International Joint Commission
Commission mixte internationale

Release date / Date de parution : April 8, 1993

Contact / Personne ressourse : Doug McTavish (519)661-2257
Anders Andren (608)262-2470
Marty Bratzel (519)257-6701 in Canada or (313)226-2170 in U.S.

PUBLIC MEETINGS TO BE HELD ON DRAFT FINAL REPORT ON VIRTUAL ELIMINATION OF PERSISTENT TOXICS FROM GREAT LAKES

The Virtual Elimination Task Force of the International Joint Commission will hold three public meetings in late April, and invites written comments until May 10, 1993, to obtain input from all interested citizens on its draft final report.

The International Joint Commission, a U.S.-Canada treaty organization that addresses water quantity and quality issues facing boundary waters, created the task force in 1990 because persistent toxic substances continue to threaten the health of fish and wildlife in the Great Lakes region, and reportedly people as well. The task force was charged with reviewing the effectiveness of present pollution control and prevention practices, and developing a strategy to virtually eliminate persistent toxic substances from entering the Great Lakes ecosystem, a goal committed to by the U.S. and Canada in the Great Lakes Water Quality Agreement.

The strategy outlined in the report recognizes the need to identify and eliminate present inputs of persistent toxics, remediate problem areas, and anticipate and prevent future inputs and problems. It recommends that the virtual elimination goal will be achieved when a broad array of legislation, regulations, technology, economic instruments, education and consultation that all focus on persistent toxics are implemented. The strategy is also applied to two case studies in the report, PCBs and mercury.

All interested citizens are invited to attend the following public meetings to comment on the draft final report:

- **April 27, 1993: Marc Plaza, 509 West Wisconsin Avenue, Milwaukee, Wisconsin**
- **April 28, 1993: Cobo Conference Center, 1 Washington Blvd., Detroit, Michigan**
- **April 29, 1993: Westin Harbour Castle, One Harbour Square, Toronto, Ontario**

All meetings will begin at 6:30 p.m. To obtain a copy of the report or to submit written comments by May 10, contact Marty Bratzel at the numbers listed above or the address below.

THREE BACKGROUND REPORTS TO THE

VIRTUAL ELIMINATION TASK FORCE

ON THE SUBJECT OF

CHLORINE AND ORGANOCHLORINES

Contents:

Note:

These background reports are being distributed for information only. They do not constitute a component of the Task Force's draft Final Report.

A REPORT ON CHLORINE

TO THE

VIRTUAL ELIMINATION TASK FORCE

BY

G.N. WEREZAK

APRIL 2, 1993

A REPORT ON CHLORINE

TO THE

VIRTUAL ELIMINATION TASK FORCE

The purpose of this paper is to present the basis for the International Joint Commission to support an exhaustive investigation of chlorine's use as a necessary first step towards determining whether any chlorine uses should be recommended for sunsetting. This investigation should give consideration to the broad range of chlorine's uses and benefits, potential health and environmental risks, the social and economic impacts of sunsetting chlorine's use, and the risks associated with alternatives. The investigation should be based on sound and defensible scientific and technical analysis that addresses each of the areas previously mentioned.

My opinion is based on a continuing review of the economic, environmental, health, legal, scientific, social and technical factors involving society's use and disposal of chlorine and compounds derived from chlorine. Further, I believe that the current structure of U.S./Canadian laws and regulations provides an appropriate legal framework for controlling the use and disposal of chlorine and chlorinated compounds, particularly those that may be determined by scientific analysis to be persistent toxics that bioaccumulate. Further, there remains a need for continuing, cooperative scientific dialogue to resolve questions regarding the risks posed by some applications of chlorine and chlorine chemistry, as well as the risks posed by potential alternatives.

To facilitate the reproduction and distribution of this document, the scientific and technical references that serve as the foundation for this document are not attached. They will be provided for the record during the comment period provided for public input on the Virtual Elimination Task Force's draft final report.

Chlorine the Element

Chlorine, a nonmetallic, naturally-occurring element, is a member of the halogen family. The halogen family comprises five elements -- fluorine, chlorine, bromine, iodine and astatine. Chlorine's atomic number is 17 and atomic weight is 35.45.

Liquid (elemental) chlorine is a clear, amber fluid, that vaporizes readily under ambient conditions to a greenish yellow gas that is roughly two and one-half times (2.5) as heavy as air. Because it is very reactive, chlorine combines readily with other inorganic and organic elements as soon as it is produced (unless restricted from doing so), so it is not commonly found in its elemental state. Chlorine, as part of stable compounds (usually chlorides), comprises roughly 0.03 percent of the earth's crust, 2.0 percent of all ocean waters and 0.17 percent of the total weight of the human body.

Chlorine & Chlorine-Containing Compounds In Nature

Chlorine-containing compounds are not solely human inventions; they are common in nature. They are part of life itself and are essential to the workings of many living organisms, including humans. Chlorine and chlorinated compounds exhibit no toxic or other harmful properties that are unique among the remaining elements.

Until recently, it was believed that nearly all chlorine-containing compounds were manmade. Improvements in our ability to detect and measure minute quantities of chemicals have demonstrated that hundreds of chlorine-containing compounds occur naturally in many settings.

Natural sources of chlorine-containing compounds include the oceans (chlorides), volcanic eruptions (hydrochloric acid), forest and grass fires (organic chlorine compounds), the bio-synthesis by a wide range of simple and complex living organisms -- fungi, bacteria, higher plants, marine organisms and humans -- in amounts that often dwarf manmade sources.

The structure of these compounds ranges from simple carbon-based gases such as methylene chloride and chloroform to unsaturated lipids to complex molecules with multiple aromatic rings. This diverse array of compounds is produced by natural catalysts (enzymes) within plant and animal cells. The purpose of these enzymes appears to be to produce chlorine-containing compounds for direct use by the organism, for intermediates that react further to form end products needed by the organism, and to defend the cell or body by altering bacterial molecules by reacting them with the chlorine compound.

Chlorine & Chlorine Chemistry Processes and Products

Making chlor-alkali chemicals is among the most basic of all chemical processes. Electricity is used to separate salt water into chlorine and its coproducts sodium or potassium hydroxide and hydrogen. From this relatively simple beginning, the chlorine molecule is estimated to be involved in more than half of all commercial chemistry. Chlorine's coproducts -- sodium and potassium hydroxide -- are widely used in every branch of industry, including mining, textile production, food processing, the production of soap and cleaning agents, and water and wastewater treatment. Thus, the products of chlorine chemistry -- chlorine, products containing chlorine, and products derived from chlorine -- directly and indirectly provide extensive social and economic benefits.

A recent conservative analysis of the major uses (90% of consumption) of chlorine and their potential alternatives revealed that U.S. and Canadian consumers annually enjoy more $100 billion in annual savings (benefits) from the use of chlorine and products based on chlorine chemistry, rather than the use of alternatives. In the Great Lakes region, these savings amount to more than $15 billion per year.

Chlorine has become important in thousands of applications because of its particular physical and chemical properties. There are limited instances where other elements can replace chlorine with modest incremental cost or performance penalties, but in most instances it would be difficult to achieve the desired performance in a cost-effective manner without chlorine. The use of alternate processes or materials (if they exist) would entail significant economic and social losses and cost increases, along with the alternative's associated human health and environmental risks.

Even though chlorine is used in almost all sectors of our economy, most consumers do not realize how broadly this element touches their daily lives because most are only aware of its direct uses. In many cases, chlorine is not contained in the end product, but it is used as an intermediate raw material, as a catalyst, or as part of a larger manufacturing sequence where chlorine may or may not end up in the final product. The properties that make these products useful to consumers depend on the chlorine content.

Direct consumption is one of three distinct ways in which society uses and benefits from chlorine. Chlorine is also incorporated into other consumable products, providing them with specific, desirable characteristics, and it is used as a facilitator in the manufacture of thousands of other products.

Consumers generally identify chlorine's role in those uses that have direct applications, such as disinfecting public water supplies and swimming pools and its use as a key component in laundry bleaches. It is also used to destroy disease-carrying organisms present in effluents from waste water treatment plants. Another direct use of chlorine is in the pulp and paper industry, where it is applied in the bleaching cycle to produce pulp for high-quality paper.

Polyvinyl chloride (PVC or vinyl) manufacturing constitutes the largest single use of chlorine. This versatile plastic is found in a wide range of household consumer products such as luggage, raincoats, furniture and packaging. PVC also is widely used in automotive applications for seat covers, floor mats, and dashboards; building and construction applications for such products as sewer and drain pipe, vinyl siding, gutters, windows and door frames, flooring, and electrical wire insulation also depend on PVC. In all these applications (and in numerous others), PVC products provide long life, strength, fire retardance, weight reductions, energy savings, ease of fabrication, and other desirable properties.

In many cases, chlorine-containing products are used in such a way that the consumer is not likely to be aware that the final product or service depends on chlorine. Chloropene is used to make fan and conveyor belts, and other heat- and oil-resistant products in automotive and industrial applications. Chlorinated solvents are used in dry cleaning and to clean metal and other parts during their conversion to consumer goods ranging from automobiles to electronics to photographic film. In the same way, reformulated chlorine-containing crop protection chemicals such as herbicides, fungicides, and insecticides are applied to increase yields and reduce losses caused by pests. Further, today's crop protection chemicals are far less persistent in the environment than those utilized in the past.

Chlorine also is used in thousands of applications where it is not a part of the final consumer product, where it plays the facilitator role. The versatility of the chlorine-containing intermediate materials is their key importance because the production of other products would be far more costly to manufacture without chlorine chemistry.

Perhaps the most notable example of chlorine's role as a facilitator is its use in pharmaceutical products. Far less than one percent of all chlorine is used in pharmaceutical product manufacturing, but nearly 85 percent of these products are based on chlorine chemistry. Only 20 percent of these drugs actually contain chlorine as an active ingredient in the final product. Most often, the chlorine molecule is replaced at an intermediate processing step by another element. The complex chemical structures that are necessary for the therapeutic functions of these drugs are extremely difficult to produce without chlorine chemistry.

Chlorine-based catalysts represent another major category of chemical facilitator. Chlorine provides the most cost-effective means of promoting high-performance chemical reactions. Some important uses of chlorine-based catalysts are in the manufacture of polyethylene and polypropylene resins, which are used in large quantities to make carpeting, rope, film, packaging, appliance manufacturing, and automobiles. Catalysts containing chlorine are used in the manufacture of ethylbenzene, which is used as a raw material for polystyrene, other styrene polymers, and unsaturated polyester resins that are fabricated into a myriad of consumer products.

Chlorine chemistry is also involved in the manufacture of other commonly used plastic products, including polycarbonate and fluoropolymer resins. Polycarbonate resins are used in such products as compact disks, shatterproof car headlamps, and bulletproof glass for buses, trains and airplanes. Fluoropolymers are used to produce nonstick cookware and industrial coatings that are designed to resist harsh and corrosive environments.

Other examples of chlorine's versatility include the manufacture of propylene oxide, which is used in food additives and polyurethanes -- foam cushions, automobile bumpers, and coatings and adhesives. The manufacture of all silicone products, which include silicone coatings and sealants, fluids for automotive application, resins for medical/surgical devices, and components of silicon chips -- the basis for all modern consumer and industrial electronics -- depend on chlorine chemistry.

The products and process uses mentioned above represent sectors of the U.S. and Canadian economies with sales that range from the hundreds of millions to the tens of billions of dollars. These sales are one measure of the value consumers assign to products and uses that depend on chlorine and chlorine chemistry. Underlying these sales are the millions of jobs tied directly and indirectly to the products of chlorine chemistry.

Hazards & Risks Associated With Chlorine Products/By-Products

The potential for any chemical to produce an adverse effect on humans or impair the environment should be determined by a systematic reference to risks on the basis of exposure. Since exposure is a requirement for an effect to occur, exposure is more important than the toxicity of a substance. Key elements of exposure include: environmental loading rates, concentration, daily intake and environmental fate processes such as biodegradation, transformation, partitioning and transport. Since all these parameters (and others) vary with each substance, there is no scientific justification for labeling all chlorine-containing compounds as presenting comparable risks to human health and the environment.

The evaluation of the potential for adverse impacts of chemicals on the environment or human health must be based on established risk assessment procedures. The fundamental principle of such assessments is that the magnitude of the response of an organism to a chemical increases with increasing dose of the chemical to the organism.

The toxicity of a chemical is governed by its physical and chemical properties, which determine how the chemical behaves in the environment and in biological systems. The addition of chlorine *per se* to a molecule does not necessarily increase the toxicity of a chemical. Available scientific evidence indicates that any current potential risk associated with chlorinated compounds must be evaluated in light of existing toxicity and exposure potential of chlorinated compounds presently in use.

For example, virtually all the chlorinated alkanes and alkenes, and most of the lower chlorinated monoaromatics, in present use have relatively short half-lives in water, air, sediment and biological tissues and therefore do not accumulate in these media. Such compounds include chloroform, methylene chloride, dichlorethane, trichlorethylene, chlorobenzene, dichlorobenzene, dichlorophenol, and many other chlorinated organics. They are critical to the manufacture of many important end products. Body burdens of such chlorinated organic chemicals do not accumulate to toxic concentrations because they are rapidly metabolized and excreted by organisms in the environment. Thence, they do not accumulate to any significant extent in the environment or in biological tissues.

Studies on chlorinated compounds presently in use indicate that at concentrations detected in the environment, wildlife and human exposures are far below those exposures noted in animal studies to produce toxic effects. For example, a number of well conducted mammalian and aquatic toxicity studies have been conducted on the alkanes (e.g., chloroform), alkenes (e.g., trichloroethylene) and lower chlorinated monoaromatics (e.g., dichlorophenols and dichlorobenzenes) which clearly indicate that environmental concentrations of these chlorinated organic chemicals presently in use are well below levels which induce adverse effects.

Any adverse effects noted in wildlife in the Great Lakes region have been associated with a limited subset of chlorinated compounds, such as PCBs, DDT and several other canceled pesticides. The distribution of these chemicals in the environment was due to their historical use or unintended generation. No such adverse effects have been reported for the chlorinated alkanes, alkenes, or lower chlorinated monoaromatics, nor would any be expected based on their inherent toxicity, fate and partitioning in the environment. The toxicological effects observed in some wildlife relate to past exposures to select chlorinated compounds. This pattern is not reflective of use patterns or environmental loading rates of chlorinated compounds in use in the Great Lakes region today.

The suggestion that some chlorinated compounds have induced adverse effects in humans in the Great Lakes is not supported by available scientific information. A number of epidemiological studies that have examined mortality rates, incidence of birth defects, reproductive outcomes, morbidity and other endpoints, have consistently found no differences in comparison with control populations.

One study has suggested possible effects in children of mothers consuming (on a regular basis) fish containing low levels of PCBs that were assumed to have originated from Lake Michigan. This report's findings have not been corroborated by follow-up studies and the study did not control for possible confounders such as smoking and drinking alcohol. Presently, there is no valid evidence that chlorinated organic compounds have had an impact on human health in the Great Lakes region. Further study on the possible effects of environmental exposures to PCBs may be warranted; specifically areas that have been delineated as "toxic hotspots."

In summary, a careful evaluation of the toxicology, environmental fate, and partitioning characteristics of chlorinated compounds must be undertaken to put in perspective the potential environmental and human health risks associated with concentrations of these compounds in the environment. Generalizations about the potential adverse environmental consequences of chlorinated compounds should not be made on the basis of adverse effects observed with a few selected substances.

Impacts & Trends of Chlorine/Chlorinated Compounds on the Great Lakes

Available scientific evidence indicates that the Great Lakes ecosystem has shown measurable recovery as a result of actions taken to reduce releases and to restrict specific uses of chlorine and chlorinated compounds. A number of recent studies have shown that with decreasing concentrations of chlorinated compounds of concern, previously affected bird species in the Great Lakes ecosystem have made significant recoveries.

Historical adverse effects in wildlife around the Great Lakes have been associated with a limited subset of chlorinated compounds, such as PCBs, DDT and several other canceled pesticides. These effects have not been reported for the majority of chlorinated compounds which differ significantly from these in terms of toxicity, fate and partitioning in the environment, and is not reflective of conditions today.

Further indications of water quality improvements and increased environmental health in the Great Lakes are presented in EPA's 1988 and 1990 Reports to Congress - National Water Quality Inventory. In Lake Superior, the largest and most pristine of the Great Lakes, the 1990 Report to Congress states that water quality remains generally very good with the exception of a few problem areas associated with urban centers concentrated along the shoreline. In 1986, a lakewide advisory for trout over 30 inches was issued for Lake Superior. This advisory was issued on the basis of new data, not worsening water quality. EPA concludes that the water quality of Lake Superior is continuing to improve and "the lake's water quality surpasses established objectives, standards, and criteria for all contaminants except PCBs."

Lake Michigan, which has experienced the biggest impact on fish contamination from chlorinated compounds, is recovering according to the 1988 and 1990 Reports to Congress. The 1988 Report to Congress indicates that levels of chlorinated compounds are declining in fish tissue in Lake Michigan. Wisconsin data demonstrate that aquatic plant communities and fish populations have improved due to a variety of factors, including improved water quality.

PCBs and pesticides such as dieldrin, endrin, chlordane, DDE and endosulfan have been detected in very low concentrations in open water samples in Lake Huron, according to the 1988 and 1990 Reports to Congress. PCBs have reportedly had a minimal effect on the fisheries of Lake Huron. Concentrations of DDT in lake trout fish tissue continue to decline and are below the concentrations reported in the 1970s.

The 1990 Report to Congress indicates that water quality in Lake Erie has improved dramatically in the last two decades. Due to continuing improvements in water quality, Lake Erie now supports the largest walleye sport fishery on the Great Lakes. Furthermore, contaminant residue levels in walleye fish tissues have not increased throughout the lake. In addition, declines in the level of various compounds in fish tissue have been observed, particularly in regard to DDT and mercury.

Contamination of fish tissue and sediments in Lake Erie was once widespread. According to the 1990 Report to Congress, however, out of 17 pesticides, PCBs and chlorinated benzenes, only PCBs and hexachlorobenzene were found in significant concentrations throughout the open water of the lake. Moreover, concentrations of PCBs, DDT and other organic compounds have not increased in the lake since monitoring began in 1977.

In Lake Ontario, data presented in the 1988 and 1990 Reports to Congress on sediment and sport fish indicated declines in the uptake of PCBs, DDT, mirex, and chlorinated benzenes between the early to mid-1970s and 1980. Other data substantiates this finding by demonstrating significant declines since 1975 in PCB and DDT residue in spottail shiners, collected at the outlet of the Niagara River.

Virtual Elimination Strategies for Chlorine/Chlorinated Compounds

Under existing U.S. federal and state laws and regulations, significant steps have been taken and continue to be taken to reduce inputs of potentially persistent and toxic chlorinated compounds into the Great Lakes. These laws also provide a proper framework for further actions to achieve additional reductions, where sufficient scientific data exist to demonstrate that a particular use or release of a substance poses an unacceptable risk to human health or the environment.

Releases of chlorinated compounds to the environment are regulated under several statutes, including the Clean Water Act (CWA), Clean Air Act (CAA) and the Resource Conservation and Recovery Act (RCRA). Section 307 of the Clean Water Act includes 32 chlorinated compounds on the list of 66 priority toxic pollutants that are regulated. The recent Clean Air Act Amendments of 1990 include a total of 189 hazardous air pollutants, of which 58 are chlorinated compounds.

In addition, uses of certain specific chlorinated compounds have been restricted or banned under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Toxic Substances Control Act (TSCA). These compounds, which include PCBs, DDT, dieldrin, chlordane, and toxaphene, have been properly singled out for restriction because of their known persistence in the environment and adverse impacts on aquatic life and wildlife.

Non-regulatory initiatives, such as the 33/50 program, are also reducing the release of some chlorinated compounds into the environment. Product stewardship is becoming a prevalent practice by industry to manage products through all stages of their life cycles in a manner that continuously improves protection of human health and the environment. Together, these regulatory programs and voluntary initiatives have resulted in significant reductions in inputs of chlorinated compounds to the Great Lakes and will continue to achieve further reductions.

The results of regulation of emissions and wastes coupled with the product stewardship efforts of industry have and will continue to insure that exposures to toxic materials are reduced. When there is adequate data to demonstrate likely adverse effects, the government has authority, through TSCA and FIFRA to regulate chemical use. These mechanisms correctly provide for consideration of health and environmental effects, magnitude of exposure, societal benefits, and economic consequences associated with chemical uses. Bans or restrictions on chemicals or products that do not take into account these considerations are arbitrary and not supportable.

In new decisions to ban it is imperative that the government use risk/benefit assessments for particular uses. In fact it is impossible to determine the risk of a particular product or chemical without considering its use. Risk assessments require the determination of the pathways of exposure and the duration and likelihood of exposure. The use of the product will define the exposure pathways and the potential for exposure. Use of hazard analysis alone ignores magnitude of exposures.

Target lists developed from an evaluation of the hazards of a chemical are too simplistic and can lead the public to make emotional decisions to ban a product without consideration of benefits and risks and without consideration of the benefits and risks of substitute products. Any listing criteria that are developed should be tied closely to full risk/benefit assessment utilizing sound scientific principles. Additionally, there should be evidence that existing ambient concentrations of a chemical are posing a potential adverse effect to the environment before a chemical is targeted.

Outlined below is a description of the regulatory framework already in place in the U.S. to regulate releases and uses of persistent and/or toxic substances. Canada has a comparable legal framework for regulating toxic materials, which is not presented here. Industry's responsibility to properly manage these materials through product stewardship also is presented.

Releases of Chlorine/Chlorinated Compounds

Significant reductions in releases of chlorinated compounds to water, air and other media have been achieved and continue to be achieved as a result of existing regulatory programs under the CWA, CAA, and RCRA and voluntary initiatives. Additional regulations are still in development while others have only begun to be implemented. Thus, further reductions in loadings of chlorinated compounds to the Great Lakes will occur in the years ahead.

For example, since 1972 when the Clean Water Act was passed, EPA has established best available technology (BAT) requirements for more than 50 industrial categories. These requirements specify technology-based standards for effluent discharges to surface water, including the Great Lakes and their tributaries. According to information cited in the EPA's recent proposed Lakewide Management Plan (LaMP) for Lake Michigan, greater than 70 percent reductions have been achieved for most constituents from the six major industrial sectors in the Great Lakes regulated by BAT guidelines. BAT guidelines are still under development for other industrial categories. Additional water-quality based effluent discharge limits are being incorporated into many industrial discharge permits to further reduce the amount of toxics released into the Great Lakes. Recent regulations on stormwater from municipal and industrial activity will reduce even further these inputs.

Specific guidelines are under development which will establish uniform, stringent water quality criteria and procedures for the Great Lakes. States will be required to adopt standards consistent with the guidelines in the next 2 to 3 years. These new water quality standards and procedures will, in turn, be incorporated into discharge permits in the form of more stringent limits on the discharge of persistent and toxic substances. The impact of these ongoing regulatory activities on water quality in the Great Lakes will be realized over the next few years.

Atmospheric transport and deposition as well as resuspension of contaminated sediments are believed to provide the primary pathways for transport of many of the pollutants of concern in the Great Lakes. Data compiled under the Clean Air Act of 1990 show that atmospheric loadings to the Great Lakes are declining. Recent atmospheric loadings of PCBs, DDT and other chlorinated compounds are less than in previous decades. These loadings will further decrease as a result of new regulatory programs under the Clean Air Act. For example, EPA currently is establishing maximum achievable control technology (MACT) requirements for hazardous air pollutants. The MACT regulation for the synthetic organic chemical manufacturing industry (SOCMI) was among the first rules proposed to regulate releases of these hazardous air pollutants. When final rules are in place in 1993, EPA estimates that releases of hazardous air pollutants from SOCMI facilities will be reduced by 80 percent nationwide.

EPA also is working on criteria and a strategy for managing contaminated sediment. This strategy includes components for preventing future contamination of sediments and remediating existing contaminated sediment sites. Criteria are being developed for use in identifying contaminated sediments which may be causing adverse impacts to human health and the environment. Existing EPA data indicate that sediment contamination is mainly confined to limited number of locations in the Great Lakes, typically downstream of urban, industrial and agricultural areas and are generally the result of past practices. Remediation of these sediments may be necessary to reduce this source of loadings of persistent toxic substances, where they are causing adverse impacts on human health or the environment. In many cases, the preferred remediation approach will involve natural cleanup processes such as biodegradation and natural sediment capping in order to avoid the resuspension of contaminants into the water column.

<u>Existing Use Restrictions/Bans</u>

Restrictions and registration cancellations under FIFRA and TSCA have significantly reduced loadings of persistent toxic substances into the Great Lakes. For example, PCBs and DDT, which are responsible for the majority of fish advisories in the Great lakes, have been restricted or banned, because of their known persistence in the environment and their association with adverse impacts on aquatic life and wildlife.

PCBs, which were commercially manufactured from 1929 until 1976, are banned, although quantities still remain in transformers, landfills, and sediments. DDT/DDE is one of four pesticides that have been canceled because of their persistent, toxic effects. (The others are dieldrin, chlordane, and toxaphene.) Although these banned and restricted substances continue to be detected in Great Lakes waters and fish, their inputs have been significantly reduced from historic levels.

Data on sources of remaining loadings of these restricted compounds are limited, but information suggests that air transport and contaminated sediments are presently the largest sources of input to the Great Lakes. Additional ongoing efforts, including "clean sweep" programs to collect and destroy existing stock-piles of banned substances, will be helpful in further reducing levels of these substances in the environment. Remediation of contaminated sediment also may be necessary to achieve further significant reductions in levels of these persistent compounds in the Great Lakes ecosystem in a reasonable timeframe.

<u>Product Stewardship/Responsible Care</u>

Many segments of industry, particularly the chemical industry, are committed to controlling hazards and managing risks associated with chlorine and chlorinated products thorough a process known as product stewardship. Product stewardship is a system for using and managing products through all stages in their life cycle in a manner that continuously improves protection of human health and the environment. The process applies to both new and existing products. It begins with research and development and continues through commercialization, disposal, and environmental fate.

Product stewardship is a shared responsibility that covers all stages of a product's life. This includes full consideration of methods to increase protection of human health and the environment in terms of: raw materials use, storage and transportation, manufacturing processes; providing a safe and healthy workplace; packaging; product use and transportation; and educating product users about safe and efficient use and disposal.

Product stewardship is initiated by industry, typically at the corporate level, in conjunction with business planning. Risk characterization, screening, and management are the key vehicles for product stewardship.

<u>Conclusion</u>

The use of chlorine and chlorine-derived materials is integral to the social and economic well-being of the United States and Canada. Annually, these materials provide more than $100 billion of benefits (savings) to the people of the U.S. and Canada, with more than $15 billion in benefits accruing to people in the Great Lakes region.

Any policy decision regarding a ban on chlorine's use that does not consider and evaluate the consequences of that action would be ill-advised and would likely have a very damaging effect on the economic and social welfare of the United States and Canada.

VIRTUAL ELIMINATION IN THE
PULP AND PAPER INDUSTRY

A REPORT TO THE

VIRTUAL ELIMINATION TASK FORCE

BY

D.K. PHENICIE

JANUARY 7, 1993

VIRTUAL ELIMINATION IN THE PULP AND PAPER INDUSTRY

In its Interim Report, the Virtual Elimination Task Force expressed particular concern over the use of chlorine by the pulp and paper industry. It is now clear that as a result of process modifications developed and implemented in the last six years, the industry has dramatically reduced discharges of persistent chlorinated compounds, including dioxin.

Pulp bleaching now accounts for less than 1% of the known sources of dioxin and furan compounds released into the environment. The industry has also significantly reduced discharges of other chlorinated organic compounds. Accordingly, there is **no reason to single out the pulp and paper industry** for differential treatment in the Final Report.

Studies show that discharges from well controlled pulp mills do not result in toxic effects in the environment. For example, experimental stream studies in the United States and a recent study at a Canadian mill (all published in the last two years) showed no significant effects on the health of fish or aquatic organisms. Whole effluent toxicity testing, as well as water quality and technology-based regulations, assure that bleached mill effluent is not resulting in any adverse effects on the environment.

Moreover, **the pulp and paper industry can achieve virtual elimination of discharges of persistent toxic compounds without eliminating chlorine completely.** The Great Lakes Water Quality Agreement calls for virtual elimination of "persistent toxic compounds," not the universe of all chlorinated compounds. The industry has demonstrated that it is achieving virtual elimination of discharges of TCDD, TCDF and other persistent compounds of concern through process modifications that reduce, but do not totally eliminate, all forms of chlorine in the pulp bleaching process.

Accordingly, the Task Force can now revise its recommendations to omit particular targeting of the pulp and paper industry, and need not call for sunsetting chlorine usage in the industry. The final report should instead focus on larger contributors of the specific persistent toxic compounds of concern.

* * *

<u>Discovery of Dioxin Associated With Pulp Mills</u>

Although the pulp and paper industry has used chlorine to bleach pulp since the 1930s, the fact that dioxin and furan compounds are produced as unwanted byproducts from chlorine bleaching is a relatively recent discovery. When improved analytical techniques measuring in the parts per trillion and quadrillion range enabled the detection of dioxin at these minute levels, the industry moved promptly to identify and dramatically reduce the sources of dioxin discharges.

Immediately following the discovery of dioxin associated with pulp mills, the U.S. industry began cooperating with the United States Environmental Protection Agency and other agencies. In 1986-87, EPA and the industry conducted a pilot study of five mills. Results pointed to an association between dioxin formation and the bleaching process.

The industry and EPA then expanded their study to include all 104 bleached pulp mills in the United States. The results of that study, released in 1989 and 1990, confirmed the initial findings. At the time of the study, the total amount of TCDD equivalents released in a year from all 104 mills was 41 ounces.

Current Dioxin Contribution

As a result of intense and voluntary efforts by the industry in a very short time, fewer than 8 ounces of dioxin (toxic equivalents) are now generated annually from U.S. pulp bleaching nationwide -- approximately one percent of all known sources of dioxin in the United States. Hence, for all the concern focused on pulp mills, they comprise only a minuscule and rapidly diminishing source of dioxin in the environment. **TCDD and TCDF are no longer measurable in the effluents of over three-quarters of U.S. mills.** Further reductions are being achieved as process modifications continue.

More than 90 percent of the known sources of dioxin in the environment stem from combustion. Municipal waste incinerators, hospital incinerators, secondary copper smelters, coal combustion and automobiles all produce significantly more dioxin than pulp and paper manufacturing. (See Figure 1.) Atmospheric deposition of these emissions is an important contributor to the total loading in the Great Lakes. Yet, the Task Force has not targeted any of these other sources.

Effect of Pulp Mill Effluents on the Environment

Scientific studies to date do not associate chlorinated organics as a class from well controlled pulp and paper mills with any adverse effects on the environment. (See the Report of the Scientific Panel on "Pulping Effluents in the Aquatic Environment," 1989.)

Experimental stream studies conducted over the past 15 years showed no negative effects on growth, survival, production or reproduction of fish and other aquatic organisms when exposed to concentrations of treated effluent representative of conditions in receiving streams. In addition, the studies found no indications of either tumors or lesions in fish exposed to effluent. (See Hall, et al., *Can. J. of Fisheries and Aquatic Sciences* 49:939 (1992); *Environmental Toxicology and Chemistry* 10:1051 (1991).)

In a recent study conducted in a riverine ecosystem in western Canada, exposure to bleached mill effluent did not have discernible impacts on either fish populations or individual fish health. (See Swanson, et al., *TAPPI Journal*, Dec. 1992 at 141.) No significant differences in histopathology, serum chemistry, or hematology were consistently observed for the target fish species compared to a reference river system. In sum, there were no impacts at lower and potentially sensitive levels of biological organization (morphological, physiological, and biochemical) at the levels in this study. The study involved a river that had received biologically treated effluent for 16 years. The authors conclude that rather than body burden of organochlorines, "other factors unrelated to the bleaching system such as operational stability and biological wastewater treatment may be as or more important in determining environmental impact."

Other Chlorinated Compounds in Bleached Mill Effluents

The Task Force has focused particular attention on TCDD and TCDF in discharges from the pulp and paper industry. However, these compounds are no longer measurable in the effluents of the majority of mills. Other persistent toxic compounds that the Water Quality Board has targeted (e.g., pesticides, PCBs) are not associated with pulp bleaching.

While there are other chlorinated compounds in bleached mill effluents, only a fraction of a percentage of them are of potential environmental significance. Only certain persistent compounds -- not all chlorinated organic compounds -- are of concern.

"AOX" (for "total adsorbable organohalides") is a measure of all of the chlorinated organic compounds in bleach pulp mill effluents. AOX does not measure or represent toxicity. Rather, of the AOX:

- About 90 percent of the chlorine used in pulp bleaching ends up as common salts.

- Less than 10 percent binds to organic material in the pulp to form chlorinated organic compounds.

- Only about 1% of the chlorine forms potentially bioaccumulable compounds.

- And only 0.1% forms highly lipophilic (fat soluble) and bioaccumulable compounds.

Since the vast majority (99.1%) of chlorinated organics associated with pulp bleaching are not readily absorbed by the human body or aquatic organisms, total elimination of all chlorinated compounds would carry little or no environmental benefit.

Regulations to address those compounds of potential environmental significance will be proposed by EPA this year. EPA will be imposing updated technology-based effluent guidelines as well as new MACT limitations on air emissions from the pulp and paper industry, covering the specific chlorinated compounds EPA has determined to be significant. The Great Lakes Initiative currently under development in the United States will undoubtedly impose further restrictions. All U.S. mills already have effective secondary (biological) wastewater treatment.

Canadian standards require secondary treatment. In addition, pulp and paper effluent standards under development in Canadian provinces -- through the National Pollutant Release Inventory and Accelerated Reduction and Elimination of Toxic Substance Emissions program -- will offer similar protections with respect to toxics.

These restrictions, along with the existing regulations and the voluntary process modifications already made by the pulp and paper industry, assure that discharges of the persistent compounds of concern will be virtually eliminated.

In addition, U.S. mills routinely perform acute and chronic toxicity tests on their whole effluent to assess potential toxicity. Similarly, Canadian mills routinely perform acute toxicity evaluations and are beginning to do chronic studies. Thus, the effect of all chlorinated compounds in bleached mill effluents is monitored through direct biological testing of the actual effluents.

Reducing Dioxin Formation

The virtual elimination of dioxins, furans and other chlorinated organic compounds of concern has been accomplished through intense research and process modification efforts since the discovery of dioxin in the paper industry six years ago.

Scientists have identified a number of process modifications that can reduce dioxin. These dioxin control measures also reduce discharges of other chlorinated organic compounds. (See Berry et al., "The Effects of Recent Changes in Bleached Softwood Kraft Mill Technology on Organochlorine Emissions - An International Perspective," 1991.)

These modifications have been put into effect, **voluntarily,** over the last several years (many coming on line since the Interim Report). While many aspects of dioxin formation are highly mill-specific, among the significant process modifications that have been used by members of the industry are:

- substitution of chlorine dioxide, which has less available chlorine, for some or all of the molecular chlorine used in the bleaching process; this step alone has in many cases reduced dioxin discharges below measurable levels;

- changes in the bleaching sequence or methods of chemical addition during bleaching;

- elimination of the use of certain defoamers or other inputs to the process that contain dioxin precursors;

- use of oxygen and/or hydrogen peroxide as supplements to chlorine in the bleaching process; and

- use of chemical or process changes (such as oxygen delignification, extended cooking, improved washing) or other steps for removing lignin in pulp so that less bleaching is required.

Using these methods, **mills have been able to virtually eliminate dioxin without having to phase out the use of chlorine completely.** Today, dioxin is not measurable in the effluents at more than three-quarters of the mills in the United States. Other mills will complete their modifications soon.

<u>Economic Impact of Process Modifications</u>

These changes have not been without substantial cost. The U.S. industry estimates that it has already spent over **$1 billion** implementing these changes in the very short time since dioxin was attributed to the pulping process.

More work is underway. It is now clear that virtual elimination is being achieved in the pulp and paper industry without the elimination of all forms of chlorine. Total elimination of all forms of chlorine would be prohibitively costly, without conferring additional benefits beyond what other process modifications can achieve.

In a paper presented at a recent EPA Pollution Prevention Conference, Drs. Phillips, Renard and Lancaster provided cost estimates for further reductions in chlorine usage. (Phillips, et al., *The Economic Impact of Implementing Chlorine-Free and Chlorine Compound-Free Bleaching Processes*, 1992.) For cost analysis, they started from a baseline that takes into account that mills are already using a bleaching sequence with reduced chlorine (50% substitution of chlorine dioxide for chlorine in the first stage of bleaching, and 100% chlorine dioxide in the final stages).

The base case results in non-detectable levels of TCDD and TCDF in mill effluents (at a 10 ppq detection limit). The baseline case also represents a 36% reduction in AOX, which as noted above refers to all chlorinated organic compounds, not just the persistent compounds of concern.

Phillips et al. estimated costs for four additional scenarios:

- The first scenario is 100% substitution of chlorine dioxide for chlorine. For the U.S. industry, this would require an additional $1.2 billion in capital costs beyond the cost for 50% substitution, and $203 million per year in additional operating costs. This scenario would move the total reduction in AOX from the 36% in the base case to 79% of the starting levels.

- The second scenario involves the addition of an oxygen delignification step prior to bleaching, along with 100% substitution of chlorine dioxide for chlorine. The cost here jumps very substantially: $6.9 billion in capital costs for the U.S. industry, and an additional $83 million in operating costs beyond the base case. This additional investment results in an overall reduction in AOX of 88% from prior levels -- only a small increment beyond the considerably less costly scenario that achieved an 79% reduction.

- A third scenario is the use of oxygen delignification and an ozone stage, still with the use of chlorine dioxide. (The ozone bleaching is just beginning to be tested commercially.) Capital costs skyrocket: an additional $9.6 billion beyond the base case investment. The additional benefit conferred by the $9.6 billion cost is moving to 97% reduction in AOX levels compared to the starting AOX levels. (This additional capital investment is about $3 billion more than the second scenario, which achieves a 88% reduction.)

- A fourth possible scenario is the hypothetical elimination of all chlorine compounds as well as molecular chlorine, instead using oxygen delignification, ozone and peroxide. This has not yet been commercially demonstrated. Projected capital costs equal that of the third scenario -- about $9.6 billion -- but with additional annual operating costs of $421 million beyond the operating costs of the 50% substitution base case.

See attached Table 1 for details.

These are staggering costs, for little or no additional benefit to the environment. (As noted, AOX reductions are <u>not</u> a meaningful measure of toxicity. The Task Force is concerned with persistent toxic compounds, not all chlorinated compounds. Thus, AOX reductions overstate any environmental benefit.)

Moreover, these costs are for just the U.S. pulp and paper industry, which now accounts for less than one percent of the known sources of dioxin released to the environment in the United States. Costs at Canadian mills also must be taken into account and on a per-mill basis are likely to be as much or greater than the U.S. costs. One estimate has put costs for Ontario mills alone at $1.2 billion.

The U.S. pulp and paper industry is a large employer -- employing over 700,000 people in the U.S., where it is the 14th largest employer, with paper products accounting for about 1 percent of the 1989 U.S. gross national product. In Canada, the industry is an even more significant part of the economy. Hence, the ***economic impact*** of expenditures for sunsetting chlorine in the pulping process goes beyond the capital and operating costs shown here.

In short, the complete elimination of all forms of chlorine would impose a prohibitive cost, with little or no environmental benefit.

<u>Importance of Chlorine in the Pulping Process</u>

The public health benefits of chlorine are well known. Its use in manufacturing food, medicines, paints, perfumes, automobiles, clothing and electronics is less familiar.

Chlorine in some form is important to the manufacture of bleached pulp for a variety of reasons unrelated to cost:

- it produces strong, bright, white paper for optimum contrast with the inks used in writing paper and printing materials;
- it prevents paper from discoloring in storage and yellowing when exposed to sunlight; this is important for recordkeeping and archiving books and documents;
- it removes bark, wood residue and other impurities that blemish paper;
- it eliminates fatty acids, resins and other substances that can cause bad odors and taste in milk and other food products packaged in paperboard products; and
- it improves absorption, strength and softness, important characteristics for products such as tissues, napkins, towels and diapers.

In short, the use of chlorine enables the industry to produce paper products with these important attributes. The totally chlorine free processes being investigated have not been able to produce the full range of products with these characteristics. (In addition, the energy and environmental impacts of totally chlorine free processes have not been evaluated.)

<u>No Need for Targeting the Pulp and Paper Industry</u>

The pulp and paper industry has demonstrated that it is achieving virtual elimination -- voluntarily, at great expense, and without having to eliminate all use of chlorine compounds.

Thus, there is no rational basis for singling out the pulp and paper industry, or for banning the use of all forms of chlorine in the pulping process, when virtual elimination is being achieved through other process modifications.

January 1993

TABLE 1

The estimated costs to implement further process modifications to reduce chlorine usage at all U.S. pulp mills are shown below. They are taken from Phillips, et al., *The Economic Impact of Implementing Chlorine-Free and Chlorine Compound-Free Bleaching Processes* (1992).

The cost analysis starts from a baseline that takes into account that mills are already using a bleaching sequence with reduced chlorine. Over $1 billion in capital costs has already been spent on process modifications to achieve the base case.

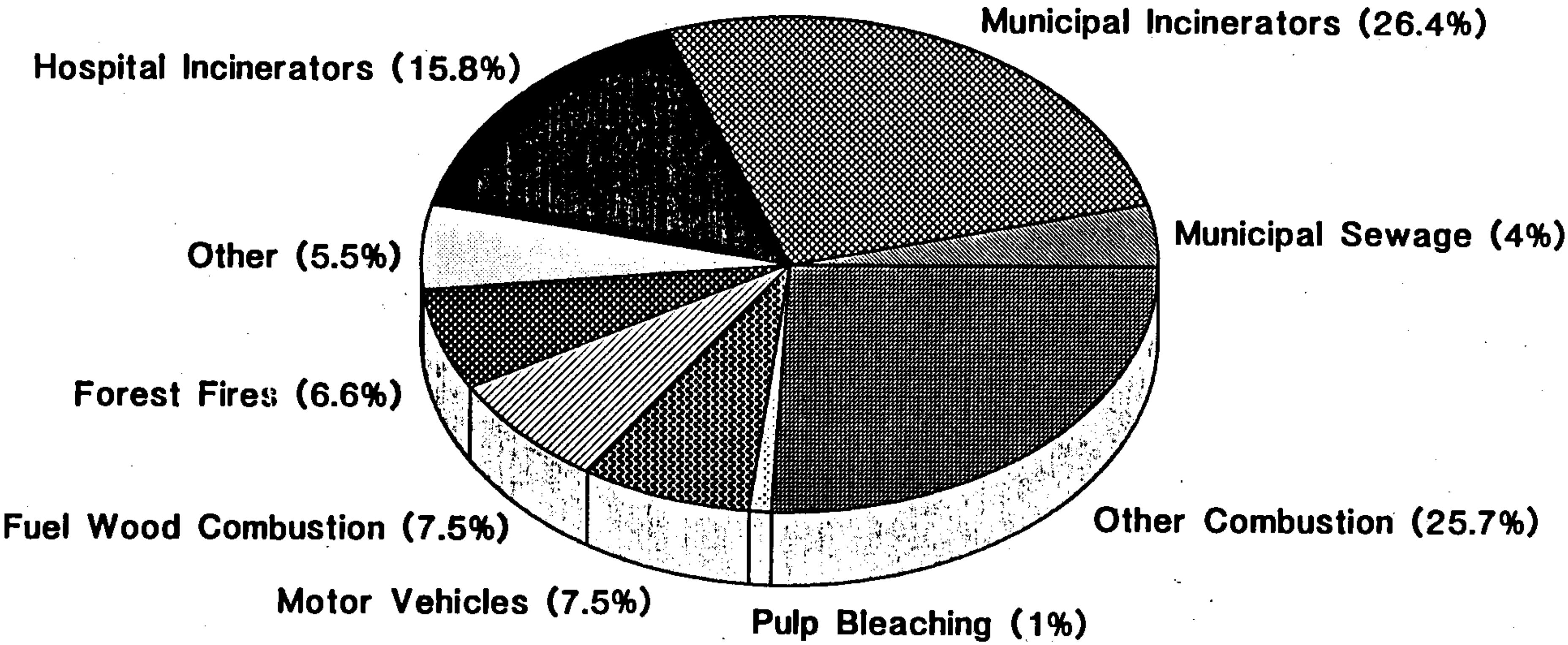
The "benefit," given as the percentage reduction in AOX, is also shown. The base case results in non-detectable levels (at 10 ppq) of TCDD and TCDF in mill effluents, and represents a 36% reduction in AOX. Note that AOX refers to all chlorinated organic compounds in the effluents, not just the persistent toxics. Thus, there is less benefit than would appear from these figures.

COSTS OF PROCESS MODIFICATIONS
IN ADDITION TO INVESTMENT IN BASE CASE

	Additional Capital Costs	Additional Annual Operating Costs	Total AOX Reduction
Base Case (est. to date)	$ >1,000,000,000		36%
1) 100% ClO_2 substitution	1,248,900,000	203,100,000	79
2) oxygen delignification	6,915,200,000	83,900,000	88
3) oxygen delig, ozone	9,585,600,000	(114,500,000)	97
4) no chlorine of any type background	9,585,600,000	421,200,000	

Base Case: substitution of 50% chlorine dioxide for chlorine in the first bleaching stage, followed by oxygen and peroxide extraction and two 100% chlorine dioxide stages

ESTIMATED RELEASES OF DIOXIN IN THE UNITED STATES (1991)



Source: National Council for Air and Stream Improvement (NCASI)
Calculated as 2,3,7,8-TCCD Equivalents (TEQ)