In addition to these six wood-fired power plants, one existing wood-fired electrical generator that had been taken out of service, is in the process of re-starting, and is expected to come on line sometime in 2001.

During the energy shortages of the 1970s and 1980s, federal and state energy policy encouraged the development of wood-fired power plants to lessen our dependence on

imported oil, and to take advantage of using wood, an abundant and renewable resource, to generate electricity. Based on the assumption that oil prices would continue to rise indefinitely, these power plants were able to enter into long-term (i.e., 20-30 years) power sales arrangements approved and issued by the New Hampshire Public Utilities Commission that guaranteed favorable rates for power production. However, with increasing electric deregulation, rate restructuring, and the recent construction of many large and efficient power plants in New England, New Hampshire's energy markets are changing. Therefore, the economics of generating electricity by burning wood may become less competitive, and may result in a reduction in wood burning to generate electricity.

Other wood-fired boilers are used to supply both steam and power mainly at sawmills, furniture manufacturers and other wood products facilities throughout the state. These units are typically smaller and burn sawdust, wood scraps, wood chips and bark generated on-site as fuel. One pulp and paper mill in New Hampshire also uses a large, wood bark-fired boiler to supply steam and power on-site, but dioxin emissions from this unit are included under the pulp and paper industry source category rather than in this section. In addition, it is anticipated that the company has plans to stop operating this boiler within the next few years.

Although wood combustion is not typically associated with substantial emissions of other PBTs such as mercury, it can result in significant emissions of dioxin. Unlike mercury that must be taken up and stored in the wood in order to be emitted during combustion, dioxin is actually formed in the wood combustion process. Wood has a lignin component, which contains phenolic carbon structures. These phenolic structures act as precursors to dioxin, reacting with the wood's natural chlorine to form dioxin when burned. At their September 17, 1997 meeting, members of the U.S. EPA's Industrial Combustion Coordinated Rulemaking (ICCR) Coordinating Committee, which included members from both the American Forest and Paper Association (AFPA) and the National Council of the Paper Industry for Air and Stream Improvement (NCASI), rated boilers burning wood and other biomass fuels as having a moderate to high potential for dioxin formation due to the fuels' organic structure, likelihood of entrained particulate matter in the combustion zone, residence time and temperatures in particulate control devices (denovo formation), and the presence of potential metal catalysts in the fuel (AFPA, November 13, 1997). Trees can also take in a small amount of dioxin directly from the air (through the leaves) and from dioxin deposited in the soil (through the roots) during their lifetime, acting as dioxin reservoirs. Relatively small amounts of this stored dioxin may be released due to incomplete combustion.

Since dioxin from wood-fired boilers is emitted into the air both in the vapor phase and as a component of particulate matter, dioxin emissions from wood-fired boilers can be minimized through the use of controls for particulates. All of New Hampshire's large, wood fired utilities already have emissions controls such as electrostatic precipitators to significantly reduce particulate emissions, which in-turn reduce dioxin emissions. Dioxin in wood ash has also been evaluated as part of this strategy, and is discussed in detail in Section 4.12.8.

To date, stack testing for dioxin has been not been required or conducted for any of New Hampshire's wood-fired boilers. As a result, emission factors used to calculate New Hampshire wood-fired boiler dioxin emissions were taken from U.S. EPA's *Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States* (EPA, April 1998). These emission factors are based on tests conducted at four similar wood-fired

utilities in California. Although the representativeness of these test results to actual emissions from New Hampshire's wood-fired boilers is not certain, the emission factors are comparable to those developed for industrial wood combustion in other countries including the United Kingdom, Netherlands, Germany, Austria and Australia. In addition, these U.S. EPA emission factors are very similar to average dioxin emissions from tests conducted by the National Council of the Paper industry for Air and Stream Improvement (NCASI) at 14 wood-fired boilers throughout the U.S. (NCASI, 1997). Other stack test results for dioxin emissions from wood-fired boilers have been reported, but show a high degree of variability when compared to published EPA and international emission factors. DES has therefore concluded that the use of EPA's dioxin emission factors for wood-fired boilers represents the best available data given the consistency of EPA emission factors with international as well as NCASI test results, and the absence of plant-specific stack test data for New Hampshire's wood-fired boilers at this time. Using these emission factors, DES estimates that New Hampshire's wood-fired boilers emitted an estimated 1,065 mg TEQ of dioxin in 1999, of which 994 mg was attributable to the six, large, wood-fired power plants. These emissions estimates make wood-fired boilers the second largest dioxin source category in the state, with over 20% of the total dioxin emissions.

DES has long considered the combustion of low-grade wood in wood-fired boilers a viable use for a valuable, renewable, native energy source as an alternative to non-renewable fossil fuels in New Hampshire. In addition, these facilities, when viewed in the context of total environmental impacts, emit less sulfur dioxide, mercury and greenhouse gases per unit of energy producted (lbs/mmBtu) than power plants burning coal or oil. In addition, having viable markets for low-grade wood helps the timber industry and enhances the value of managed woodlands for sustainable forestry. However, due to de-regulation of the utility industry in New Hampshire, the economics of generating electricity by burning wood may become less cost effective, and may result in a reduction in the use of wood as a fuel for production of electricity. To address this potential change, the New Hampshire Department of Resources & Economic Development, Division of Forests and Lands is in the process of conducting a study to investigate alternative uses for some of the low-grade wood that is currently used to fuel New Hampshire's large, wood-fired utility boilers. Based on the findings and recommendations of the New Hampshire Dioxin Reduction Strategy, this effort to develop alternative markets for low-grade wood has added significance as a way to reduce the impacts of dioxin emissions in New Hampshire while ensuring that the timber harvesting industry is not adversely affected.

4.3.1 Recommended Actions Regarding Wood-fired Boilers

R-9 Develop emission factors and dioxin emissions testing requirements for large, wood-fired boilers by:

a) Conducting initial DES dioxin emissions screening stack tests on representative sources by January 1, 2002.

b) Re-evaluating the actual contribution of dioxin from New Hampshire's wood-fired boilers based on these stack test results, and if appropriate, developing emissions testing requirements by June 1, 2002.

R-10 Work with US EPA, American Forest and Paper Association, New Hampshire Timberland Owners Association, representatives of New Hampshire's large wood-fired boilers and other stakeholders to examine options for reducing dioxin emissions from wood-fired boilers if warranted.

R-11 Encourage greater implementation of energy efficiency and conservation programs for sources by:

a) Participating actively in the Public Utility Commission proceedings relating to energy efficiency (ongoing);
b) Encouraging the initiation of and active participation in proceedings at the NHPUC (and in regional efforts) relating to disclosure of the environmental characteristics of power sales (ongoing);
c) Assisting New Hampshire's Interagency Energy Efficiency Committee in energy saving efforts such as expeditiously implementing Energy Star Building Programs for State buildings (1998-2003);
d) Assisting the Governor's Office of Energy and Community Services in outreach to electricity consumers about reducing dioxin emissions through greater energy efficiency (ongoing).

R-12 Develop and implement by July 1, 2002, standards that minimize dioxin emissions and assure efficient combustion for wood-fired boilers by:

a) Setting maximum limits for carbon monoxide;
b) Setting minimum limits for excess oxygen;
c) Setting minimum limits for combustion temperature;
d) Establishing minimum requirements for particulate emissions controls;
e) Establishing and stabilizing maximum fuel feed rates;
f) Establishing recommendations for boiler maintenance schedule and frequency.

R-13 Strongly encourage and work with the New Hampshire Department of Resources and Economic Development (DRED), United States Forest Service (USFS), Society for the Protection of New Hampshire Forests (SPNHF), New Hampshire Timberland Owner's Association (NHTOA), New Hampshire Timber Harvester's Association (NHTHA) and other stakeholder groups to develop alternative markets for lower value wood and wood wastes produced in New Hampshire.

R-14 If studies confirm that the large wood-fired power plants are, in fact, major sources of dioxin in New Hampshire; and if alternative uses for lower value wood and wood wastes are identified and established creating a viable market for wood produced by New Hampshire's timber harvesting and forest products industries; New Hampshire's legislature should consider phasing out these plants to dramatically decrease dioxin emissions.

4.4 Backyard Burning of Domestic Wastes

"Backyard burning" is a term commonly used to describe the practice of burning domestic waste in homemade incinerators, often in metal drums or "burn barrels". Backyard burning is generally allowed in New Hampshire where the municipality does not provide "curbside pick-up" of domestic waste, and where it is not otherwise prohibited by local ordinances. The New Hampshire Code of Administrative Rules, Env-A 1000, state that the burning of combustible domestic waste is permissible without authorization from DES in an area which has been classified as "attainment" for ambient air quality standards for particulates, and where the following conditions exist:

a. There is no public removal service;

b. The burning occurs on-premises in a waste burner having a capacity of 7 cubic feet or less, and;

c. The waste is generated from a residential building containing 4 or less "dwelling units".

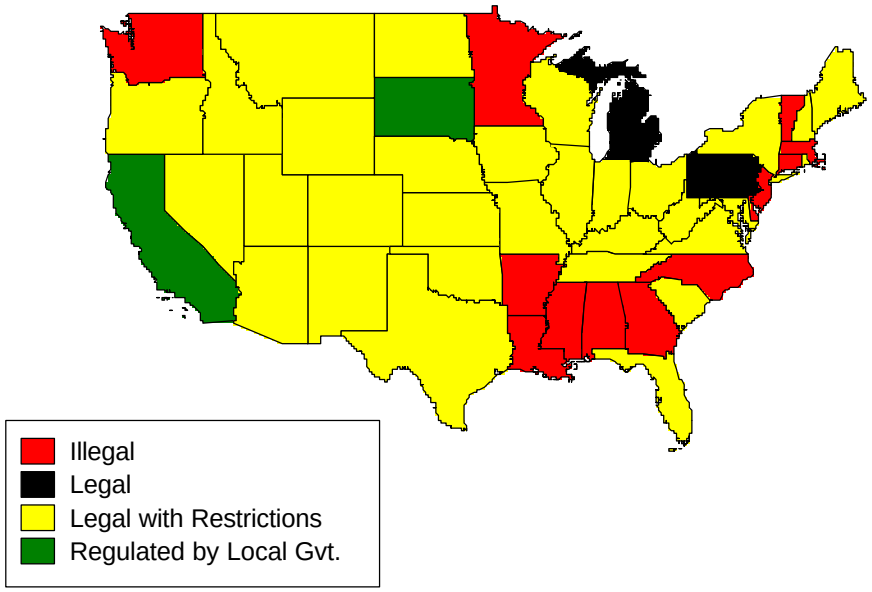
Backyard burning is more prevalent in rural areas of the state where access to a disposal facility is less convenient.

When domestic waste is burned in a backyard incinerator, conditions that support efficient combustion are generally very poor. Combustion temperatures are usually very low and ventilation is usually inadequate. Household domestic waste also usually contains chlorine, a necessary precursor to dioxin formation, from a number of sources ranging from table salt to plastics. Recent EPA studies showed that between 2 and 40 households burning domestic waste in their backyards produces as much dioxin as a well controlled municipal waste combustor serving 40,000 to 120,000 households (Lemieux *et al*, 2000).

Open burning permits are required by most New Hampshire municipalities, and from these permits it is estimated that about 5,000 New Hampshire households regularly burned their domestic waste in burn barrels in 1999. Using emission factors for backyard burning from the EPA studies referenced above, backyard burning accounts for an estimated 897 mg TEQ of dioxin in New Hampshire annually, or about 17% of the total dioxin emitted in the state.

Fourteen states have banned open or backyard burning of domestic waste, including Massachusetts, Connecticut, and Vermont. **See Figure 4-2**. Maine currently allows backyard burning of ***wood and paper only*** with restrictions, and prohibits outdoor burning of all plastics, rubber, styrofoam, metals and chemicals. Open burning in Rhode Island is regulated on a local level, but is prohibited in most areas.

Figure 4-2: Backyard Burning of Household Waste in the U.S. – Current State Regulations



(Source: NH DES survey of state and local waste disposal regulations as of November 2000)

Backyard burning of household domestic wastes presents serious health concerns for New Hampshire residents. In addition to dioxin, many other air toxics are generated and emitted from backyard burning including volatile organic compounds (such as acetone, benzene, ethylbenzene, chloromethane, phenol, toluene, xylenes, and styrene); polyaromatic hydrocarbons (such as naphthalene, acenaphthalene, benzo(a)pyrene, phenanthrene, pyrene,

and fluoranthene); chlorobenzenes; aldehydes (such as formaldehyde, propionaldehyde and acetaldehyde); and inorganic compounds (such as hydrochloric acid). Data shows that in all cases these compounds are emitted at rates thousands of times greater than that of a well-controlled municipal waste combustor (MWC), due to the poor combustion conditions typical in backyard burners (EPA, November 1997). Also, since burn barrels are close to the ground and dispersion of the dioxin-containing exhaust is very localized, those that live, work or eat locally raised food are at a particularly higher risk for exposure to pollutants from these units. Finally, ash residue from backyard burners may also contain high levels of many toxic pollutants including dioxin, and this ash is rarely handled or disposed of properly.

The amount of chlorine (including PVC plastics) in the waste stream can have an enormous impact on the amount of dioxin produced by backyard burning. In fact, one study showed that up to 1,000 times more dioxin is emitted from burn barrels that contain domestic waste with high chlorine content, whether PVC plastics (organic chlorine) or calcium chloride (inorganic chlorine), than from burning domestic waste that contains little or no chlorine (Gullette et al, 1999). As a result, it is clear that the elimination of chlorine-containing products, including PVC plastics from the waste stream is key to reducing dioxin formation from backyard burning.

Alternative waste disposal practices to backyard burning are available in all New Hampshire communities. RSA 149-M requires all New Hampshire municipalities to provide residents with access to an approved solid waste disposal facility, and encourages waste reduction through source reduction, recycling, reuse, and composting; making backyard burning of household domestic waste an unnecessary practice.

4.4.1 Recommended Actions Regarding Backyard Burning

R-15 Draft legislation by January 1, 2001 to ban all backyard burning of household wastes in New Hampshire. This action alone will reduce dioxin emissions from New Hampshire sources by more than 17% if full compliance is achieved.

R-16 If legislation to ban backyard burning of household waste is not enacted, DES will work to reduce dioxin emissions by:

a) Undertaking an outreach initiative to educate the public about the causes of and risks related to dioxin formation from backyard burning of household waste, including chlorine and PVC plastics by June 1, 2001;
b) Draft legislation by November 1, 2001 to ban all backyard burning of PVC containing plastics;
c) Draft legislation by January 1, 2002 to require all products containing PVC plastics to be clearly labeled.

4.5 Residential Wood Combustion

Residential heating with wood has also been identified as a major dioxin source in New Hampshire. The U.S. Department of Energy, has estimated that from 1960 to 1997, between 136,000 and 276,000 cords of wood were consumed annually for residential heating in New Hampshire. In 1997, the last year for which statistics are available, 168,000 cords of wood were burned to heat New Hampshire homes, accounting for approximately 10% of New Hampshire's home heating energy use. A survey conducted in November 2000 by the New Hampshire Governor's Office of Energy and Community Services of 400 New Hampshire

households showed that over 10% of NH households used wood as their primary heating fuel, while 15% used woodstoves and fireplaces for supplementary heat.

As with other combustion sources, incomplete and inefficient wood combustion in residential woodstoves and fireplaces results in higher dioxin emissions. In the early 1990's, EPA established strict minimum combustion efficiency standards for all new woodstoves sold in the U.S. Although no specific data are currently available, it is expected that these newer, more efficient woodstoves, especially those equipped with catalytic combustors, as well as high efficiency wood pellet stoves, emit less dioxin than older, less efficient units. A test program is currently being conducted by a number of government organizations and industry stakeholders in Canada to determine if the advanced combustion technology found in modern, EPA-approved residential woodstoves reduces dioxin emissions compared with emissions from conventional woodstoves. From 1994 to 1998, the Governor's Office of Energy and Community Services, in conjunction with other states and the Northeast Hearth Products Association (NEHPA), participated in an initiative to improve air quality in the northeast by encouraging the replacement of older, less efficient wood stoves with new, clean-burning, energy-efficient, EPA certified stoves. Through this initiative, participating stove shops throughout New Hampshire offered a $200 credit to customers that agreed to turn in their old wood stove in exchange for purchasing a new one. The old wood stoves that were collected as a result of this program were permanently retired (destroyed). The *Clean Heat Wood Stove Exchange Program* was discontinued in 1999 due to a combination of the natural turnover of the population of woodstoves to newer models since EPA's woodstove certification began, and an overall decrease in wood heating in the northeast in recent years. The program, however, resulted in the replacement of approximately 3,000 non-certified woodstoves in the Northeast with new, energy efficient models, reducing particulate emissions from woodstoves in New Hampshire by over 40 tons in five years. With winter fuel costs and a potential winter fuel shortage significant immediate and long-term concerns, woodstove use may increase over the next several years.

Burning any type of painted or treated wood, especially wood that has been pressure treated with creosote or pentachlorophenol (PCP), can greatly increase dioxin formation from woodstoves. Although DES prohibits the combustion of these materials in industrial processes and outdoor burning, combustion of these materials in residential woodstoves is not specifically regulated at this time.

Emission factors used to calculate New Hampshire residential wood combustion dioxin emissions were taken from U.S. EPA's *Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States* (EPA, April 1998). Using these emission factors, DES estimates that residential wood combustion in New Hampshire emits an estimated 513mg TEQ of dioxin each year, making residential wood combustion the fourth largest source category in the state, with approximately 9.8% of the total dioxin emissions. Currently there are no state or federal regulations that directly govern dioxin emissions from residential wood combustion, although the EPA does require manufacturers to certify that all new woodstoves meet strict requirements for combustion efficiency and air emissions.

4.5.1 Recommended Actions Regarding Residential Wood Combustion

R-17 Draft legislation to prohibit the burning of pressure treated wood by January 1, 2002;

R-18 Work with the Governor's Office of Energy and Community Services to increase public education and outreach programs that encourage efficient residential wood combustion and combustion technologies, and promote the replacement of older, more polluting woodstoves with more efficient, cleaner burning wood and wood pellet stoves.

4.6 Mobile Sources

The combustion of fuels (gasoline and diesel fuel) in trucks and cars as well as non-road vehicles (boats, snowmobiles, all terrain vehicles, construction equipment, etc.) in New Hampshire is the fifth highest source of dioxin emissions in the state, accounting for 409 mg TEQ per year, or 7.8% of the state's total. Of these fuels, diesel fuel combustion accounts for almost 370 mg TEQ, or about 90% of all dioxin emissions from mobile sources.

As with other types of fuel, dioxin formation generally results from incomplete combustion where chlorine and organic materials in the fuel react to form dioxin. Although the dioxin formed from the operation of each individual vehicle is relatively small, the combined dioxin emitted by the state's 1.1 million registered cars and trucks make mobile sources a significant dioxin contributor in New Hampshire.

The dioxin emissions from mobile sources were based upon emission factors from the U.S. EPA's Draft *Inventory of Sources of Dioxin in the United States* (April, 1998). In this report, EPA cites several studies that demonstrate that, for gasoline-fueled vehicles, the switch from leaded gasoline to unleaded gasoline has reduced dioxin formation from these vehicles by approximately 80%. In addition, these studies also show that the introduction of catalytic converters on gasoline-powered vehicles has further reduced dioxin emissions by an additional 50% over non-catalyst equipped vehicles.

The emission factors for diesel combustion are higher than those found for unleaded gasoline combustion. Emissions from diesel engines, however, are currently far less regulated by EPA than emissions from gasoline engines. Historically, EPA has focused efforts to control mobile source emissions on gasoline-powered vehicles, but a greater focus on diesel fuel-powered vehicles, and heavy-duty trucks in particular, is now underway. For example, EPA will soon issue new rules that are expected to significantly reduce emissions from new diesel trucks and buses by 2007, by requiring diesel fuel to be cleaner and engines to be equipped with catalytic converters. The New Hampshire legislature passed a joint resolution last year supporting these efforts by EPA to reduce emissions from these sources.

Dioxin emissions are based on annual statewide fuel use and EPA emission factors for on-road vehicles. Non-road mobile sources also burn these fuels and are therefore also included, although no separate emission factors for non-road engines are available. Emissions from non-road vehicles are currently far less regulated and controlled than those from on-road vehicles. As a result, it is expected that dioxin emissions from non-road mobile sources may potentially be higher than estimated in this report.

4.6.1 Recommended Actions Regarding Mobile Sources

R-19 Support and encourage more stringent federal regulations to reduce emissions from mobile sources including:

- Aggressive new emission reduction standards for non-road heavy-duty diesel engines and fuels during the EPA's 2001 technology review for this emissions source category.
- Aggressive emission reduction requirements for on-highway and non-road mobile sources and their fuels through the EPA's rulemaking under Section 202(l) of the Clean Air Act.
- Regional and federal fuels and emissions standards (RFG/MtBE, Low Sulfur Diesel, HD Diesel 2007 standards, and various nonroad regulations).

R-20 Seek early introduction of the federally required On Board Diagnostics (OBD) emissions inspection requirement on a voluntary repair basis for year 2001 and mandatory for 2002 and beyond;

R-21 Support NH Department of Safety implementation of motor vehicle Enhanced Safety Inspection and Diesel Opacity testing program requirements;

R-22 Adopt the proposed California Heavy Duty Diesel Not-to-Exceed (NTE) rule for the years 2005, 2006 to prevent backsliding by HDD engine manufacturers on emission requirements;

R-23 Review feasibility, technical benefits associated with adoption of California LEV II standards and make recommendations regarding adoption;

R-24 Continue promotion of Marine Engine MOU to New Hampshire dealers to encourage early introduction of cleaner burning marine engines;

R-24 Work with NH Department of Transportation (via transportation conformity review process, ongoing I93 study, rail study, smart growth initiative, etc.) to promote transportation control measures and increase the availability of alternative transportation modes (bus, HOV lanes, rail, etc.);

R-25 Continue promotion of low emission advanced technology vehicles via Granite State Clean Cities Coalition initiative (jointly with GOECS), NH Alternative Fuel Vehicle Coalition (joint venture of DES, GOECS, DOT), NH Green Car Label Project (joint effort of DES, ALANH, NHADA, and AMC), and State Green Car purchasing initiative (joint effort w/ Bureau of Purchase and Property);

R-26 Increase implementation of NESCAUM diesel idling reduction initiative;

R-27 Seek voluntary reductions of aircraft and related ground equipment at Manchester Airport through NEPA review and General Conformity process and participation in the national FAA Airport Emissions Reduction Stakeholder process.

4.7 Pulp and Paper

4.7.1 Introduction

Pulp and paper operations in New Hampshire account for about 226 mg TEQ of dioxins annually, or approximately 4.3% of all dioxin emitted by New Hampshire sources. There are currently six paper mills and two pulp mills in New Hampshire. Many of the sources of dioxin at New Hampshire's pulp and paper mills, such as the combustion of wood and fossil fuel, are similar to those discussed elsewhere in this Strategy. However, for the purposes of this Strategy, the pulp and paper industry is considered a separate source category and, therefore, all associated dioxin emissions are included in this section.

Dioxin can be released throughout the pulp and paper manufacturing process. Nationwide, the pulp and paper industry had been implicated as one of the largest sources of

dioxin, primarily from contaminated wastewater from bleaching processes discharged into surface waters. Dioxin can also be emitted into the air through the chemical recovery operations at pulp mills, as well as through the burning of ordinary fuels such as oil and wood. Dioxins may also be found in paper mill sludge that can be landfilled, land applied as fertilizer, or incinerated. In recent years, the pulp and paper industry in New Hampshire has taken several major steps toward reducing and eliminating dioxin, and has significantly reduced its contribution to New Hampshire's dioxin emissions. In addition, DES is implementing EPA's combined air and water "cluster rule" for the pulp and paper industry that protects human health and the environment by reducing toxic pollutant releases, including dioxin, to both the air and water. The technology standards in the rule will cut overall toxic air pollutant emissions by almost 60 percent from current levels and virtually eliminate all dioxin discharged from pulp, paper, and paperboard mills into rivers and other surface waters. The following sections discuss the major areas of dioxin emissions from New Hampshire's pulp and paper industry and efforts undertaken to reduce these emissions.

4.7.2 Releases to the Air

The majority of dioxins from the pulp and paper industry in New Hampshire are emitted into the air primarily through fuel combustion. Currently, the pulp and paper industry burns approximately 39 million gallons of fuel oil annually, accounting for about 30 mg TEQ of dioxin. In addition, about 465,000 tons of black liquor solids are burned annually at New Hampshire's two pulp mills, accounting for almost 12 mg TEQ of dioxin each year. Finally, the majority of pulp and paper dioxin emissions in New Hampshire result from the combustion of almost 250,000 tons of bark and wood waste at the pulp mill in Berlin. Using EPA emission factors, this bark-fired boiler accounts for approximately 184 mg TEQ of dioxin annually. However, the company plans to stop operating this boiler within the next few years.

4.7.3 Releases to Surface Water

According to EPA, pulp and paper facilities that use elemental chlorine bleaching processes are the largest known industrial dischargers of dioxin into the surface waters of the U.S. The new EPA "cluster rules" will require all U.S. pulp and paper mills to discontinue the use of elemental chlorine in the bleaching process by April 2001, by instituting either elemental chlorine free (ECF) or totally chlorine free (TCF) bleaching techniques. When the cluster rule is fully implemented, dioxin discharges from U.S. pulp and paper mills to the water will be reduced by 96%. There are currently two pulp mills in New Hampshire: the Berlin mill, now owned by Pulp and Paper of America and Groveton Paperboard in Groveton. The Berlin mill is the only New Hampshire facility that produces bleached pulp (the Groveton mill manufactures unbleached pulp). Prior to 1994, the Berlin mill used elemental chlorine in the bleaching process. Dioxin levels in the wastewater from the facility resulted in a buildup of dioxin levels in the Androscoggin River downstream of the mill, prompting the states of Maine and New Hampshire to issue a fish consumption advisories for this section of the river.

While some pulp mills are still using elemental chlorine, the Berlin mill took steps in the late 1980s and early 1990s to reduce the use of elemental chlorine in the bleaching process. By 1994, the mill completely eliminated the use of elemental chlorine, seven years prior to the compliance date in the cluster rule. The mill is required to periodically monitor its wastewater discharge for dioxin contamination. Since 1991, tests show greater than a 98%

reduction in total dioxins and furans in the wastewater effluent, and the most recent tests conducted this year demonstrate that dioxin concentrations in the wastewater were below the limits of detection. Although significant dioxin reductions have been achieved through the implementation of ECF bleaching at the Berlin mill, it should be noted that ECF bleaching may still allow the release of low concentrations of dioxin while TCF bleaching would completely eliminate dioxin formation from this process.

Paper produced using alternative processes other than elemental chlorine bleaching is commercially available today. Purchasing paper products that are labeled and certified "elemental chlorine-free", "totally chlorine free" or "process chlorine free" (TCF with recycled, post-consumer content) should be encouraged as a way to support reducing dioxin contamination from paper producers.

4.7.4 Releases to Land

Pulp and paper mills are required to treat their wastewater to remove contamination prior to discharge. The by-product of the wastewater treatment process is a solid material referred to as sludge. Dioxins produced in the pulp and paper manufacturing processes tend to accumulate in wastewater treatment sludge, and therefore dioxins present may be discharged into the environment depending on the method of disposal (landfilled, land applied as fertilizer, or burned in an incinerator). EPA estimates that elemental chlorine free bleaching reduces dioxin in sludge by 96%. There are no pulp or paper mills that are permitted to burn sludge in New Hampshire, and currently only one, smaller paper mill is certified to land-apply sludge as fertilizer. Thus, almost all pulp and paper mill sludge generated in New Hampshire is disposed of in an approved, secure, lined landfill. Assuming the landfill functions properly, any dioxin contamination in the sludge is for the most part contained within the landfill and therefore not discharged elsewhere into the environment. At the Berlin mill, wastewater treatment plant sludge is disposed of at the secure, lined landfill owned by the facility. Leachate (containing water and contaminants) accumulates at the bottom of the landfill and is collected and treated at the wastewater treatment plant prior to discharge into the Androscoggin River. As a result, small amounts of dioxin that may be contained in the leachate have the potential to be re-introduced into the wastewater treatment system and perhaps ultimately discharged into the river.

4.7.5 Recommended Actions Regarding Pulp and Paper Mills

R-28 Continue to support and implement federal rules (Cluster Rules) requiring air and water pollution reductions from large pulp and paper manufacturing facilities;

R-29 Work with members of the NH pulp and paper industry to encourage pollution prevention and energy efficiency; and investigate the costs and benefits of substituting TCF for ECF bleaching processes.

R-30 Work with Pulp and Paper of America to re-institute periodic fish tissue monitoring for dioxin both up and downstream of the facility with the goal of measuring environmental improvement and lifting fish consumption restrictions once fish tissue downstream reaches acceptable levels;

R-31 Support and encourage the purchase of alternative, chlorine free paper products throughout New Hampshire, including state government.

4.8 Fossil Fuel-Fired Utility and Industrial Boilers

4.8.1 Utility Boilers

Electric utilities burn large quantities of oil and coal to generate electricity. The combustion of oil and coal emits dioxin because these fuels contain both chlorine and organic precursors. New Hampshire has three major fossil fuel-fired power plants, all owned by Public Service Company of New Hampshire (PSNH). The three PSNH facilities are Merrimack Station in Bow, Schiller Station in Portsmouth, and Newington Station in Newington. Together, these plants emit about 185mg TEQ of dioxin annually, or 3.5% of the state total. PSNH Merrimack Station is the largest dioxin emitter of the three facilities (82 mg/yr TEQ), followed by Newington Station (75 mg/yr) TEQ, and Schiller station (28 mg/yr TEQ).

No state or federal regulations currently exist for dioxin emissions from electric utilities. However, PSNH in recent years has added air pollution controls at these facilities, greatly reducing emissions of particulate matter and oxides of nitrogen. Although no testing for dioxin emissions has been conducted, it is expected that these control measures have also greatly reduced dioxin emissions. Also, since 1998, these PSNH facilities have been required to report emissions to the U.S. EPA Toxics Release Inventory (TRI) annually. Beginning in 2001, these facilities will be required to report their dioxin emissions to EPA through the TRI program on an annual basis.

4.8.2 Industrial Boilers

Fossil fuel-fired industrial boilers are typically much smaller than utility boilers, but there are a large number of industrial boilers located in the state. New Hampshire has over 280 permitted fossil fuel-fired industrial boilers that emit slightly more than 28 mg/yr TEQ of dioxin. Most of these boilers are fueled by oil, although some are fueled by propane, diesel, or natural gas. Natural gas has negligible dioxin emissions, and further investigation is necessary to estimate dioxin emissions from propane and industrial diesel fuel.

4.8.3 Recommendations Regarding Fossil Fuel Fired Boilers

R-32 Work with EPA to establish emission factors for burning propane and diesel fuel in industrial boilers.

R-33 Encourage greater implementation of energy efficiency and conservation programs for sources by:

a) Participating actively in the Public Utility Commission proceedings relating to energy efficiency (on-going);

b) Encouraging the initiation of and active participation in proceedings at the NHPUC (and in regional efforts) relating to disclosure of the environmental characteristics of power sales (ongoing);

c) Assisting New Hampshire's Interagency Energy Efficiency Committee in energy saving efforts such as expeditiously implementing Energy Star Building Programs for State buildings (1998-2003);

d) Assisting the Governor's Office of Energy and Community Services in outreach to electricity consumers about reducing dioxin emissions through greater energy efficiency (on-going).

R-34 Reduce dioxin emissions from fossil fuel-fired utilities and industrial boilers by encouraging expeditious development of natural gas, solar photovoltaics, wind generation and fuel cells through the permitting process and in the allocation of emission allowances (on-going).

4.9 Municipal Waste Combustors

4.9.1 Introduction

Although municipal waste combustors (MWCs) have long been considered one of the nations largest sources of dioxin emissions, pollution controls and improved combustion technologies required under provisions of the Clean Air Act have decreased dioxin emissions dramatically. In New Hampshire, MWCs comprise only 2.5% of New Hampshire's dioxin emissions. Recent data shows that the state's two sizeable MWCs (Wheelabrator Concord and Wheelabrator Claremont) account for over 99% of these emissions, while 7 smaller MWCs account for less than 1%. Besides dioxin, many other pollutants, including mercury, lead, and hydrochloric acid, are released from MWCs, but have not been routinely reported until recently (in 1999, DES began requiring all permitted sources to report speciated air toxic emissions on an annual basis). Emissions of dioxin and other pollutants from MWCs, however, are much lower than from backyard burning of waste because combustion in MWCs is conducted at much higher temperatures and under more controlled conditions. In addition, New Hampshire's largest municipal waste combustors employ emissions control equipment that further reduces emissions.

EPA has recognized the importance of MWCs as potential emitters of dioxin, and has promulgated several new emissions regulations. EPA regulations for MWCs that burn more than 250 tons per day became effective on August 17, 1997, and all of these MWCs must comply with the dioxin standards of this rule by December 19, 2000. Due to its size, the only New Hampshire facility subject to these regulations is the Wheelabrator Concord facility. Since this compliance date is imminent, most of the country's affected MWCs, including Wheelabrator Concord, have already installed and begun operating the equipment required by this rule. EPA estimates that once fully implemented, dioxin emissions from these MWCs will be reduced by over 99%.

In December 2000, EPA published new final rules for MWCs that burn between 35 and 250 tons per day. This regulation applies to the Wheelabrator Claremont facility and perhaps at least one other small MWC in New Hampshire. The new EPA rule for existing affected sources becomes effective February 5, 2001, and will be fully implemented by 2005. By this date all affected MWCs must be in compliance with the rule, which will achieve a 97 percent annual reduction in dioxin emissions over 1998 levels.

4.9.2 Large Municipal Waste Combustors

For the purposes of this strategy, "large" MWCs include the two Wheelabrator facilities previously mentioned, and "small" MWCs include all other municipal waste combustors in the state. DES has required Wheelabrator to conduct periodic stack testing for dioxin for a number of years, and the new federal regulations will require additional testing. Since this source-specific test information is available, the most recent stack test data (1998) was used to generate the annual dioxin emissions from these two facilities rather than the more general

EPA emission factors. While it is important to note that actual emissions may vary somewhat from these values due to inherent variations in the composition of municipal solid waste (MSW) which lead to dioxin formation during the incineration process, the results of the stack tests conducted at each of the facilities were relatively consistent and should be far more representative of actual current emissions.

The stack test results indicate that actual dioxin emissions from these two facilities are already about 3 to 5 times below the levels allowed by the new and proposed EPA regulations. In addition, when installation and operation of the emissions control equipment required by the new regulations is complete, dioxin emissions are expected to be even lower.

4.9.3 Small Municipal Waste Combustors

Municipalities in New Hampshire currently operate seven smaller MWCs, located in Candia, Hebron-Bridgewater, Nottingham, Litchfield, Ossipee, Sutton, and Wilton. These units are all relatively small, operate at reasonably high temperatures (1400 to 1600 deg F.), and do not employ any auxiliary air pollution control devices. Dioxin emissions from these sources were calculated using current (1998) EPA emission factors. Based on the results these small MWCs contribute less than 0.20% of the state's total dioxin emissions.

4.9.4 Municipal Waste Combustor Ash Generation and Disposal

Ash is the solid waste residue produced from the combustion of materials including municipal solid waste. Ash from solid waste combustors is commonly broken into two major categories: bottom ash, and fly ash. Bottom ash refers to the residue that remains in the incineration chamber after combustion has taken place, and fly ash is the finer particulate matter that is collected from the exhaust gas by the air pollution control equipment. The management of ash is an important regulatory concern because ash may contain many toxic contaminants such as metals and dioxin that could contribute to groundwater or surface water contamination if improperly handled or disposed of. In New Hampshire, ash is regulated primarily under the New Hampshire Solid Waste rules. These rules regulate all aspects of ash management including temporary on-site ash storage, ash sampling and analysis, ash handling and transportation, and ash disposal.

Ash from the Wheelabrator Concord facility is disposed at a dedicated double-lined monofill located in Franklin at a rate of about 70,200 tons/year. In the past, ash from the Wheelabrator facility in Claremont was disposed in a dedicated double-lined monofill in Newport at a rate of about 22,000 tons/year. However, in 2000, the NH/VT Solid Waste Project, a bi-state organization serving 29 communities in New Hampshire and Vermont voted to discontinue use of its landfill, and in the future the ash generated at the facility will be transported out-of-state for disposal. Ash from the remaining small municipal waste combustors is disposed at either the secure double-lined municipal solid waste landfill in Bethlehem, or the secure Turnkey municipal solid waste landfill located in Rochester, or it is shipped out-of-state for disposal. Since all ash from all of New Hampshire's MWCs is disposed of in secure lined landfills, any dioxin contamination in the ash is contained within the landfill and therefore not likely to be discharged elsewhere into the environment.

4.9.5 Alternatives to Waste Incineration in New Hampshire

Supporters of MWCs as viable alternatives to landfilling point to some of the benefits of incineration including:

- large MWCs use the fuel value in the incinerated waste to generate electricity;
- incineration reduces the ***volume*** of material that must be landfilled by at least two thirds, and in the case of large, modern MWCs (such as Wheelabrator Concord and Wheelabrator Claremont) by more than 90%;
- required emissions controls substantially reduce the amount of air pollution that is generated during the waste combustion process; and
- MWC's may provide tax revenues to the communities in which they are located.

There are, however, negative aspects of these facilities. They include:

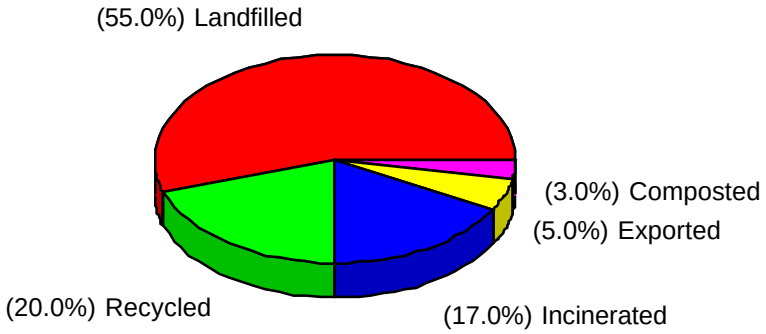
- MWCs generate multiple air pollutants (far more than landfills), and these pollutants are emitted and spread over a large geographic area. MWCs transfer pollution to downwind communities many of whom derive no benefit from the facility creating this pollution.
- Although incineration does substantially reduce the ***volume*** of material that must be landfilled, the ***weight*** of material that must be disposed of is typically reduced by less than 65%, and landfills are still necessary to dispose of this material (ash) and its toxic contaminants. This results in the need to site, operate and monitor two solid waste facilities rather than just one.
- Despite the ability for New Hampshire's large MWCs to produce electricity from the combustion of waste, new natural gas-fired power plants that are expected to soon come on line in New Hampshire (due in part to electric deregulation) will result in excess generating capacity and perhaps reduce the economic viability for power producers such as MWCs.

As shown in **Figure 4-3**, in 1999, 55% of all municipal wastes generated in New Hampshire were disposed of at in-state landfills, 17% were processed at MWCs, 5% were exported to other states for disposal, and 23% were recycled or composted (excluding source reduction and reuse). Of the total amount incinerated, 1% of municipal wastes were treated in "small" municipal waste combustors. The State currently has adequate capacity for its own municipal waste through the year 2010, mostly through in-state private and publicly owned landfills.

Many of the municipalities that continue to operate small MWCs in New Hampshire are investigating alternative waste disposal options, and over the past several years at least one small MWC in New Hampshire each year chooses to shut down and institute a combined recycling, waste collection and transfer station. For these municipalities, the costs for operation, maintenance, repair, emissions controls and ash disposal must be weighed against the costs for collection, transportation, and off-site disposal. Unfortunately, the cost of emissions impacts to municipalities and citizens downwind is rarely a consideration. Towns that have recently changed to a drop-off facility with the loose collection of waste and little or no recycling have seen a dramatic increase in solid waste management costs. Towns that use compactors and have adopted mandatory recycling or Pay-As-You-Throw (PAYT) programs

with extensive recycling have kept their solid waste management costs low. In some cases, towns have worked through their solid waste districts or through regional agreements to develop facilities or negotiate contracts with private disposal facilities to reduce their solid waste costs. There are 24 regional recycling programs to date that have proven that recyclables can be marketed cooperatively, and 38 communities have adopted curbside recycling for all or part of their residents. Almost 99% of New Hampshire's population now has access to recycling, and the state is looking at ways to increase the amount of material that they recycle.

Figure 4-3: Management of Municipal Waste in New Hampshire – 1999



(Source: 1999 Annual Reporting – DES Planning and Community Assistance Section)

DES has been involved in an aggressive program designed to increase the recycling rate and meet the state's solid waste reduction goals. New Hampshire municipalities have been our partners in this effort and many have exceeded the legislative goal of 40% diversion of recyclable materials by the year 2000. Communities with a strong commitment to recycling can reduce solid waste disposal costs and reduce the amount of waste that needs to go into state-of-the-art landfills.

4.9.6 New Hampshire Toxics in Packaging Law

Single-use packaging makes up about one-third of all municipal solid waste. Concerns have been raised regarding the presence of toxic substances in packaging that may harm the environment and public health when the package enters the waste stream. These substances, which may be used to enhance the quality of the packaging, pose a risk to the public and to the environment if they leach out of the packaging in landfills or if they are released during incineration.

These concerns led to the development of the Model Toxics in Packaging Legislation by the Coalition of Northeastern Governors (CONEG) through its Source Reduction Task Force (SRTF). The legislation was drafted through a consensus process involving representatives from the nine CONEG states, concerned non-profit and environmental organizations, and representatives of affected industries. New Hampshire's law is consistent with the Model. The law requires manufacturers to phase out the presence of mercury, lead, cadmium, and hexavalent chromium in packaging and packaging components to a maximum of 100 parts

per million. New Hampshire passed the law in 1990 with amendments in 1995 and 1999. At least 17 other states including Connecticut, Florida, Georgia, Illinois, Iowa, Maine, Maryland, Minnesota, Missouri, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, Washington and Wisconsin have also enacted laws based on the Model. Due to concerns over dioxin and its formation in the incineration process, research should be conducted to examine whether or not New Hampshire's toxics in packaging law should potentially be expanded to reduce the formation of dioxin by eliminating dioxin precursors such as chlorine and PVC plastics from the waste stream.

4.9.7 Recommended Actions Regarding Municipal Waste Combustors

R–35 Assure that federal requirements for dioxin emissions controls for both large and small MWCs are fully implemented and enforced.

R-36 Continue pollution prevention efforts, including encouraging mandatory recycling programs, Pay-As-You-Throw (PAYT) programs, and household hazardous waste collection programs, that divert recyclable materials from the waste stream.

R-37 Investigate the expansion of the New Hampshire Toxics in Packaging Law to include dioxin and dioxin precursors such as chlorine and PVC plastics.

R-38 Draft legislation by November 1, 2001 to study the impact of implementing a moratorium on the construction of new MWCs in New Hampshire not subject to federal New Source Performance Standards (NSPS).

R-39 Phase-out existing small municipal waste combustors in New Hampshire as existing units reach the end of their useful lives.

R-40 Conduct outreach, through the solid waste operator training program, on proper operating procedures to reduce dioxin formation.

4.10 Residential Fossil Fuel Combustion

Of the major fossil fuels used in New Hampshire for residential heating (oil, natural gas, propane, coal, and electric), oil use results in the highest annual dioxin emissions, with 114 mg TEQ per year, or 2.2% of statewide emissions. Coal is used very sparsely, resulting in less than 0.20 mg TEQ dioxin per year. Natural gas combustion has resulted in non-detectable dioxin emissions in several studies (EPA, 1997).

Oil and coal combustion produce dioxin due to the presence of organic molecules and chlorine in the fuel. Oil and coal formed in marine or brackish environments will have higher chlorine concentrations, and as a result greater dioxin forming potential, than oil and coal formed in freshwater environments. Inefficient operation and combustion also aid in the formation of dioxin.

Today, New Hampshire residents rely on the combustion of fossil fuels for the majority of our home heating needs. Therefore, the most productive way to reduce emissions of dioxin from the combustion of fossil fuels for home heating is to reduce fuel consumption by encouraging energy efficiency and fuel conservation. Energy efficiency and fuel conservation will not only help to reduce dioxin emissions, but emissions of many other pollutants including mercury, lead and volatile organics as well. In addition, such programs will help reduce our dependence on these non-renewable resources and at the same time save on the cost of energy and home heating for New Hampshire residents.

4.10.1 Recommended Actions Regarding Fossil fuel for Residential Heating

R-41 Work with the Governor's Office of Energy and Community Services to promote programs that encourage fuel conservation, energy efficiency and proper maintenance of home heating systems.

R-42 Support efforts to encourage the use of low or non-polluting renewable energy sources in homes such as solar, wind, etc.

4.11 Municipal Wastewater Treatment Plant Sludge and Biosolids

4.11.1 Introduction

Sludge and biosolids are the by-products that result from the biological treatment of wastewater at municipal wastewater treatment plants or publicly owned treatment works (POTWs). Once wastewater reaches a treatment plant, it goes through physical, chemical and biological processes that clean the water and remove the solids. After further treatment to break down organic materials and remove pathogens, these sewage sludge solids are called biosolids. Sludge and biosolids have a high nutrient content and an inherent value as fertilizer, but also contain contaminants, including dioxins, collected in the wastewater treatment process. Because of this, sludge and biosolids are sometimes considered a resource and sometimes considered a waste product. As a resource, biosolids can be composted or used directly on land as a nutrient-rich soil enhancement. If treated as a waste product, sludge is either disposed of in landfills or incinerated. DES data indicates that, in New Hampshire, approximately 46% of the sewage sludge produced is landfilled, 33% is land-applied as biosolids, and the remaining 11% is incinerated. Since all landfills that accept sludge are lined and secured, the majority of dioxin released into the environment involves land application and incineration.

Dioxin in sludge and biosolids from municipal wastewater treatment varies in concentration, source, and congener profile according to the purpose the treatment plant serves. Studies performed in the early 1990s show that the major source of dioxins at POTWs could be wastewater from laundering and bathing (EPA, 1998). Horstmann *et al.* (1993a) and Horstmann and McLachlan (1994a) concluded that the presence of dioxin in washing machine wastewater is widespread and could account for 27 to 94 percent of the total dioxin measured in biosolids. The dioxin in this laundry wastewater was not found to be a result of detergents, common bleaching agents, or the washing cycle process itself. Instead, residual pentachlorophenol (PCP) and the use of dioxin-containing dyes and pigments to treat unfinished cotton in some developing countries appear to be the main source of the dioxin found in washing machine wastewater (Horstmann *et al,* 1993b; Horstmann and McLachlan, 1994a &1994b; Klasmeier and McLachlan, 1995). Although found at low concentrations in wastewater, dioxins collect and accumulate in the sludge and biosolids that are produced as a by-product of the biological wastewater treatment process. As such, wastewater treatment and biosolids management do not actually create dioxin, but rather represent the "recycling" of dioxin that is produced elsewhere in the environment and is contained in the products that our citizens purchase.

4.11.2 Sewage Sludge Incinerators

New Hampshire has only one existing sewage sludge incinerator, located at the Manchester POTW. Previously, the POTW had two multiple hearth incinerator units. In 1993, a new fluidized bed unit was installed and one of the multiple hearth units was taken out of service. In June 1998, the second multiple hearth unit was shut down, and since that time only the fluidized bed incinerator has operated. In 1998, the fluidized bed unit incinerated 5,828 dry tons of sludge, emitting an estimated 37 mg TEQ of dioxin. Dioxin emitted from sewage sludge incinerators can come from two different sources. Dioxin can form as a result of reaction of chlorine and organic materials in the sludge in the combustion process, or it can be released due to incomplete combustion of dioxin contained in the sludge. Emissions from sewage sludge incineration at the Manchester facility make up less than 0.70% of the total emissions in the state. Alternatives to incineration are limited to disposal in landfills or biosolids land application.

4.11.3 Land-Applied Biosolids

About one third of all sludge generated in New Hampshire meets the state standards for land application and is considered as biosolids. In 1999, 12,813 wet tons of biosolids were land-applied in the state, with about 90% of that amount coming from in-state sources. Both state and federal regulations govern the allowable concentration of dioxin in land-applied biosolids. EPA has recently proposed a dioxin limitation for land-applied biosolids of 300 ng/kg TEQ[3]. New Hampshire Code of Administrative Rules, Env-Ws 800 limits dioxin concentration in land-applied biosolids to a much more stringent level of 27 ng/kg TEQ[4]. As part of the state Sludge Quality Certification (SQC) program, all facilities generating biosolids for land application must submit results of dioxin testing before being sold or spread. The results of all biosolids testing thus far show levels well below the state limit, with an average dioxin concentration of 6.3 ng/kg TEQ (Rainey, 2000). In addition to biosolids from POTWs, 9,500 wet tons of papermill sludge was land-applied in New Hampshire in 1999. However, the same strict dioxin limitation of 27 ng/kg also applies to the land application of this material, and recent test data for permitted sources of paper mill sludge show an average dioxin concentration of less than 2.0 ng/kg TEQ (Rainey, 2000). As a result, land applied biosolids and sludge result in about 85mg TEQ of dioxin returned to the soil each year through direct application. This is approximately 1.6% of the statewide total dioxin that is released into New Hampshire's environment. Alternatives to land application of biosolids and sludge are limited to disposal in landfills or construction of new sewage sludge incinerators. By land-applying adequately clean biosolids/sludge where appropriate, this material can be recycled as valuable fertilizer, instead of taking up a significant amount of space in landfills or being incinerated.

4.11.4 Recommended Actions Regarding Sewage Sludge and Biosolids

R–43 Require dioxin emissions stack testing for sewage sludge incinerators every three years beginning no later than July 1, 2001.

R-44 Work with federal regulatory authorities to limit the allowable residual dioxin found in garments and fabric with dioxin-containing dyes, pigments and pesticides.

[3] EPA used TEQ_{DFP}-WHO in their proposed regulations. This TEQ scheme includes 12 co-planar PCBs.
[4] I-TEQs (no PCBs included)

R-45 Continue to work with the University of New Hampshire in conducting research on land-application of biosolids and sludge and its impacts.

R-46 Continue to participate in the regional initiative coordinated by the New England Interstate Water Pollution Control Commission (NEIWPCC) to assess the risk from dioxins emissions associated with land application of biosolids.

R-47 Review current requirements for land application of sewage sludge to assure that there is adequate protection to assure that dioxin is not allowed to exceed health protective levels in treated soils.

R-48 Work with the business community to provide incentives for industry to strive toward a goal of "zero emissions discharge" (ZED) for wastewater discharges. The goal of ZED is to achieve zero discharge and zero emissions of pollutants including dioxin and other persistent bioaccumulative toxics from wastewater systems through pollution prevention and source reduction efforts.

4.12 Other Sources

4.12.1 Introduction

As part of this Strategy, DES has attempted to quantify dioxin emissions from all New Hampshire sources. The sources discussed all contribute to the dioxin burden on New Hampshire's environment. Many of these sources are only minor contributors, while others are suspected dioxin contributors that cannot be accurately quantified, due to lack of sufficient information at the present time.

4.12.2 Pesticide Use

Dioxins are found as contaminants in the manufacture of organochlorine pesticides and herbicides, and can be released into the environment through the use of these products. Although the use of many organochlorine pesticides, such as dichlorodiphenyltrichloroethane (DDT) have been banned in the U.S. for many years, others are still commonly used. One organochlorine pesticide, 2,4-dichlorophenoxyacetic acid (2,4-D) is found in many common herbicides and weed killers used throughout the U.S. including New Hampshire. 2,4-D is one of the top-ten pesticides in terms of quantities used in the U.S. New Hampshire Department of Agriculture statistics show that 6,279 pounds of 2,4-D were applied in New Hampshire in 1997 (the most recent year for which data are available). Using EPA's emission factor of 0.70ug/kg TEQ of 2,4-D applied, 2.0 mg TEQ of dioxin are released to the environment annually through application of 2,4-D.

4.12.3 Forest Fires and Wild Fires

As with all forms of wood combustion, forest fires and wild fires also contribute to dioxin in New Hampshire's environment. Records from the New Hampshire Department of Resources and Economic Development, Division of Forest and Lands, show that in 1999 there were 1,301 fires reported covering approximately 452.3 acres of forest land. Using emission factors from EPA's *Documentation of the 1996 Base Year National Toxics Inventory for Area Sources*, this would result in approximately 0.000080 mg TEQ of dioxin being released into the environment each year, making forest and wild fires a very minor source of dioxin emissions in New Hampshire. These results do not include prescribed open

burning of brush or wood debris, which is routinely conducted throughout the state, since estimates of the volume of this material burned each year are not readily available.

4.12.4 Crematoria

Cremation as an alternative to burial is a growing trend in the U.S. According to data from the Cremation Association of North America, in 1999 there were 4,662 cremations at 12 crematories in New Hampshire, or an overall cremation rate of more than 50%. The human body contains levels of both chlorine and dioxin, and this can result in dioxin emissions during the cremation process. Using EPA emission factors (*EPA, April, 1998*), cremation of human remains in New Hampshire results in the release of approximately 2.1 mg TEQ of dioxin annually. These results are for cremation of human remains only. Data on dioxin emissions from the cremation of animal remains are not currently available.

4.12.5 Landfill Gas Combustion

Municipal solid waste in landfills typically generates gases that consist mainly of methane and carbon dioxide with trace contaminants of other chemicals found in the waste or generated during decomposition. These trace contaminants often include chlorine and chlorine-containing compounds. Many of the larger landfills in New Hampshire collect and burn these gases. In some cases the gas is collected and burned in flares, in other instances the gas is collected and burned in internal combustion engines or gas turbines to produce electricity. When landfill gas is burned, chlorine and volatile organic compounds in the gas can react to form dioxin.

New Hampshire landfills burn an estimated 83.72 million cubic meters of landfill gas each year in eight reciprocating engines, two gas turbines and at least five flares resulting in almost 46 mg TEQ of dioxin annually. Combustion of landfill gas is extremely beneficial in reducing emissions of methane, a greenhouse gas, as well as hundreds of toxic pollutants generated by decomposition of materials disposed of at landfills. For this reason, federal air pollution regulations require that landfill gas be collected and burned at all large landfills.

4.12.6 Stationary Engines

There are over 150 permitted engines used primarily to power stationary electrical generators in New Hampshire. Together, these stationary engines burn over 2.6 million gallons of diesel fuel and distillate oil annually, and emissions from the combustion of this fuel contribute to the overall dioxin burden in New Hampshire. Although little data are available on dioxin emissions from these sources, EPA estimates an emission factor of 0.00000057 mg TEQ per gallon of fuel consumed for stationary engines (EPA, 1998). Using this factor, dioxin emissions from stationary engines in New Hampshire total approximately 1.8 mg TEQ of dioxin annually.

4.12.7 Utility Poles and Other Pressure Treated Wood

Researchers have demonstrated that two commonly used wood preservatives, pentachlorophenol (PCP) and creosote, can be potential contributors to dioxin in the environment. PCP is a halogenated hydrocarbon, composed of a benzene ring attached to a

hydroxide radical making a phenol which is then chlorinated. By-product contaminants of the PCP manufacturing process include tetrachlorophenol, hexachlorobenzene and dioxin. There is also evidence that dioxin can be formed when PCP treated wood is exposed to sunlight. PCP and creosote have been used for years to preserve telephone poles, railroad ties, fence posts, and water-exposed decking. EPA has restricted the use of PCP and creosote, and today the last remaining use of PCP and creosote is as wood preservatives for railroad ties and utility poles. It is estimated that there are over 377,000 pressure treated utility poles in New Hampshire, and more than half of these may be treated with PCP or creosote.

Dioxin from creosote PCP treated utility poles can be released into the environment in several ways. First, dioxin can be leached into the soil surrounding the pole. It can also be washed from poles by rainwater or released directly into the air during warm weather. The useful life of these utility poles is approximately 25 years. When utility poles are replaced, they are generally not considered hazardous waste since results from testing of used utility poles over 10 years old show that they do not exceed toxicity characteristic (TC) regulatory levels for cresol and PCP. As a result, these poles are often discarded in municipal landfills, or are sometimes mismanaged by being left along roadsides. Many of these poles are picked up by homeowners and recycled for use as fence posts and some may be burned as supplemental fuel. Combustion of creosote and PCP treated wood is believed to result in significant dioxin formation.

Although there is evidence to suggest that they may be significant contributors to dioxin in the environment, EPA has been unable to estimate the rate of release of dioxin from treated utility poles. However, emission rates of releases of dioxin from utility poles into the air have been estimated in an inventory of sources of dioxins and furans prepared by the Canadian government (Environment Canada, January 1999). Using these data, it is estimated that New Hampshire's PCP treated utility poles release a total of approximately 0.00010 mg TEQ of dioxin annually into the air. Although this emissions estimate does not include dioxin releases to the soil or water, the potential contribution of pressure treated utility poles should be noted.

4.12.8 Land-Applied Wood Ash

Another potential source of dioxin is the application of wood ash to agricultural land in New Hampshire. Ash that is collected as a by-product from the combustion of wood in industrial and utility boilers has an inherent value as a nutrient enhancing soil conditioner, and much of the wood ash generated at these sources is either applied directly to agricultural land, or is mixed with biosolids and land-applied. Some of the land-applied wood ash in New Hampshire is generated from out-of-state sources. As such, dioxin associated with the land application of wood ash has been treated separately, and was not included under the *Wood Fired Boilers and Utilities* source category in Section 4.3.

In 1999, 21,797 wet tons of wood ash were recycled through landspreading in New Hampshire. DES requires that all wood ash that is land-applied in New Hampshire be periodically tested for a number of toxic metals, and the concentration of these metals must be within established, health protective guidelines. Although not currently required, White Mountain Resource Management, Inc. conducted a laboratory analysis for dioxin in representative wood ash from five of New Hampshire's wood fired utilities in 1997. These results were used to estimate total dioxin released into New Hampshire's environment

through the landspreading of wood ash. Results show that less than 1.1 mg TEQ of dioxin is released to the environment annually due to the land application of wood ash from these sources.

4.12.9 Asphalt Mixing Plants

There are 30 asphalt mixing plants currently operating throughout New Hampshire. Studies have been conducted in Europe to determine dioxin emissions from asphalt mixing plants, and EPA has identified them as potential sources of dioxin emissions, although no data are available on dioxin emissions from U.S. asphalt mixing operations (EPA, April 1998). Although little data are available, European data indicate that, although dioxin may be present, asphalt mixing plants are most likely not a major source of dioxin, and represent only a minor contribution to New Hampshire's dioxin emissions.

4.12.10 Secondary Metals Production

One potential source of dioxin in New Hampshire is secondary metals production, or the recycling of scrap metals and metal wastes. Scrap metal often contains impurities such as plastics, paints, coatings and solvents. The metal is often recycled by melting the scrap in ovens and burning off these impurities. In addition, for some metals such as aluminum, chemicals such as NaCl, KCl and other salts are added during the recycling process. The combustion of these impurities and chlorine salts in the presence of metals in the recycling process can result in the formation of dioxins.

Secondary metals production units, often referred to as "sweat furnaces", are typically relatively small and at this time it is unclear exactly how many are operating in New Hampshire. EPA has targeted secondary aluminum production as a source of dioxin emissions and recently issued a final rule requiring all secondary aluminum smelters to reduce dioxin emissions by instituting maximum available control technology (MACT) standards. DES has notified potentially affected sources and is in the process of identifying New Hampshire sources subject to these MACT standards.

4.12.11 Recommended Actions Regarding Other Sources

R-49 Continue to work with the New Hampshire Department of Agriculture, Markets and Food ensure the safe and proper use of chemical pesticides by enforcing state pesticide laws affecting sale, storage and application of all registered pesticides; examining and licensing pesticide dealers and users; and registering all economic poisons sold and used within the state.

R-50 Work with the New Hampshire Department of Agriculture, Markets and Food to encourage farmers to increase the use of alternatives to chemical pesticides, including integrated pest management techniques.

R-51 Encourage the New Hampshire Department of Economic Development, Division of Forest and Lands to continue their public education efforts regarding forest fire prevention.

R-52 Encourage and work with EPA in developing dioxin emission factors and establishing dioxin emissions inventory estimates for source categories such as

animal crematoria, PCP and creosote treated utility poles, asphalt mixing plants, and other sources in New Hampshire.

R-53 Continue to identify, gather information and enforce current state and federal standards affecting dioxin emissions from secondary metals production facilities in New Hampshire

5.0 DISCUSSION AND FINDINGS

5.1 Overview

Although dioxin is released into the environment in very minute quantities, it is extremely toxic, pervasive and persistent in the environment. Over the last 20 years researchers have examined the effects of dioxin contamination on both humans and wildlife. While there are still many uncertainties regarding its potency and mechanisms of toxicity, most researchers agree that dioxin is a carcinogen that can also have serious effects on the reproductive, endocrine and immune systems. In addition, data suggests that low-level exposure of the general population to dioxin is widespread, and that the risk of experiencing cancer as a result of dioxin exposure for some people could be as high as 1 in 100 to 1 in 1,000 (EPA, September 2000).

Citizens, industry, environmental regulators, environmentalists, and political leaders have expressed much concern about dioxin and other PBTs due to these human health and environmental consequences. Regulators, including DES and EPA have already completed a number of initiatives and regulatory actions over the last several years to address the sources and impacts of dioxin (see **Appendix 1**). It is estimated that these actions have already resulted in a decrease in dioxin emissions of about 80% since the 1980s. However, new information on dioxin toxicity as well as widespread interest and concern for this problem at the state, regional and national levels are spurring increased efforts to achieve further reductions in dioxin contamination.

DES initiated the *New Hampshire Dioxin Reduction Strategy* in an effort to proactively address environmental and public health concerns regarding dioxin, and to abate further environmental dioxin contamination in New Hampshire. Section 4 of this document lists the major known sources of dioxin in the State as well as a number of recommendations to achieve significant dioxin emission reductions from each of these sources. Many of the source categories that were identified as major contributors, however, are not those typically thought of as major polluters. This may be due to a number of factors including:

- Most sources typically associated with dioxin emissions, such as hazardous waste incinerators, metal smelters, and pesticide manufacturers are not located in New Hampshire;

- Those sources in New Hampshire that may have previously been associated with dioxin emissions such as municipal solid waste incinerators and pulp and paper mills have already significantly reduced their emissions due to recent regulatory actions;

- Dioxin is not produced intentionally, but is formed through chemical processes in the combustion of fuels containing chlorine, organic molecules and catalytic metals that react under certain specific conditions to form dioxin. Therefore dioxin can only be emitted where these unique combustion conditions exist.

As a result, DES believes that an innovative, multimedia approach is necessary in order to achieve significant dioxin reductions from these non-traditional sources. This approach will encompass mandatory, voluntary and educational efforts to both prevent, and control dioxin

emissions. The specific recommendations for each source category presented in Section 4 are summarized and discussed below.

5.2 Recommended Regulatory Actions

Specific regulatory actions are the basis for the bulk of dioxin reductions, particularly from hospital/medical/infectious waste incinerators (HMIWIs) and backyard burning of domestic wastes. These proposed regulatory actions are listed below.

Hospital/Medical/Infectious Waste Incinerators

- Reduce dioxin emissions from HMIWIs by assuring that all facilities are either closed by April 10, 2001, or are in compliance with applicable dioxin emission requirements of the HMIWI rule by September 15, 2002.
- Draft legislation by November 1, 2001 (with an effective date of July 1, 2005) to prohibit the disposal of PVC-containing products and materials in medical waste incinerators.
- Draft legislation by November 1, 2001 (with an effective date of July 1, 2002) to:
    c) ban the construction of medical waste incinerators in New Hampshire, and
    d) phase out the operation of all existing HMIWIs in the state by 2010.
- Work to revise DES Solid Waste Rules to require that all infectious medical wastes treated using alternate treatment technologies be required to be disposed of directly in approved landfills rather than incinerated at municipal waste combustors.

Wood-fired Boilers and Utilities

- If studies confirm that the large wood-fired power plants are, in fact, major sources of dioxin in New Hampshire; and if alternative uses for lower value wood and wood wastes are identified and established creating a viable market for wood produced by New Hampshire's timber harvesting and forest products industries; then New Hampshire should strongly consider phasing out these plants.

Backyard Burning of Domestic Waste

- Draft legislation by January 1, 2001 to ban all backyard burning of household wastes in New Hampshire.
- If legislation to ban backyard burning of household waste is not enacted, DES will work to reduce dioxin emissions by drafting legislation by November 1, 2001 to ban all backyard burning of PVC containing plastics.

Residential Wood Combustion

- Draft legislation to prohibit the burning of treated wood in residential woodstoves by January 1, 2002.

Mobile Sources

- Support and encourage more stringent federal regulations to reduce emissions from mobile sources including:
    a. Aggressive new emission reduction standards for non-road heavy-duty diesel engines and fuels during the EPA's 2001 technology review for this emissions source category.

b. Aggressive emission reduction requirements for on-highway and non-road mobile sources and their fuels through the EPA's rulemaking under Section 202(l) of the Clean Air Act.
c. Regional and federal fuels and emissions standards (RFG/MtBE, Low Sulfur Diesel, HD Diesel 2007 standards, and various nonroad regulations).

- Seek early introduction of the federally required On Board Diagnostics (OBD) emissions inspection requirement on a voluntary repair basis for year 2001 and mandatory for 2002 and beyond;
- Support NH Department of Safety implementation of motor vehicle Enhanced Safety Inspection and Diesel Opacity testing program requirements;
- Adopt the proposed California Heavy Duty Diesel Not-to-Exceed (NTE) rule for the years 2005, 2006 to prevent backsliding by HDD engine manufacturers on emission requirements;
- Review feasibility, technical benefits associated with adoption of California LEV II standards and make recommendations regarding adoption;
- Increase implementation of (NH initiated) NESCAUM diesel idling reduction initiative;

Pulp and Paper Mills

- Continue to support and implement federal rules (Cluster Rules) requiring air and water pollution reductions from large pulp and paper manufacturing facilities.
- Work with Pulp and Paper of America to re-institute periodic fish tissue monitoring for dioxin both up and downstream of the facility with the goal of measuring environmental improvement and lifting fish consumption restrictions once fish tissue downstream reaches acceptable levels.

Municipal Waste Combustors

- Assure that federal requirements for dioxin emissions controls for both large and small MWCs are fully implemented and enforced.
- Draft legislation by November 1, 2001 to study the impact of implementing a moratorium on the construction of new MWCs in New Hampshire not subject to federal New Source Performance Standards (NSPS).
- Investigate the expansion the New Hampshire Toxics in Packaging Law to include dioxin and dioxin precursors such as chlorine and PVC plastics.

Wastewater Treatment Sludge and Biosolids

- Work with federal regulatory authorities to limit the allowable residual dioxin found in garments and fabric with dioxin-containing dyes, pigments and pesticides.

Other Sources

- Continue to identify, gather information and enforce current state and federal standards affecting dioxin emissions from secondary metals production facilities in New Hampshire.
- Continue to work with the New Hampshire Department of Agriculture, Markets and Food ensure the safe and proper use of chemical pesticides by enforcing state pesticide laws affecting sale, storage and application of all registered pesticides; examining and licensing pesticide dealers and users; and registering all economic poisons sold and used within the state.

These regulatory actions together are expected to result in an overall reduction in dioxin from New Hampshire sources by 50% by July 1, 2003.

5.3 Recommended Voluntary Actions

Several key voluntary actions are recommended as part of this strategy in order to further reduce dioxin emissions, particularly in areas where strict regulation or prohibition is not practical or appropriate. Many of these voluntary actions involve the promotion of pollution prevention (P^2) and energy efficiency activities. These voluntary actions are listed below.

Hospital/Medical/Infectious Waste Incinerators

- Work with the workgroup on Pollution Prevention in the Healthcare Industry (established under the October, 1998 *New Hampshire Mercury Reduction Strategy*) to facilitate the goal of virtual elimination of all PVC-containing products from the medical waste stream by January 1, 2005.
- Work with the workgroup on Pollution Prevention in the Healthcare Industry to facilitate the goal of reducing the volume of waste incinerated at all remaining medical waste incinerators in the state by encouraging alternative medical waste handling/disposal methods including waste minimization, recycling, source separation and sterilization.

Wood and Fossil Fuel-Fired Boilers and Utilities

- Encourage greater implementation of energy efficiency and conservation programs for wood-fired and fossil fuel-fired electric utilities by:
    a) Participating actively in the Public Utility Commission proceedings relating to energy efficiency (ongoing);
    b) Encouraging the initiation of and active participation in proceedings at the NHPUC (and in regional efforts) relating to disclosure of the environmental characteristics of power sales (ongoing);
    c) Assisting New Hampshire's Interagency Energy Efficiency Committee in energy saving efforts such as expeditiously implementing Energy Star Building Programs for State buildings (1998-2003).
- Work with US EPA, American Forest and Paper Association, New Hampshire Timberland Owners Association, representatives of New Hampshire's large wood-fired boilers and other stakeholders to exam options for reducing dioxin emissions from wood-fired boilers if warranted.
- Strongly encourage and work with the New Hampshire Department of Resources and Economic Development (DRED), United States Forest Service (USFS), Society for the Protection of New Hampshire Forests (SPNHF), New Hampshire Timberland Owner's Association (NHTOA), New Hampshire Timber Harvester's Association (NHTHA) and other stakeholder groups to develop alternative markets for lower value wood and wood wastes produced in New Hampshire.
- Reduce dioxin emissions from wood-fired and fossil fuel-fired utilities and industrial boilers by encouraging expeditious development of natural gas, solar photovoltaics and fuel cells through the permitting process and in the allocation of emission allowances (on-going).

Mobile Sources

- Continue to promote the Marine Engine MOU to New Hampshire dealers to encourage early introduction of cleaner burning marine engines;
- Work with NH Department of Transportation (via transportation conformity review process, ongoing I93 study, rail study, smart growth initiative, etc.) to promote transportation control measures and increase the availability of alternative transportation modes (bus, HOV lanes, rail, etc.);
- Continue promotion of low emission advanced technology vehicles via Granite State Clean Cities Coalition initiative (jointly with GOECS), NH Alternative Fuel Vehicle Coalition (joint venture of DES, GOECS, DOT), NH Green Car Label Project (joint effort of DES, ALANH, NHADA, and AMC), and State Green Car purchasing initiative (joint effort w/ Bureau of Purchase and Property);
- Seek voluntary reductions of aircraft and related ground equipment at Manchester Airport through NEPA review and General Conformity process and participation in the national FAA Airport Emissions Reduction Stakeholder process.

Pulp and Paper Mills

- Work with members of the NH pulp and paper industry to encourage pollution prevention and energy efficiency; and investigate the costs and benefits of substituting TCF for ECF bleaching processes.
- Support and encourage the purchase of alternative, chlorine free paper products throughout New Hampshire, including state government.

Municipal Waste Combustors

- Continue pollution prevention efforts, including encouraging mandatory recycling programs, Pay-As-You-Throw (PAYT) programs, and household hazardous waste collection programs that divert recyclable materials from the waste stream.
- Phase-out existing small municipal waste combustors in New Hampshire as existing units reach the end of their useful lives.

Residential Fossil Fuel Combustion

- Work with the Governor's Office of Energy and Community Services to promote programs that encourage fuel conservation, energy efficiency and proper maintenance of home heating systems.
- Support efforts to encourage the use of low or non-polluting renewable energy sources in homes such as solar, wind, etc.

Other Sources

- Work with the New Hampshire Department of Agriculture, Markets and Food to encourage farmers to increase the use of alternatives to chemical pesticides, including integrated pest management techniques.

5.4 Recommended Research and Monitoring

As noted elsewhere in this report, reliable dioxin emissions data for many source categories are either very limited or non-existent. This is especially true of New Hampshire sources where dioxin emissions testing has been limited mainly to large municipal solid waste combustors and one hospital/medical/infectious waste incinerator. As a result, several

recommendations in this strategy deal with monitoring and research initiatives to establish statewide emissions data and to gauge the effectiveness of the recommended control strategies. These recommended research and monitoring actions are listed below.

Hospital/Medical/Infectious Waste Incinerators

- Assure that the dioxin emissions testing is conducted and completed within 6 months of the applicable compliance date as required under Env-A 3500 in order to assure that dioxin emission reduction objectives are being met.

Wood-Fired Boilers and Utilities

- Develop emission factors and dioxin emissions testing requirements for large, wood-fired boilers by:
  a) Conducting initial DES dioxin emissions screening stack tests on representative sources by January 1, 2002.
  b) Based on the results of initial stack tests, re-evaluating the actual contribution of dioxin from New Hampshire's wood-fired boilers, and if appropriate, developing emissions testing requirements by June 1, 2002.
- Develop and implement by July 1, 2002, standards that minimize dioxin emissions and assure efficient combustion for wood-fired boilers by:
  a) Setting maximum limits for carbon monoxide;
  b) Setting minimum limits for excess oxygen;
  c) Setting minimum limits for combustion temperature;
  d) Establishing minimum requirements for particulate emissions controls;
  e) Establishing and stabilizing maximum fuel feed rates;
  f) Establishing recommendations for boiler maintenance schedule and frequency.

Fossil Fuel-Fired Boiler and Utilities

- Work with EPA to establish emission factors for burning propane and diesel fuel in industrial boilers.

Wastewater Treatment Sludge and Biosolids

- Require dioxin emissions stack testing for sewage sludge incinerators every three years beginning no later than July 1, 2001.
- Continue to work with the University of New Hampshire in conducting research on land-application of biosolids and sludge and its impacts.
- Continue to participate in the regional initiative coordinated by the New England Interstate Water Pollution Control Commission (NEIWPCC) to assess the risk from dioxins emissions associated with land application of biosolids.
- Review current requirements for land application of sewage sludge to assure that there is adequate protection to assure that dioxin is not allowed to exceed health protective levels in treated soils.

Other Sources

- Encourage and work with EPA in developing dioxin emission factors and establishing dioxin emissions inventory estimates for source categories such as animal crematoria, PCP and creosote treated utility poles, asphalt mixing plants, and other sources in New Hampshire.

5.5 Recommended Public Outreach and Education

Much of the dioxin in New Hampshire is generated not only by businesses and industry, but by all segments of the population. As a result, outreach, education and technical assistance are an integral part of the dioxin reduction strategy. The outreach and education activities identified in this strategy are summarized below.

Hospital/Medical/Infectious Waste Incinerators

- Work with the workgroup on Pollution Prevention in the Healthcare Industry (established under the October, 1998 *New Hampshire Mercury Reduction Strategy*) to facilitate the goal of virtual elimination of all PVC-containing products from the medical waste stream by January 1, 2002. The workgroup will conduct outreach and education to encourage proper waste management practices including source separation, purchase of alternative materials and recycling.
- Support and promote the DES Solid Waste Operator Training Program for all HMIWI operators. This program, approved by EPA through New Hampshire's HMIWI rule, provides education, outreach and training on waste handling, source reduction, proper incinerator operation and ash management.

Backyard Burning of Domestic Waste

- If legislation to ban backyard burning of household waste is not enacted, DES will work to reduce dioxin emissions by undertaking an outreach initiative to educate the public about the causes of and risks related to dioxin formation from backyard burning of household waste, including chlorine and PVC plastics by June 1, 2001.

Residential Wood Combustion

- Work with the Governor's Office of Energy and Community Services to increase public education and outreach programs that encourage efficient residential wood combustion and combustion technologies, and promote the replacement of older, more polluting woodstoves with more efficient, cleaner burning wood and wood pellet stoves.

Wood and Fossil Fuel-Fired Boilers and Utilities

- Encourage greater implementation of energy efficiency and conservation programs for sources by assisting the Governor's Office of Energy and Community Services in outreach to electricity consumers about reducing dioxin emissions through greater energy efficiency (ongoing).

Municipal Waste Combustors

- Conduct outreach, through the solid waste operator training program, on proper operating procedures to reduce dioxin formation.

Other Sources

- Encourage the New Hampshire Department of Economic Development, Division of Forest and Lands to continue their public education efforts regarding forest fire prevention.

5.6 Recommended Actions for Reducing Human Exposure to Dioxin

The strategies for reducing dioxin releases to the environment recommended in this report will take many years to result in lower dioxin exposures for the general population. As a result, the best way for people to reduce their risk in the short-term is for them to reduce their personal exposure to and intake of dioxin as soon as possible. For most people, 95% of exposure to dioxins is through food consumption, particularly animal fat and fish. There are also certain groups of people, including those who smoke, those who may have been exposed to dioxin as a result of a food contamination incident, those that may have been exposed in the workplace, and those that may have been exposed through an industrial accident; that may have higher levels of dioxin than the general population.

By following fish consumption advisories, reducing fat intake, and eating a balanced diet most people can begin to reduce their dioxin body burden. In addition, assuring healthy and safe workplaces, protecting the food supply from contamination and promoting healthy lifestyle habits will also assure that dioxin exposures are minimized while the reduction strategies recommended in this report are implemented and take effect. The recommendations listed below will help assure that New Hampshire residents have the ability to immediately begin to minimize their potential exposure to dioxin.

- Continue to support and promote the statewide fish consumption advisory program conducted by the New Hampshire Department of Health & Human Services (DHHS), Office of Community and Public Health (OCPH).
- Continue to support the public outreach and education efforts of the New Hampshire DHHS that promote healthy diet and eating habits such as the “5 A Day for Better Health “ Program, “New Hampshire Celebrates Wellness” Program, and others.
- Continue to support and promote the New Hampshire DHHS Office of Community and Public Health, Tobacco Prevention Program.
- Continue to support and promote the New Hampshire Department of Agriculture, Bureau of Markets programs that provide for the inspection of farm commodities offered for sale within the state to assure they meet grade and quality standards. The bureau also administers the Seal of Quality program and conducts lime, feed, seed and fertilizer inspection programs to ensure their content and quality.
- Continue to support and promote the New Hampshire DHHS Division of Public Health Services Occupational Health Program that provides outreach and assistance to assure safe and healthy workplaces in new Hampshire.

6.0 SUMMARY AND CONCLUSIONS

The term "dioxin" refers to a group of chemical compounds that share certain similar chemical characteristics, and common mechanisms of toxicity. Dioxin is a likely human carcinogen that may increase the risk of cancer even at extremely low exposure levels. Other health concerns include reproductive and developmental effects as well as effects to the endocrine and immune systems. Children are particularly vulnerable to dioxin exposure. Although dioxin is released into the environment in very minute quantities, it builds up in soils, sediments and plants, bioaccumulates in animal and fish tissue, and is then passed up the food chain. As a result, most human exposure to dioxin is through the consumption of foods such as beef, pork, fish and dairy products. Wildlife is also affected by dioxin exposure resulting in low fertility and reproductive rates, low birth weights and developmental problems.

Unlike many other toxic environmental contaminants, most dioxin is formed as an unintended byproduct of "anthropogenic" or man-made processes such as combustion of fuels, wastes and some manufacturing processes. Most dioxin is released into the air, where it can travel thousands of miles before being deposited on the earth's surface. As a result, much of the dioxin deposited in New Hampshire is a result of emissions from sources far upwind. Likewise, emissions of dioxin from New Hampshire sources may affect areas thousands of miles downwind.

State and federal regulatory programs to reduce dioxin emissions from several large source categories have been in place in New Hampshire for several years and much progress has already been made. But low levels of dioxin are still being produced and are accumulating in the environment from many smaller source categories that are identified in this strategy. In New Hampshire, five source categories account for over 83% of the local dioxin emissions to the environment. These categories include:

1) medical waste incinerators,
2) wood-fired boilers,
3) backyard burning of household waste,
4) residential wood combustion, and
5) mobile source fuel combustion.

These five categories include not only industrial sources, but also many activities we as individuals conduct everyday, such as disposing of wastes, driving cars or trucks, and using woodstoves. As a result, we must all be accountable for doing our part to reduce dioxin in New Hampshire and cannot just pass the responsibility for reductions onto business and industry alone. Through the implementation of the recommended actions in this strategy, DES believes that over a 50% reduction in emissions from New Hampshire sources can be achieved over the next three years. By taking the initiative in reducing our own dioxin emissions, New Hampshire can insist on similar reductions of dioxin from upwind regions, thus significantly reducing the public health and ecological threat of dioxin contamination in our environment.

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APPENDICES

APPENDIX 1 - PAST AND PRESENT NEW HAMPSHIRE DIOXIN REDUCTION EFFORTS

To minimize potential health risks posed by dioxins, the New Hampshire Department of Environmental Services has already taken action and adopted legislation, rules, and policies to reduce dioxin releases to the environment. These include:

- Env-A 3505 Hospital/ Medical/Infectious Waste Incinerators constructed before June 20, 1996.
    - Small incinerators (≤200 lb/hour) are limited to an emission rate of ≤2.3 ng/dscm TEQ or ≤125 ng/dscm total PCDDs/PCDFs.
    - Small rural incinerators that are greater then 50 miles from the nearest standard metropolitan statistical area and burn less then 2000 lb/week, are limited to an emission rate of ≤15 ng/dscm TEQ or ≤125 ng/dscm total PCDDs/PCDFs.
    - Medium incinerators that burn greater than 200 lb/hr and less than 500 lb/hr are limited to an emission rate of ≤2.3 ng/dscm TEQ or ≤125 ng/dscm total PCDDs/PCDFs.
    - Large incinerators that burn more than 500 lb/hr are limited to an emission rate of ≤2.3 ng/dscm TEQ or ≤125 ng/dscm total PCDDs/PCDFs.

- 40 CFR Part 60, Subpart Ec, New Source Performance Standards for Hospital/Medical/ Infectious Waste Incinerators constructed after June 20, 1996, which have been delegated by EPA to DES for implementation and enforcement.
    - New small incinerators are limited to an emission rate of ≤2.3 ng/dscm TEQ or ≤125 ng/dscm total PCDDs/PCDFs.
    - New medium and large incinerators limited to an emission rate of ≤0.6 ng/dscm TEQ or ≤25 ng/dscm total PCDDs/PCDFs.

- Env-A 3303 Adopts the emission limits of 40 CFR 60.33b in Subpart Cb and applies to municipal waste combustors burning greater than 250 tons/day and constructed before September 20, 1994.
    - Combustors with an electrostatic precipitator (ESP) are limited to an emission rate of ≤60 ng/dscm total PCDDs/PCDFs.
    - Combustors without an ESP are limited to an emission rate of ≤30 ng/dscm total PCDDs/PCDFs.

- 40 CFR Part 60, Subpart Ea, New Source Performance Standards for municipal waste combustors burning greater than 250 tons per day and constructed after November 20, 1994, which have been delegated by EPA to DES for implementation and enforcement.
    - Combustors are limited to an emission rate of ≤30 ng/dscm total PCDDs/PCDFs.

- Env-Ws 807.03 Sludge to be used for land application.
    - Sludge cannot exceed 10 ng/kg TEQ for 2,3,7,8 TCDD and 2,3,7,8 TCDF and 27 ng/kg TEQ for all congeners.

- Env-A 1450.01 Emission limits for regulated toxic air pollutants.

- Sources of dioxin can not exceed an annual or 24-hour ambient air limit of 0.001 g/m^3 for 2,3,7,8-TCDD.

- 40 CFR Part 63, Subpart S Maximum Achievable Control Technology standards for the pulp and paper industry (Cluster Rule), which have been delegated by EPA to DES for implementation and enforcement.
  - Pulp and paper mills must comply with the effluent limitation for 2,3,7,8 TCDD in 40 CFR 430.24(a)(1) no later than April 16, 2001.
  - Locations where chlorinated compounds are introduced must be enclosed and vented into a closed-vent system and routed to a control device.

- Env-A 1001 Open Burning Rules.
  - Persons are prohibited from burning treated wood in campfires and bonfires
  - Cities, towns, and commercial operations are prohibited from burning treated wood in construction or demolition debris fires.

- 40 CFR Part 63, Subpart RRR Maximum Achievable Control Technology standards for secondary aluminum production, which have been delegated by EPA to DES for implementation and enforcement.
  - Operators of sweat furnaces must not discharge emissions in excess of 0.80 ng of dioxin/furan TEQ per dscm at 11 % oxygen.

APPENDIX 2 - COMPREHENSIVE LIST OF ESTIMATED NEW HAMPSHIRE DIOXIN EMISSIONS BY SOURCE CATEGORY - 1999

CATEGORY	mg TEQ/YR	% of total
Hospital/Medical/Infectious Waste Incinerators	1,503	28.7%
Wood-Fired Boilers and Utilities [1]	1,064	20.3%
Backyard Burning of Domestic Waste	896.9	17.1%
Residential Wood Combustion	513.3	9.79%
Diesel-Fueled Vehicles [2]	369.6	7.05%
Gasoline-Fueled Vehicles [2]	39.84	0.760%
Pulp and Paper Mills	226.1	4.31%
Fossil Fuel-Fired Utilities	184.5	3.52%
Fossil Fuel-Fired Industrial Boilers	28.20	0.538%
Large Municipal Waste Combustors	129.3	2.47%
Small Municipal Waste Combustors	0.2478	0.0047%
Residential Oil Combustion	114.1	2.17%
Residential Coal Combustion	0.1851	0.0035%
Land-Applied Biosolids	84.46	1.61%
Sewage Sludge Incineration	37.01	0.706%
Pesticide Use	1.994	0.038%
Forest Fires and Wild Fires	0.000082	0.0000016%
Crematoria [3]	2.109	0.040%
Landfill Gas Combustion	45.91	0.875%
Stationary Engines	1.799	0.034%
Utility Poles and Other Pressure Treated Wood	0.00011	0.0000021%
Land-Applied Wood Ash	1.078	0.021%
TOTAL BURDEN	5,244	100.0%

Tolerable **D**aily **I**ntake is 4.536x10^-10 - 1.814x10^-9 mg/lb of body weight
For a 150 lb person, the TDI is 6.804x10^-8 - 2.722x10^-7 mg
this is the equivalent of 2.483x10^-5 - 9.935x10^-5 mg per year.

[1] - includes industrial and utility wood fired boilers

[2] - this emission number includes non-road use

[3] - this emission number does not include cremation of animals.

APPENDIX 3 - COMPARISON OF STATE AND NATIONAL SOURCES OF DIOXIN, BY CATEGORY

TOTAL DIOXIN BURDEN IN NEW HAMPSHIRE BY CATEGORY (1999)

CATEGORY	TEQ mg/yr	% of total emissions
Hospital/Medical/Infectious Waste Incinerators	1502.94	28.66%
Wood-Fired Boilers & Utilities	1064.44	20.30%
Backyard Burning of Domestic Waste	896.90	17.10%
Residential Wood Combustion	513.31	9.79%
Mobile Sources	409.45	7.81%
Pulp and Paper Mills	226.06	4.31%
Fossil Fuel-Fired Boilers & Utilities	212.73	4.06%
Municipal Waste Combustors	129.52	2.47%
Wastewater Treatment Sludge & Biosolids	121.47	2.32%
Residential Fossil Fuel Combustion	114.24	2.18%
Other	52.89	1.01%
Total	**5243.94**	**100.00%**

TOTAL DIOXIN BURDEN IN THE UNITED STATES BY CATEGORY (1995)*

CATEGORY	TEQ grams/yr	% of total emissions
Municipal Waste Combustors	1100.00	22.12%
Landfill Fires	1000.00	20.11%
Backyard Burning of Domestic Waste	1000.00	20.11%
Secondary Copper Production	541.00	10.88%
Hospital/Medical/Infectious Waste Incinerators	477.00	9.59%
Wastewater Treatment Biosolids & Sludge	213.00	4.28%
Forest and Wild Fires	208.00	4.18%
Cement Kilns Burning Hazardous Waste	153.00	3.08%
Fossil Fuel-Fired Boilers & Utilities	82.10	1.65%
Residential Wood Combustion	62.80	1.26%
Other	136.10	2.74%
Total	**4973.00**	**100.00%**

- Data for US sources taken from: U.S. EPA. The Inventory of Sources of Dioxin in the United States (DRAFT). Office of Research and Development, Washington DC. April 1998 (Reference year for most recent US data is 1995). Subsequently, EPA has reported that dioxin emissions from medical and municipal waste combustors have dropped significantly nationwide.

APPENDIX 4 – LIST OF ACRONYMS

AFPA	American Forest and Paper Association
CAA	Clean Air Act
CAAA	Clean Air Act Amendment
CONEG	Coalition of Northeastern Governors
DES	New Hampshire Department of Environmental Services
DRED	New Hampshire Department of Resources and Economic Development
ECF	Elemental Chlorine-Free
Env-A	New Hampshire Code of Administrative Rules - Air Resources Division
Env-Wm	New Hampshire Code of Administrative Rules – Waste Management Division
EPA	United States Environmental Protection Agency
HCl	Hydrochloric Acid
ICCR	U.S. EPA's Industrial Combustion Coordinated Rulemaking
HMIWI	Hospital/Medical/Infectious Waste Incinerator
MACT	Maximum Achievable Control Technology
MSW	Municipal Solid Waste
MWC	Municipal Waste Combustor
NACEC	North American Commission for Environmental Cooperation
NCASI	National Council of the Paper Industry for Air and Stream Improvement
NEHPA	Northeast Hearth Products Association
NEIWPCC	New England Interstate Water Pollution Control Commission
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NHPUC	New Hampshire Public Utilities Commission
NHTHA	New Hampshire Timber Harvester's Association
NHTOA	New Hampshire Timberland Owner's Association
NOAA	U.S. National Oceanographic and Atmospheric Administration
NSPS	New Source Performance Standard
PAYT	Pay-As-You-Throw
PBT	Persistent Bioaccumulative Toxic
PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzo-p-furan
PCF	Process Chlorine-Free
PCP	Pentachlorophenol

POTW	Publicly Owned Treatment Works
ppb	part per billion
ppt	part per trillion
PVC	Polyvinyl Chloride
SAB	U.S. EPA Science Advisory Board
SPNHF	Society for the Protection of New Hampshire Forests
SQC	Sludge Quality Certification
TCDD	Tetrachlorodibenzo-p-dioxin
TCF	Totally Chlorine-Free
TDI	World Health Organization's Tolerable Daily Intake
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalent
TRI	U.S. EPA Toxics Release Inventory
USFS	United States Forest Service
VOC	Volatile Organic Compound
WHO	World Health Organization
ZED	Zero Emissions Discharge