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Control of Discharges of Toxic Pollutants into the Great Lakes and their Tributaries: Development of Benchmarks. A Report to the International Joint Commission

George Washington University. Department of Health Care Science

Jeffery A. Foran

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by Jeffery A. Foran, Ph.D.
Associate Professor and Director
Environmental Health and Policy Program
Department of Health Care Science
George Washington University
2150 Pennsylvania Ave., NW
Washington, D.C. 20037

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Preface

This report was originally submitted in fulfillment of a contract let by the Loadings and Sources Subcommittee of the Great Lakes Water Quality Board. During the review of this report, the governments of the United States and Canada have assumed many of the responsibilities formerly placed under the Water Quality Board, including those of the Loadings and Sources Subcommittee which has since been disbanded. The IJC Regional Office has now taken responsibility for publishing this report.

Note to the Reader

The interpretation and application of the rules, regulations and guidelines which govern the discharge of toxic substances into the Great Lakes system are the responsibility of the individual jurisdictions and are subject to change through normal procedures. This understanding is of special importance at a time when policies regarding toxic limits are in a rapid state of change, with new laws and regulations and interpretations emerging and evolving. A comprehensive comparison of the various regulatory programs requires a more extensive and detailed evaluation than was possible in this report. As noted in the Foreword, this report presents a comparative analysis of selected portions of these programs, using a hypothetical discharger. Therefore, the results of this report cannot be used to estimate the actual amounts of toxic substances discharged into the Great Lakes.

Broader comparisons and the development of greater consistency regarding these programs are underway as a result of several activities, including the U.S. EPA's "Great Lakes Initiative" and the bilateral "Lake Superior Initiative." The Great Lakes Water Quality Board is also planning to address the "Comparison of Present and Emerging Regulatory Programs" in the coming year. This comparison will seek to evaluate the impact of the many subtleties associated with the application of rules, regulations and guidelines. It will also evaluate criteria and procedures for the allowance of a variance for a discharger.

The views expressed in this report are those of the author and are not necessarily those of the Great Lakes Water Quality Board or the International Joint Commission.

Foreword

This report was prepared at the George Washington University under contract to the International Joint Commission (IJC). It is a comparative evaluation of some of the myriad procedures that the Great Lakes states and Ontario use to regulate the discharge of toxic pollutants from point sources. As such, this evaluation will be useful in assessing progress toward achievement of the "virtual elimination" goal of the Great Lakes Water Quality Agreement.

State and provincial activities to regulate point sources are extremely complex and multileveled. Some of these activities, such as the use of technology-based effluent limits, are clearly mandated by the federal or provincial governments and are easily assessed and compared among jurisdictions. Other activities, such as the selection and use of numeric water quality criteria (WQC) or the incorporation of mixing zones in the process of developing effluent limits, are defined in state or provincial statutes and regulations.

When a cursory comparison of point source regulatory activities is made, differences between jurisdictional activities are easily identified as are jurisdictions that are "less stringent" or "more stringent" for those specific regulatory activities. However, over a range of regulatory activities, it is often **suggested** that "everything balances out," that is, most jurisdictions are neither less nor more stringent over their entire regulatory program than are other jurisdictions.

This report presents a comparative analysis of ***selected portions*** of each of the jurisdictional programs in the Great Lakes basin, designed to regulate the discharge of toxic pollutants from point sources. The report seeks to determine whether "everything balances out." It is not, however, a complete programmatic analysis; rather, it highlights the profound differences in the concentration and mass of pollutants that may be discharged from point sources, based on a selected set of criteria and application procedures used in the Great Lakes basin.

Ideally, the "balancing" issue would be examined by a comparative analysis of the regulation of several specific point source dischargers of several toxic pollutants in each jurisdiction. The result of this analysis could then be quantified and compared among jurisdictions. We have attempted such an analysis previously, without success. Success requires extensive, detailed information for each regulatory activity, information which is usually not available as part of jurisdictional regulatory programs. Yet, a comparative analysis of jurisdictional regulatory activities is desirable, particularly where jurisdictions are granted flexibility in the development and implementation of those activities.

We created a hypothetical discharger and "placed" the discharger in each jurisdiction. We then employed procedures specific to each jurisdiction to determine how each regulates the discharge of a set of toxic pollutants. We used this method to evaluate only toxicant control activities based on water quality. We did not evaluate technology-based activities applied to control the discharge of toxic pollutants. Further, we did not evaluate all regulatory procedures based on water quality in each jurisdiction. We evaluated the use of a select set of parameters [numeric water quality criteria, mixing zones and dilution, analytical detection capability, background concentrations of each pollutant, and whether and how jurisdictions addressed concurrent exposure to more than one pollutant]. The use of these parameters in point source regulatory programs is clearly defined in most state statutes and regulations. Further, these parameters are extremely important in determining the concentrations and loads of pollutants that can be legally discharged from individual point sources. Many state and provincial activities are not documented in statutes or rules; thus, these activities are neither amenable to the analytical procedures used, nor are they analyzed in this report.

Individuals from regulatory agencies from each jurisdiction reviewed our assessment of their programs prior to submission of this report to the International Joint Commission. The reviews were conducted on two components of this analysis: development of numeric water quality criteria and use of application procedures. All states submitted reviews of our analysis on both sets of activities and comments from these reviews have been incorporated into the final report.

A future evaluation of state and provincial regulatory activities, using the procedures in this report, will provide an assessment of the progress (within limitations of the analysis conducted) that jurisdictions are making toward limiting the discharge of persistent toxic pollutants into the Great Lakes and their tributaries. Ideally, future evaluation should include the assessment of actual (real) limitations on point source discharges by means of an assessment of NPDES permits and MISA effluent limits as well as other data that affect the jurisdictions' point source regulatory process (such as monitoring and compliance data, sampling frequency, detection limits). However, a comparative assessment of jurisdictional regulatory activities that focuses on program components covered in this report, and an assessment of the allowable discharges of concentrations and loads of pollutants that result from the use of those program components, will be particularly beneficial in the measurement of progress toward achievement of the Agreement's virtual elimination goal.

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Ackowledgements

Susan Sang conducted the Ontario portion of this study. Michael Penn collected a substantial portion of the wasteload allocation data from the Great Lakes states and was instrumental in conducting the quantitative analysis. Helen Longbottom collected water quality criteria, guidelines and objectives from the states, the U.S. EPA and the International Joint Commission. We extend thanks to Paul Muldoon (Canadian Institute for Environmental Law and Policy), Burkhard Mausberg (Pollution Probe), Laura Kolb (George Washington University) and Tim Eder (National Wildlife Federation) for assistance during this study. Special thanks are extended to Dr. John Clark (IJC), Mr. David Dolan (IJC) and their associates for assistance and oversight during all phases of the project. Special thanks are extended also to individuals in the regulatory agencies of each state, the U.S. EPA and Ontario for spending considerable time explaining their programs and in reviewing portions of our analysis.

Executive Summary

Introduction

The U.S. Clean Water Act, the Ontario Water Resources Act (OWRA) and the Ontario Environmental Protection Act (OEPA) are the primary statutes used to regulate the quality of surface waters in the Great Lakes basin. The Great Lakes Water Quality Agreement also plays an important role in protecting the health and integrity of the Great Lakes ecosystem. However, the U.S. Clean Water Act (CWA) goals of zero discharge and fishable/swimmable waters, and the Great Lakes Water Quality Agreement goal of "virtual elimination of the discharge of persistent toxicants" have been and remain elusive.

This report evaluates the status of components of jurisdictional regulatory programs for toxic substances in the Great Lakes basin. The Great Lakes states and Ontario have adopted or proposed the adoption of water quality criteria or guidelines for many toxic pollutants. However, substantial variation in water quality criteria and guidelines exists among jurisdictions as it does in how jurisdictions regulate point source discharges of toxic pollutants through the application of guidelines and criteria.

The objectives of this project are: 1) to determine, as far as possible, how the states and Ontario regulate point source discharges of toxic pollutants into the Great Lakes and their tributaries; 2) to document differences among state and provincial procedures used to regulate point sources of toxic pollutants and 3) to estimate quantitatively the result of variations in state and provincial water quality programs as measured by the concentrations and loads of selected toxicants discharged into the Great Lakes.

We evaluated only toxicant control activities based on water quality. We did not evaluate technology-based activities applied to control the discharge of toxic pollutants. Further, we did not evaluate all of each jurisdiction's regulatory procedures based on water quality. Rather, we evaluated the use of a select set of parameters [numeric water quality criteria, mixing zones and dilution, analytical detection capability, background concentrations of each pollutant, and whether and how jurisdictions addressed concurrent exposure to more than one pollutant]. These parameters are critical in determining the concentrations and loads of pollutants that can be legally discharged from individual point sources.

The Study

The evaluation was begun by examining state and provincial water quality criteria and guidelines and U.S. and IJC criteria and objectives for seventeen pollutants. These substances were selected for their variety of physical, chemical and toxicological characteristics and for their appearance on the IJC Great Lakes Critical Pollutant List. Seven of these substances (benzene, cadmium, chromium, lead, mercury, PCB and TCDD) were selected to evaluate state and provincial point source regulatory programs.

The loads of pollutants discharged from a hypothetical industry were evaluated as the benchmark for comparison among regulatory programs in the various jurisdictions. In most cases, state programs regulate the concentrations of pollutants to a point where they should not exceed a state's numeric water quality criteria after mixing with the receiving stream. Thus, the comparison of state WQC allows a comparison of point source regulatory programs, based on concentrations at the point of discharge. However, a point of discharge evaluation of the concentrations of toxic pollutants does not promote an evaluation at the ecosystem level of the impacts of toxic pollutants. Rather, such an evaluation recognizes only toxic impacts in the immediate vicinity of the discharge. Since pollutants are diluted as they move downstream from a point source, or are lost in sediments and through volatilization and other pathways, the concentration of pollutants at any time, downstream from a source, is likely of little consequence for the whole ecosystem. Therefore, the loads of pollutants discharged over long periods of time from one or more point sources were analyzed to evaluate the impacts of point source discharges of pollutants in the Great Lakes basin.

A standard wasteload allocation (WLA) model was developed to calculate the loads of pollutants from point source discharges that result from individual state's regulatory activities. The standard wasteload allocation model was developed by utilizing each state's water quality criteria and its procedures for addressing dilution and background concentrations. The impacts of policies for handling levels of detection and combinations of pollutants were also examined.

The U.S. Program

Substantial variation exists among state, provincial, federal and IJC criteria and objectives for the pollutants examined in this study. For example, differences of over three orders of magnitude exist among criteria and objectives for mercury, depending on the jurisdiction and the endpoint used to develop the criterion. These differences will have relatively little meaning, however, until criteria and objectives are applied in a regulatory setting. In the U.S. this situation occurs when numeric WQC are utilized to develop effluent limits for point source discharges of pollutants.

Point source regulatory programs in the Great Lakes basin vary widely among jurisdictions. States in the basin approach the application of WQC to develop effluent limits based on water quality in similar ways. However, the use of mixing zones, the concurrent discharge of multiple pollutants (additivity), the incorporation of background concentrations of pollutants in the development of the Water Quality-Based Effluent Limit (WQBEL) and the use of analytical detection levels vary widely among the states. The result of the different approaches to the use of mixing zones, dilution and other program components may yield highly variable limitations on the concentrations and loads of toxic pollutants that are discharged from point sources within each jurisdiction.

Large loads of all seven pollutants examined in this study were discharged by the hypothetical industry when policies specific to each state were utilized to develop limitations on the loads of pollutants. The range between the highest and lowest loads of pollutants discharged by the hypothetical industry, using each state's regulatory procedures, spans an order of magnitude or more. For example, the hypothetical discharger in Illinois would receive a WQBEL that allowed the discharge of over 7000 kg/year of lead while the same discharger in Michigan would be allowed to discharge just over 700 kg/year. Similarly, the hypothetical discharger would receive a WQBEL that allowed the discharge of over 145 kg/year of mercury into New York waters while the same entity in Michigan would be allowed to discharge less than 1 kg/year.

Disparities in allowable loads are the result of two parameters: use of different state water quality criteria and different approaches to the use of dilution in the WLA. For example, most states have relatively similar numeric WQC for lead. However, Illinois uses a much less stringent lead criterion to regulate discharges of this metal into surface waters. Variation among lead criteria in other states is minor. However, variation exists in the use of dilution in the WLA equation for lead. The use of different dilution flows in the WLA for the hypothetical discharger results in variation among allowable loads of lead of nearly an order of magnitude.

Incorporation of background policies, consideration or lack of consideration of the impacts of combinations of pollutants, and incorporation of state policies addressing analytical levels of detection further compromise the regulation of discharges of persistent toxic pollutants from point sources. The discharge of very large loads of pollutants may occur in some states as a result of state-specific regulatory policies that address these issues.

The Ontario Program

Water pollution control in Ontario currently is exercised under the Ontario Water Resources Act and the Ontario Environmental Protection Act. Effluent requirements for discharges into Ontario's waters of the Great Lakes are established on a case-by-case basis. However, neither the Ontario Water Resources Act nor its regulations prescribe enforceable effluent limitations for point sources. Rather, water quality objectives are set, which are used in prescribing the terms of Certificates of Approval.

When effluent requirements are established, the characteristics of the receiving water body are considered as are federal and provincial guidelines for water quality. Effluent requirements are incorporated into Certificates of Approval and Control Orders under Section 42 of the OWRA. Certificates of Approval and Control Orders can regulate both the concentration and loads of waste discharges.

Effluent limits for toxic substances, such as those used by the states on the U.S. side of the Great Lakes basin, are not currently utilized by Ontario to regulate the discharge of toxic substances. Further, the program to regulate the discharge of toxic pollutants into Ontario's waters is "lacking", even where effluent limits are incorporated into Certificates of Approval or Control Orders, since these limits are subject to appeal (R. Cornillius, Mgr., Industrial Waste Water Approval Branch, Personal communication).

Ontario has recently developed the Municipal-Industrial Strategy for Abatement (MISA) to address the discharge of toxic substances into Ontario's waters. This program should ultimately produce enforceable water quality laws in the province. One component of MISA, a monitoring program for selected classes of dischargers, has been implemented and has generated the Effluent Monitoring Priority Pollutant List (EMPPL). The EMPPL has produced a compilation of several pollutants discharged from pulp and paper mills directly into the Great Lakes for the first six months of 1990. Of the pollutants examined in this study, discharges into the Great Lakes of mercury, chromium, lead, cadmium, benzene and dioxins were monitored. Large loads of chromium, lead, cadmium and benzene were discharged from many of the twenty-three mills monitored in the study. Dioxins were discharged from thirteen of the twenty-three mills; mercury, from eleven.

Conclusions

Several of the components of state and provincial water quality regulatory programs have been examined in this report. Clear differences exist among programs and the analysis in this report suggests that programmatic differences may result in substantial differences in the concentrations and loads of toxic pollutants discharged from point sources within each jurisdiction.

Numeric water quality criteria, guidelines and objectives for toxic pollutants have been developed by jurisdictions and entities in the Great Lakes basin. However, criteria are not used in most cases to directly control the discharge of toxic pollutants into the Great Lakes and their tributaries. Rather, a series of what can only be termed compromises has been incorporated into the regulatory programs of U.S. jurisdictions; these compromises are designed to regulate the discharge of persistent toxic pollutants. The compromises may result in the discharge of very large loads of persistent toxic pollutants into the Great Lakes ecosystem.

Discharges of toxic pollutants from industries in the Canadian portion of the Great Lakes basin are regulated differently and perhaps much less stringently than their counterparts in the U.S. We were not able to compare the loads of persistent pollutants discharged from the hypothetical industry located in Canada since the Canadian regulatory program is not amenable to this type of analysis. The development of MISA should, for the first time, provide a comprehensive mechanism to regulate the discharge of persistent toxic pollutants from Canadian industries into the Great Lakes basin, and allow a quantitative comparison between Canadian regulations and those on the U.S. side. It should be noted that a technology-based program, particularly one which considers economic feasibility, may not adequately control those substances which pose the greatest threat to the Great Lakes ecosystem.

Substantial improvements in ecosystem protection may be realized through elimination of the compromises inherent in components of the U.S. regulatory system relating to point source discharges of toxic pollutants. Development and implementation of MISA in Ontario should also have clear benefits for water quality. However, as a technology-based approach that considers economics, MISA may suffer the same failings as U.S. regulatory programs that relied in the past on technology-based treatment to regulate point sources of persistent toxic pollutants.

Introduction

The U.S. Clean Water Act, the Ontario Water Resources Act and the Ontario Environmental Protection Act are the primary statutes used to regulate the quality of surface waters in the Great Lakes basin. The Great Lakes Water Quality Agreement also plays an important role in protecting the health and integrity of the Great Lakes ecosystem. The U.S. Clean Water Act has adopted the goals of zero discharge of toxic pollutants and fishable/swimmable waters; the Great Lakes Water Quality Agreement includes the goal of "virtual elimination of the discharge of persistent toxicants" and provincial water quality objectives have been adopted "to ensure that surface waters of the province are of a quality which is satisfactory for aquatic life and recreation." However, Great Lakes water quality does not reflect attainment of these goals.

In a report from the Institute for Research on Public Policy, some of the impacts of toxic chemicals in the Great Lakes basin were noticeable in fish and wildlife. These effects include population decline, reproductive impairment, eggshell thinning, morphological deformities, tumors/cancer, immune system suppression, behavioral changes, and population and community-level effects.

Similarly, the health of human populations in the basin has also been affected or threatened. The risk of cancer associated with the consumption of Great Lakes sport fish is substantially higher than that associated with the consumption of fish sold commercially. Evidence also exists that contaminated sport fish, eaten by pregnant women and nursing mothers, may adversely affect their fetuses and young children. In April 1990, the International Joint Commission concluded:

> When available data on fish, birds, reptiles and small mammals are considered along with human research, the Commission must conclude that there is a threat to the health of our children emanating from our exposure to persistent toxic substances, even at very low ambient levels.

Controls on the discharge of substances into the Great Lakes and their tributaries that cause the impacts described above have lagged behind controls on conventional pollutants (e.g. nutrients, BOD). This phenomenon is illustrated by the detection of elevated concentrations of pesticides in the lakes near many agricultural regions in the basin. It is also illustrated by the considerable array of environmental insults caused by persistent, bioaccumulative toxicants.

This report evaluates the status of important components of regulatory programs in the jurisdictions, designed to control the discharge of toxic substances into the Great Lakes basin. The Great Lakes states and Ontario have adopted or proposed the adoption of water quality criteria or guidelines for many toxic pollutants. However, substantial variation in water quality criteria and guidelines exists among jurisdictions and in how jurisdictions regulate point source discharges of toxic pollutants through the application of guidelines and criteria.

This report presents a comparative analysis of **selected portions** of programs in the Great Lakes basin designed to regulate the discharge of toxic pollutants from point sources. The report does not present a complete programmatic analysis; rather, it focuses on differences in the concentration and mass of pollutants that may be discharged from point sources, based on a selected set of criteria and application procedures used in the Great Lakes basin.

The objectives of this project are: 1) to determine how the states and Ontario regulate point source discharges of toxic pollutants into the Great Lakes and their tributaries; 2) to document the differences among state and provincial procedures used to regulate point sources of toxic pollutants and 3) to estimate quantitatively the effects of variations in state and provincial water quality programs on the concentrations and loads of selected toxicants discharged into the Great Lakes.

We evaluated jurisdiction-specific criteria, guidelines and application procedures to determine how each regulates the discharge of a set of toxic pollutants. We used this method to evaluate only water quality-based toxicant control activities. We did not evaluate technology-based activities. Further, we did not evaluate all water quality-based regulatory procedures in each jurisdiction. Rather, we evaluated the use of a select set of parameters [numeric water quality criteria, mixing zones and dilution, analytical detection capability, background concentrations of each pollutant, and whether and how jurisdictions addressed concurrent exposure to more than one pollutant]. These parameters are extremely important in determining the concentrations and loads of pollutants that can be legally discharged from individual point sources.

This report presents the water quality criteria and guidelines, and components of regulation processes relating to point sources used by each jurisdiction. It then analyzes in detail the use of criteria and guidelines in regulatory programs for point sources of toxic pollutants. As part of this analysis, different levels of regulatory activity are quantified and evaluated.

Finally, conclusions on the quality of existing regulatory programs for point sources are presented and recommendations made for improving program components, in the context of protecting the Great Lakes ecosystem.

Background

The regulation of point sources of toxic pollutants in the U.S. is comprised of three primary components:

- Development of numeric water quality criteria for individual toxic pollutants to protect human health, aquatic life and terrestrial life
- Determination of the level of protection to be given to a receiving stream or other water body (its designated use)
- Development of effluent limits for specific toxic pollutants to be regulated in the point source discharge

Numeric water quality criteria define the maximum concentration of individual toxic pollutants that can occur in surface waters without posing unacceptable threats to any level of biological organization, including human and ecosystem health. This paper will not address the development of criteria since these processes have been presented elsewhere (see U.S. EPA's Water Quality Criteria Documents). Nor does this paper address processes which determine the level of protection to be given to a receiving stream. In most cases, states protect the Great Lakes and their tributaries to the highest extent possible. Exceptions include the Grand Calumet River and some areas of Ohio's portion of Lake Erie). This paper does, however, present specific numeric criteria or guidelines for seventeen toxic pollutants, including the IJC's eleven critical pollutants, that are used to protect Great Lakes waters and their tributaries.

The bulk of this paper is devoted to the use of numeric WQC that regulate point sources of toxic pollutants. Criteria are used in an elaborate process to determine the concentrations and loads of toxic pollutants that can be discharged from point sources. This process and some of its components are described below.

Wasteload Allocations and Effluent Limits

Effluent limits for toxic pollutants are developed using information on the impacts of pollutants in the ecosystem and information on the treatability of pollutants at the point of discharge. Treatability issues are addressed through effluent limits based on technology. For most of the pollutants examined in this study, technology-based effluent limits are not stringent enough to protect the health of resident biota in receiving streams or humans who may utilize the resources associated with receiving streams. Therefore, Water Quality-Based EffluentLimits are developed and utilized when technology-based effluent limits are inadequate to protect human and ecosystem health.

Water Quality-Based Effluent Limits are developed using a **wasteload allocation** process. Numeric water quality criteria, effluent and stream dilution (described below) and ambient (background) toxicant concentrations are utilized in the calculation of the wasteload allocation. The simplest form of the wasteload allocation occurs for a single pollutant from a single discharger. The goal of the WLA is to prevent the pollutant from reaching an instream concentration that will exceed numeric WQC. The following formula is used to calculate a steady-state WLA for a single pollutant:

$$WLA = \frac{WQC\ (Qs + Qe) - (QsCs)}{Qe} \qquad \text{Equation (A),}$$

where:

WLA = Steady-state wasteload allocation for a single discharger
WQC = Water quality criterion for a single toxic pollutant
Qs = Stream dilution flow
Qe = Effluent flow
Cs = Stream background concentration of the toxicant.

The Water Quality-Based Effluent Limit in the National Pollutant Discharge Elimination System permit is based on the wasteload allocation for a single discharger of a pollutant. Where there is more than one discharger of a pollutant on a water body, the WLA is divided among the dischargers; the effluent limit for individual dischargers is some fraction of the WLA. Variations on this application of the WLA for developing the WQBEL are used by some states and are incorporated in the quantitative analysis portion of this report.

Effluent limits for toxic pollutants that are incorporated in NPDES permits are not based solely on the WQC. Rather, dilution, analytical detection capabilities, the source of intake water and the co-occurrence of other toxic pollutants in the effluent are considered as part of the effluent limit development process. These issues, along with background concentrations and stream dilution flows, are discussed briefly below.

Mixing Zones and Stream Dilution Flows

Mixing zones and dilution flows are traditionally considered separate concepts in water quality regulation programs. A **mixing zone** is that portion of a water body where a point source discharge is mixed with receiving water. Mixing zones in which less stringent criteria for the protection of aquatic life apply than in the rest of the water body, are allowed in most Great Lakes states. Effluent limits, applied at the point of discharge, may be less stringent than numeric water quality criteria when a mixing zone is allowed. The EPA mixing zone policy, formulated in 1983 and revised in the 1991 revisions to EPA's *Technical Support Document for Water Quality Based Toxics Control* (TSD), describes the mixing zone as an allocated impact zone. This is a zone where numeric water quality criteria can be exceeded as long as acutely toxic conditions (usually defined by the Final Acute Value - [FAV]) are prevented.

Dilution flows are used to define available dilution capacity for toxic pollutants discharged into lakes and streams. The rationale for the use of dilution in the development of the WLA is that the existing flow of a stream will dilute the concentration of pollutants in a discharge after mixing occurs. Further, because of this dilution capacity, dischargers of toxic pollutants do not need to meet water quality criteria at the point of discharge. What flow to allow for the dilution of a discharge is a question that must be answered. Generally, most states and EPA agree that, since stream flows change throughout the year, preventing concentrations of pollutants that exceed water quality criteria can be reasonably assured by using a stream flow for the dilution of pollutants that is near the low flow. However, as described below, some states have used higher dilution flows to determine allowable dilution for human carcinogens and non-carcinogens.

Several types of stream flows are used to calculate dilution in the Great Lakes basin. These include the 7Q10, 30Q10, some fraction of the 7Q10 or 30Q10, the 50% or 95% exceedance flow or some fraction of these flows, and others. Flows based on an xQy format (e.g. 7Q10) refer to stream flows that are less than the average minimum x-day low flow that occurs once every y years. The 50% or 95% exceedance flows are defined as the stream flows that are exceeded 50% or 95% during some designated time period. Some states now use the average stream flow or the mean harmonic flow when defining allowable dilution for human toxicants. The mean harmonic flow is less than the arithmetic mean (average), but substantially greater than the 7Q10 or the 95% exceedance flow.

Analytical Levels of Detection

Limit of Detection (LOD) - The LOD is the lowest concentration of a substance in a sample matrix that can be determined to be significantly different from a blank (zero) for a particular analytical test method (i.e. - the lowest concentration that can be **detected** with the equipment in use).

Limit of Quantitation (LOQ)- The LOQ is the concentration of a substance in a sample at which one can state, with a specified degree of confidence (statistically based for that test method), that the substance is present at a specific concentration in the sample tested (i.e. - the lowest concentration that can be **quantified** with a certain amount of confidence using the available equipment).

The LOD/LOQ issue arises when a water quality-based effluent limit for a toxicant is incorporated into a permit and the effluent limit is less than the LOD or LOQ for that toxicant. Then the discharger may not detect or quantify the toxicant in the effluent, but he may still discharge some concentration of the substance that causes water quality problems. Water quality problems would occur when the toxicant is discharged in amounts that result in ambient stream levels greater than the water quality criterion.

Method Detection Level - Minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte.

Practical Quantitation Limit - A specific (and sometime arbitrary) multiple of the method detection level. The PQL has no one definition and is not recommended for use by the U.S. EPA Technical Support Document.

Background Concentrations of Pollutants in Surface Water

Some pollutants occur naturally in surface waters, occasionally at concentrations that may be near or even exceed water quality criteria. Examples of these pollutants include some of the metals (copper, iron, mercury), which may derive naturally from geologic structures. Some pollutants also occur in surface water as a result of past discharges or spills, or from sources that are not or cannot be regulated by means of an NPDES permit. Examples include the historical dumping of PCBs and atmospheric deposition of some chlorinated organic pesticides. When a background concentration of a pollutant exists, regulation of an existing point source discharge of that pollutant is modified through incorporating the background concentration in the WLA formula. When the background concentration is less than the WQC for that pollutant, the WLA (and ultimately the WQBEL) is reduced in proportion to the background concentration. However, when a background concentration is greater than the

WQC, use of the background concentration in the WLA results in a negative WQBEL. In effect, the discharger could potentially be required to remove pollutants that it did not generate. Generally, dischargers are not required to remove pollutants; rather, alternative effluent limits are developed by jurisdictions and these alternatives are presented and discussed later in this report.

To complicate matters further, some dischargers draw process water from non-receiving stream sources that also contain background concentrations of toxic pollutants. States in the Great Lakes basin have developed procedures to address each of these situations, a phenomenon which results in the modification of the WQBEL and the extent and nature of the regulation of some pollutants. These procedures are presented and evaluated below.

Regulating Combinations of Pollutants in Effluents

It is not unusual for more than one pollutant to be discharged concurrently from a single point source. Traditionally, combinations of pollutants have been regulated only on a single pollutant basis. Some methods and models have been developed recently to address the impacts of concurrent exposure to combinations of pollutants. Procedures exist to address combinations of carcinogens in effluents, based on the assumption that their potency is additive. For example, where an acceptable cancer risk level of 1×10^{-5} has been adopted, the risk associated with concurrent exposure to more than one carcinogen is assumed to be additive, and the total risk is not to exceed 1×10^{-5}. The effluent limit for two carcinogens is derived by the formula:

$$C_1 / C_{R1} + C_2 / C_{R2} \leq 1$$

where C_1 and C_2 are the concentrations of carcinogens 1 and 2 in the effluent and C_{R1} and C_{R2} are the WQC for carcinogens 1 and 2 associated with individual risks of 1×10^{-5}.

Methods

Quantitative Comparison of State Procedures to Regulate Point Sources of Toxic Pollutants in the U.S.

The evaluation was begun by selecting seventeen pollutants for analysis (Table 1). These substances were selected for their variety of physical, chemical and toxicological characteristics and their appearance on the IJC Great Lakes Critical Pollutant list. Seven of these substances (Table 1) were selected to evaluate state and provincial point source regulatory programs. These seven substances were chosen as representative of different types or classes of discharges both in the U.S. and Canada as well as for their chemical, physical and toxicological characteristics, which are generally well known. Several substances in Table 1 were not chosen for detailed analysis (e.g. DDT, dieldrin, toxaphene), even though they pose significant hazards in the Great Lakes basin, since they are no longer discharged from point sources.

The outcome of the use of WQC in the wasteload allocation process and its incorporation into the WQBEL is regulation of concentrations and loads of toxic pollutants discharged into the Great Lakes and their tributaries. In this report, the loads of pollutants are presented as the benchmark for comparison among regulatory programs in different jurisdictions. In most cases, states regulate concentrations of pollutants to a point where they should not exceed a state's numeric water quality criteria after mixing with the receiving stream. Thus, the comparison of state WQC allows interstate comparison of point source regulatory programs, based on concentrations at the point of discharge. However, the evaluation of concentrations of toxic pollutants at the point of discharge does not promote an evaluation at the ecosystem level of the impacts of toxic pollutants. Evaluation of the concentration of pollutants at the point of discharge recognizes toxic impacts only in the immediate vicinity of the discharge. Since pollutants are diluted as they move downstream from a point source, or are lost in sediments and through volatilization and other pathways, the concentration of pollutants at any time, downstream from an individual point source, is likely of little consequence to the whole ecosystem. Rather, the load of persistent (conservative) pollutants discharged over long periods of time from one or more point sources is the important parameter for evaluating the impacts of point source discharges at the level of the ecosystem. Therefore, the analysis presented in this report is based on annual loads of selected toxic pollutants that can be discharged from point sources as a result of state and provincial regulatory programs.

A standard wasteload allocation model was developed to calculate the loads of pollutants from point source discharges that result from individual state regulatory activities. The simplest case of a single discharger of a toxic pollutant into a stream with no ambient background concentration of any toxic pollutant was chosen to examine and compare state point source regulatory activities. The standard wasteload allocation model was developed using equation (A) and utilizing each state's WQC and its procedures for addressing dilution and background concentrations in the equation. This procedure allowed analysis of the impacts of different dilution flows, WQC and background concentrations in the calculation of the WLA and the development of the WQBEL. The impacts of policies for handling levels of detection and combinations of pollutants are discussed separately.

Effluent flow (Qe) in equation (A) was held constant at 100 cubic feet per second (cfs) for all calculations. Stream dilution flows for the Grand River at Grand Rapids, Michigan were collected from the U.S. Geological Survey and used for all analyses. States use different dilution flows in equation (A); the flows are specific to the numeric WQC used in the formula. The state- and criterion-specific dilution flows were used to calculate all state-specific wasteload allocations (Table 2). Stream flows corresponding to these dilution flows are shown in Table 3 for the Grand River. Chemical-specific WLAs were calculated for seven pollutants (Table 1) for each Great Lake state, utilizing state-specific WQC, dilution flow policy and policy on background concentrations.

The WLA formula was used to determine the chemical-specific effluent limit at the point of discharge for each of the seven pollutants. The annual load of each pollutant discharged as a result of the effluent limit was then calculated. Annual loads were calculated by assuming that each pollutant was discharged constantly at the effluent limit based on water quality. The WQBEL was multiplied by the daily effluent flow, then by 365 to calculate the annual load.

States in the Great Lakes basin utilize each criterion and criterion-specific dilution flow in the development of the WLA. That is, several different WLAs are calculated by a state for each pollutant. For example, a WLA for benzene that addresses human cancer is calculated by Indiana, using the human cancer criterion for benzene and 1/4 of the 50th percentile dilution flow in the WLA (equation A). A WLA for benzene that addresses the protection of aquatic life in Indiana is calculated using the chronic aquatic criterion and 1/2 of the 7Q10 in the WLA. The most stringent WLA, based on each WQC/dilution combination, is then used to determine the WQBEL if the WLA is more stringent than the acute toxicity criterion (usually the FAV). If it is less stringent, the FAV becomes the effluent limit. If a state does not have a criterion for an endpoint (e.g. wildlife impacts), a wasteload allocation is not calculated for that endpoint.

Background concentrations of pollutants are also utilized in the WLA formula. Where a background concentration is less than the WQC, then the WLA is reduced in proportion to the background concentration. However, when the background concentration is greater than the WQC, the states modify their processes to avoid the development of negative effluent limits (discussed in the Background section). To analyze state-specific procedures for addressing background concentrations in the calculation of the WQBEL, the background concentration of each of two pollutants (lead and mercury) in the receiving stream was assumed to be two times the chronic criterion in the least stringent state for that pollutant. The least stringent criterion for lead, used to develop the WQBEL in the Great Lakes states, is 10.1 µg/L (Wisconsin). Therefore, the background concentration of lead was set arbitrarily at 20.2 µg/L. The least stringent chronic criterion for mercury is 0.2 µg/L (NY); thus, the background concentration of mercury was set at 0.4 µg/L. State-specific guidance was then followed to develop the WQBEL and the annual discharge load for lead and mercury in each state, as described above.

Examination of Water Quality Regulation in Ontario

The Ontario Ministry of the Environment utilizes a variety of mechanisms to control the discharge of toxic pollutants into surface waters. These include voluntary measures, formal programs, Control Orders, Requirements and Direction, and Certificates of Approval (MOE Report on the 1988 Industrial Direct Discharges in Ontario, 1989). These regulatory processes, however, are not amenable to the type of analysis conducted for U.S. jurisdictions. Although elements of the Ontario approach are similar to that for U.S. jurisdictions, there is no uniform approach to water quality-based controls. Rather, parameters such as numeric water quality criteria, mixing zones and dilution are considered on a case-by-case basis. Therefore, this report reviews the activities that have occurred in Ontario to regulate point source dischargers, the activities that are planned for the near future and the implications for Great Lakes water quality of the existing regulatory activities in Ontario.

Results

Water Quality Criteria and Objectives

The U.S. EPA, the International Joint Commission, Ontario and the eight Great Lakes states have developed criteria, objectives or guidelines for some or all of the seventeen pollutants evaluated in this study (Table 4). Substantial variation exists among state, provincial, federal and IJC criteria and objectives for several pollutants. For example, differences of over three orders of magnitude exist among criteria and objectives for mercury, depending on the jurisdiction and the endpoint used to develop the criterion. Similar differences exist for PCBs and other pollutants (Table 4). These differences have relatively little meaning however, until criteria and objectives are applied in a regulatory setting. In the U.S. this process occurs when numeric WQC are utilized to develop effluent limits for point source discharges of pollutants.

Wasteload Allocations and Pollutant Loads -U.S.

Point source regulatory programs in the Great Lakes basin vary widely among jurisdictions. States in the basin approach the application of WQC to develop water quality-based effluent limits in similar ways. However, the use of mixing zones, consideration of the concurrent discharge of multiple pollutants (additivity), the incorporation of background concentrations of pollutants in the development of the WQBEL, and the use of analytical detection levels vary widely among the states (Appendix Table 1A). The result of different approaches to the use of mixing zones, dilution and other factors may be highly variable limitations on the concentrations and loads of toxic pollutants that are discharged from point sources. The impact of three parameters - numeric water quality criteria, dilution flows and background concentrations - on the WLA was determined for seven pollutants: benzene, cadmium, chromium, lead, mercury, PCB and TCDD.

Most states use relatively small dilution flows to develop the WLA for the protection of aquatic life (Table 2). The 7Q10 or some fraction of the 7Q10, the 30Q10 or 95% exceedance flows (which are slightly larger than the 7Q10 - Table 3) are used for aquatic life WLAs. States use much larger dilution flows to develop the WLA for human toxicants. The largest dilution flow for these criteria, the mean annual flow, is used by Wisconsin for both carcinogens and non-carcinogens. The mean annual flow for the river used in this study is approximately five times the 7Q10 (Table 3).

The specific criteria used to limit discharges of the seven pollutants (Tables 5 through 11) are not amenable to inter-jurisdictional comparison. The criterion used to calculate the WQBEL, marked with an asterisk in the tables, may not be the most stringent of a state's criteria since states use several different criteria/dilution flow combinations to derive the most stringent WLA. Therefore, the loads of the seven pollutants discharged from the hypothetical industry were compared among states to examine the impacts of the use of different criteria and dilution flows on the regulation of water quality.

Effluent limits and loads were developed, using the standard wasteload allocation (equation A) for a hypothetical discharger into a river the size of the Grand River (Michigan) with an effluent flow of 100 cfs. Since states in the Great Lakes basin do not utilize identical procedures for WLA development (Appendix Table 1A), the standard WLA equation was adjusted to account for state-specific variations in WLA derivation. As described above, states calculate wasteload allocations for all criteria and associated dilution flows for each pollutant. The most stringent WLA is then used to derive the WQBEL. The criterion that is utilized in the most stringent WLA is indicated with an asterisk in Tables 5 through 11. Annual loads are generated by multiplying the effluent limit by the facility effluent flow and by 365.

The utilization of different WQC and different dilution flows by states to develop the WLA may result in substantial differences in the WQBEL and the loads of pollutants discharged from point sources (Tables 5 - 11 and Figure 1). For all seven pollutants, the range between the highest and lowest loads in the states spans an order of magnitude or more. For example, the hypothetical discharger in Illinois would receive a WQBEL that allowed the discharge of over 7000 kg/year of lead, while the same discharger in Michigan would be allowed to discharge just over 700 kg/year (Figure 1). Similarly, the hypothetical discharger would receive a WQBEL that allowed the discharge of over 145 kg/year of mercury into New York waters, while the same entity in Michigan would be allowed to discharge less than 1 kg/year.

Disparities in allowable loads are the result two parameters: the use of state water quality criteria and state-specific approaches to the use of dilution in the WLA. For example, most states have relatively similar numeric WQC for lead (Figure 1). However, Illinois uses a much less stringent lead criterion to regulate discharges of this metal into surface waters.

The result of using this criterion to regulate point sources of lead would be substantially elevated lead discharges in Illinois. Variation among lead criteria in other states is minor. Substantial variation exists, however, among these states in their use of dilution in the WLA equation for lead. The use of different dilution flows in the WLA, while using similar WQC, may result in variation among allowable loads of lead of nearly an order of magnitude.

There are some consistent patterns among states in the degree of regulation of the seven pollutants. In most cases of regulating the seven pollutants, the Michigan procedure results in smaller loads of pollutants than do the procedures of other Great Lakes states. This phenomenon results from Michigan's use of a stringent dilution flow policy and relatively stringent WQC for most of the pollutants. Alternatively, Illinois, Ohio and New York allow larger loads of the seven pollutants than do most of the other Great Lakes states. This phenomenon results from a combination of the use of relatively less stringent criteria and larger dilution flows by these states.

No state limits the loads of pollutants by using either stringent WQC or stringent dilution flows alone. In fact, stringent state WQC are frequently offset by the allowance of large dilution flows. For example, Wisconsin uses comparatively stringent WQC for PCB and TCDD. Yet, relatively large loads of these pollutants may be discharged in Wisconsin as the state allows the largest dilution in the Great Lakes basin for these pollutants. Alternatively, stringent dilution flows are offset by lax WQC as evidenced by the case of lead regulation in Illinois (Figure 1). In this case, Illinois would actually allow zero dilution, but would effectively compromise the use of zero dilution by applying a lax WQC for lead at the point of discharge.

Dilution, WQC and Loads - U.S.

Three pollutants, (lead, mercury, TCDD) were examined further to explore the relationship between the use of different WQC and dilution flows. Loads of these three pollutants were calculated for the hypothetical discharger, using state-specific WLA procedures, as described above. In the first case (Constant Criterion - Figure 2), a single WQC was used in the WLA calculations for all states (Pb - 3.2 µg/L, Hg - 0.01 µg/L, TCDD - 0.0001 ng/L), while dilution varied on a state-specific basis. In the second case (Constant Design Flow - Figure 2 and Appendix Table 2A-4A), a single dilution flow (7Q10) was used in the WLA calculation for all states, while numeric WQC varied on a state-specific basis. However, since Illinois does not use a WLA process to calculate the loads of these pollutants, Illinois' actual WQC (Pb - 81.6 µg/L, Hg - 0.5 µg/L) were used in the first set of calculations (Constant Criterion - Figure 2). Further, TCDD loads for Illinois and Minnesota were not calculated since these states do not have numeric WQC for these pollutants.

This analysis demonstrates the impact of both the dilution flow and the WQC in the derivation of the WLA. The load of a toxicant discharged from a point source varies as a function of the amount of dilution allowed when one criterion is used in all WLA calculations. In the case of TCDD, Wisconsin allows the largest load to be discharged from the hypothetical industry since it uses the least stringent dilution flow in the WLA (mean annual flow). Alternatively, states with the least stringent criteria allow the largest loads of pollutants to be discharged from the hypothetical industry, as shown in the second case where one dilution flow is used in all state WLA calculations. Again for TCDD, New York allows the largest load to be discharged from the hypothetical industry by virtue of its use of the least stringent criterion for TCDD in the Great Lakes basin (although Illinois and Minnesota have not developed criteria for TCDD).

Background Concentrations - U.S.

A third part of the wasteload allocation equation is the background concentration. States do not incorporate background concentrations into the WLA calculation when these concentrations are greater than the WQC. States do, however, modify the WQBEL when background concentrations exceed the WQC. State-specific procedures for WQBEL modification as a function of background concentrations are described in Appendix Table 1A.

Most states do not allow a net increase in toxicant discharges when the background concentration is above the WQC and the source of the process water is the receiving stream. In this case, states generally allow the effluent limit to equal the concentration in the ambient receiving stream. The effect of this policy is to prohibit additional loads of the pollutant to be discharged into the receiving stream. However, when process (intake) water is drawn from a source other than the receiving stream, and that source contains concentrations of pollutants above the WQC for the receiving stream, additional loads of pollutants can be discharged to an already polluted system. In this case, most states require that the WQC be met at the point of discharge, although Indiana currently allows the effluent limit to match the background concentration in the receiving stream.

The outcome of state policies on background concentrations, expressed as loads of pollutants discharged from the hypothetical industry, is shown for lead in Figure 3 and Appendix Table 5A. For this analysis, the background concentration for this pollutant was assumed to be two times the least stringent chronic criterion (20.2 µg/L) in the Great Lakes states. The loads associated with background concentrations of zero in Figure 3 are those calculated using the standard WLA derivation procedures.

The load of pollutants discharged from the hypothetical industry in each state when background concentrations are greater than the WQC (and the receiving stream is also the source stream) is a reflection of the background load (black bars in Figure 3) and should not represent an increased load of pollutants into the receiving stream. However, Illinois provides an exception due to its use of a criterion for lead that is much less stringent than criteria used in other Great Lakes states. For the case of the hypothetical discharger examined in this report, Illinois would allow the contribution of massively increased loads of pollutants into receiving streams that are already polluted (as evaluated by chronic criteria).

When intake water is drawn from a source that is a non-receiving stream and the concentration of pollutants in the intake water is above the WQC, most state policies result in additional loads of pollutants to an already polluted system, in contrast to state policies that address intake water drawn from a polluted receiving stream. In states such as Indiana, Illinois, Wisconsin and Ohio, the additional load of pollutants may be several times the load allowed when background concentrations are zero. More importantly, these state policies may allow contributions that are several times the load that exists in an already polluted receiving stream.

Analytical Detection Levels - U.S.

It is not unusual for the water quality-based effluent limit for the pollutants examined in this study (Tables 5-11) to be below the analytical detection limits approved by EPA for those pollutants. In such a case, most states allow the analytical level of detection or a related parameter (Level of Quantitation, Practical Quantitation Limit, Method Detection Limit; see Background section for definitions) to serve as the basis for compliance with the NPDES permit; that is, the LOD becomes the effective effluent limit. For example, WQBELs for PCB in the Great Lakes states range between 0.001 µg/L and 0.00006 µg/L (Table 10). Yet the analytical detection levels used in the Great Lakes states for PCB range between 0.07 and 0.6 µg/L (Appendix Table 1A). Thus, the effective permit limits for PCB in the Great Lakes basin may be as much as five orders of magnitude higher than the limits designed to protect water quality. The result of this difference can be the discharge of substantially higher loads of PCB and other pollutants.

If the concentration of PCB in a discharge is at or near the detection level used for compliance purposes by Wisconsin (0.6 µg/L), the load of PCB discharged by the hypothetical facility will be approximately 54 kg/year or 118 pounds/year Table 12. Contrast this load with a load resulting from an effluent with a PCB concentration at the level in the U.S. EPA Water Quality Criterion, 0.007 kg/year or 0.02 pounds/year. Even discharges at the detection level used in most Great Lakes states result in annual loads over 800X greater than the load resulting from an effluent with a PCB concentration set at the EPA Water Quality Criterion. Further, discharges at half this detection level result in annual loads over 400X greater than the same PCB load.

Combinations of Pollutants - U.S.

Only two states in the Great Lakes basin, Wisconsin and Minnesota, address the regulation of cumulative impacts of combinations of human toxicants in a discharge. Both states use an additivity model, as described in the Background section of this paper, to develop effluent limits for human carcinogens. The use of this model does not result in specific effluent limits for combinations of carcinogens. Rather, a discharger is charged with maintaining at less than unity the sum of the ratios of effluent concentrations of individual toxicants and their respective WQBELs. For example, individual concentrations of two carcinogens in an effluent, such as TCDD and PCB, must be one-half of their respective WQBELs, or one toxicant must be one-quarter and the other three-quarters of their respective WQBELs, or any similar combination that results in a sum of the ratios of equal to or less than one. The purpose of this method is to reduce the total concentration, and thus the total risk, of all carcinogens in the combination to the acceptable level of cancer risk designated by each state. The purpose is also to reduce the loads of pollutants in the combination in proportion to their reductions in the ratio of individual pollutants into their respective WQBELs. In some cases, loads of individual pollutants can be reduced by 50% or more, depending on the ratio of their concentrations and their WQBEL. However, the practical outcomeof this procedure has little or no effect on the concentrations or loads of carcinogens discharged into receiving streams.

Water quality-based effluent limits for most carcinogenic toxicants are well below the analytical detection capability for those toxicants. When this situation occurs, most states do not regulate these pollutants in effluents at the WQBEL. Rather, they employ the analytical level of detection as the compliance point (discussed above), which is often several orders of magnitude above the WQBEL. Therefore, reduction of the WQBEL to account for additive or other interactions will have no effect on the compliance limits in the permit or on the actual concentrations or loads of pollutants discharged in the effluent. However, this approach will prove valuable when analytical detection capability ultimately improves or when innovative detection methods are employed to determine and quantify the co-occurrence of multiple toxic pollutants.

Discharges Directly into the Great Lakes - U.S.

Several of the Great Lakes states allow discharges directly into the Great Lakes. New York, Ohio and Wisconsin allow a dilution factor with Great Lakes water of 10X or more for discharges of toxic pollutants. Illinois discourages or prohibits direct discharges into the Great Lakes, while Indiana, Michigan (new discharges) and Minnesota prohibit mixing or dilution of discharges with Great Lakes water. Pennsylvania addresses direct discharges into Lake Erie on a case-by-case basis.

The result of the Great Lakes dilution policies of New York, Ohio and Wisconsin may be the discharge of large loads of pollutants directly into the Great Lakes. Compared with states that do not allow mixing or prohibit direct discharges, these three states allow loads for the hypothetical discharger that, for some pollutants, are as large as or larger than loads of pollutants discharged into streams (Figure 4). The hypothetical discharger examined in this study and located in Wisconsin would be allowed to discharge nearly four times the lead load if it discharged directly into the Great Lakes than if it discharged into the riverine system examined in this study (Figure 4).

The Ontario Program

Water pollution control in Ontario currently occurs under the Ontario Water Resources Act and the Ontario Environmental Protection Act. Effluent requirements for discharges into Ontario's waters of the Great Lakes are established on a case-by-case basis. However, neither the Ontario Water Resources Act nor its regulations prescribe enforceable effluent limitations. Rather, water quality objectives are set and are used in prescribing the terms of Certificates of Approval.

When effluent requirements are established, the characteristics of the receiving water body are considered as are federal and provincial guidelines for water quality. Effluent requirements are incorporated into Certificates of Approval and Control Orders under Section 42 of the OWRA. Certificates of Approval and Control Orders can regulate both the concentration and loads of waste discharges.

Certificates of Approval and Control Orders are most often issued to approve construction of new facilities or expansion of existing plants. In the past, Certificates of Approval did not contain legally enforceable effluent limits, but rather guidelines that indicated expected effluent quality. New Certificates of Approval can include effluent requirements that are legally enforceable and some of these include metals. Control Orders, which may contain some controls for toxic pollutants, are issued when existing discharges occur in areas where water quality does not meet provincial water quality objectives. In those cases, the Ministry of the Environment develops a pollution control program for individual dischargers including defined abatement actions and compliance dates that should result in a water body ultimately meeting water quality objectives. However, effluent limits for toxic substances, such as those used by the states on the U.S. side of the Great Lakes basin, are not currently utilized by Ontario (except in a few cases) to regulate the discharge of toxic substances. Further, the program to regulate the discharge of toxic pollutants into Ontario's waters is "lacking", even where discharge controls are incorporated into Certificates of Approval or Control Orders, since these controls are subject to appeal (R. Cornillius, Mgr., Industrial Waste Water Approval Branch, Personal communication).

Ontario has recently developed the Municipal-Industrial Strategy for Abatement (MISA) to address the discharge of toxic substances into its waters. This program should ultimately produce enforceable water quality laws in the province. MISA divides all dischargers of pollutants into two broad categories: direct and indirect. Direct dischargers are those whose effluents enter a surface water system directly, while indirect discharges are those that enter surface waters indirectly by way of a sewer and a wastewater treatment plant.

The development of "technology-based" effluent limits will serve as the basis of MISA for both categories of dischargers. Technology-based effluent limits will be based upon the best available technology economically achievable. Effluent limits under MISA are currently under development for several classes of dischargers, including electric power generation, industrial minerals, inorganic chemicals, iron and steel, metal casting, metal mining and refining, organic chemicals, petroleum refining, pulp and paper, and sewage treatment plants. However, technology-based effluent limits for toxic substances have not been established for any of these classes as of the writing of this report, even though MISA has been in existence since June 1986.

One component of MISA, a monitoring program for selected classes of dischargers including the pulp and paper industry, has been implemented and has generated the Effluent Monitoring Priority Pollutant List. The EMPPL has produced a compilation of several pollutants discharged from pulp and paper mills directly into the Great Lakes for the first six months of 1990. Of the pollutants examined in the current study, discharges into the Great Lakes of mercury, chromium, lead, cadmium, benzene and dioxins were monitored. Large loads of chromium, lead, cadmium and benzene were discharged from many of the twenty-one mills monitored in the study (Table 13). Dioxins were also discharged from thirteen of the twenty-one mills; mercury, from eleven.

Conclusions and Recommendations

Water quality regulatory programs in the Great Lakes basin are highly complex. Numeric water quality criteria, guidelines, and objectives for toxic pollutants have been developed by several jurisdictions and entities in the Great Lakes basin. Criteria, guidelines, and objectives define the maximum concentrations of toxicants that can occur in surface waters. It is assumed that these toxicants will not cause deleterious effects at or below those concentrations. However, criteria are only one component of a complex program to control the discharge of toxic pollutants into the Great Lakes and their tributaries.

The traditional mechanism to regulate the discharge of pollutants to lotic (flowing water) systems has involved a stream's ability to dilute discharges of those pollutants. This consideration results in allowable concentrations of a pollutant at the point of discharge, that are greater than the desired concentration in the receiving stream. For toxic pollutants, the desired concentration in the receiving stream is defined by the numeric water quality criterion and the discharge concentration is calculated by the wasteload allocation, which incorporates the stream's dilution capacity. However, this traditional mechanism is not appropriate for the regulation of discharges of persistent toxic pollutants into systems that serve as a sink for those pollutants. One such system is the Great Lakes basin, including the tributaries. Substances discharged anywhere in the basin may ultimately accumulate in the Great Lakes, their sediments, biota or other ecosystem compartments and result in deleterious impacts described earlier in this report.

Programs to regulate the discharge of persistent toxic pollutants into the Great Lakes and their tributaries, which utilize traditional mechanisms that incorporate dilution, may result in the allowable discharge of large loads of toxic pollutants into a system already contaminated by those pollutants. For example, the hypothetical industry examined in this study, with an effluent flow of 100 cfs, discharging into a tributary of the Great Lakes with a 7Q10 flow of 722 cfs would be allowed to discharge 1000 kg/year of cadmium if it were located in Ohio, over 8000 kg/year of chromium if it were located in New York, over 5000 kg/year of lead if it were located in Ohio, 147 kg/year of mercury if it were located in New York, 300 g/year of PCB if it were located in Indiana, and approximately 1,000 mg/year of TCDD if it were located in Wisconsin. These loads of pollutants, some of which currently contaminate the Great Lakes ecosystem, result from large dilution flows incorporated into the wasteload allocation, which is used to regulate their discharge from point sources.

The State of Michigan utilizes relatively stringent criteria and dilution flows, a situation which results in comparatively small loads of pollutants being discharged from the hypothetical industry. However, even stringent WLA procedures will not adequately limit the loads of pollutants discharged into a system in cases where a receiving stream provides large dilution capacity. For example, the Detroit Wastewater Treatment Plant discharges into the Detroit River, which flows into Lake Erie. The discharge plume stays mainly on the Michigan side of the river and enters the Trenton Channel. Michigan uses a design flow for the Trenton Channel of 16,245 cfs or 10,500 million gallons per day (MGD), a treatment plant design flow of 1,423 cfs (920 MGD), and a lead criterion of 3.0 µg/L to calculate the WLA and the effluent limit for lead for this discharger (Michigan Department of Natural Resources, Unpublished). The effluent limit is 36 µg/L. The annual load of lead discharged into the Detroit River from the Detroit Wastewater Treatment Plant would be 45,600 kg/year (over 100,000 pounds per year), should the treatment plant discharge lead at or near the effluent limit of 36 µg/L.

On the Canadian side, the absence of a comprehensive program for the regulation of point sources of toxic pollutants similar to the program used in the U.S. does not allow a quantitative comparison of Canadian and U.S. regulatory activities. There is some indication, however, that large loads of persistent toxic pollutants are discharged into the Great Lakes by Canadian industries. Clearly, a comprehensive point source regulatory program is needed in Ontario.

Several of the components of state and provincial regulatory programs for water quality have been examined in this report. Clear differences exist among programs and the analysis in this report suggests that differences in programs may result in substantial differences in the concentrations and loads of the toxic pollutants that are discharged from point sources within each jurisdiction. Several of the programmatic components are discussed below and recommendations are made for improvement in some of these activities.

Dilution, Mixing and Wasteload Allocations - The U.S. Program

The use of dilution in the WLA for persistent toxic pollutants is critically important in limiting the mass of pollutants discharged into the Great Lakes ecosystem. The discharge of large loads of persistent toxic pollutants poses threats to human and ecosystem health, both immediately down stream of the discharge and in the ultimate receptor of discharges of persistent toxicants, the Great Lakes. Even when a toxic substance meets numeric water quality criteria a short distance from the point of discharge, the accumulation of toxicants in sediments, or combinations of small concentrations of pollutants from several discharges may pose a threat to ecosystem health. Thus, the discharge of any load of a persistent pollutant from an individual point source contributes to the total mass of a pollutant discharged into a watershed. It is the total mass of persistent pollutants entering systems such as the Great Lakes that ultimately should be controlled to protect ecosystem health.

EPA has not taken a strong regulatory position on the use of dilution in determining water quality-based effluent limits for persistent toxicants in the 1991 revisions to the Technical Support Document. In fact, the EPA has stated that, for carcinogens, a relatively large dilution flow can be used to develop effluent limits. Since at least some carcinogens are classified as persistent, this policy seems ill-advised, particularly for systems which serve as a sink, such as the Great Lakes. However, as long as numeric criteria are used in the WLA process to determine the effluent limits of persistent toxic pollutants in streams and lakes, the concept of dilution will continue to be rationalized since any unpolluted receiving waterprovides some dilution for chemicals discharged from point sources.

A clear argument exists for the elimination of dilution in regulating point sources of persistent toxic pollutants. Such elimination in the WLA would provide an important step toward the complete elimination of the discharge of persistent toxic pollutants into the Great Lakes ecosystem. As an interim step toward prohibition of dilution, regulatory agencies should consider the use of no greater than 1/4 of the 7Q10 as the dilution flow in all new permits and those permits up for renewal. During the following permit cycle, the states should then prohibit the use of any dilution in the WLA and in water quality-based effluent limit development. This mechanism would provide a phased approach to the elimination of discharges of persistent toxic pollutants into the Great Lakes and their tributaries.

Alternatively, a technology-based approach may be employed to eliminate discharges of persistent toxic pollutants. EPA has established a precedent for **eliminating** the discharge of toxic pollutants from point sources through technology-based regulatory activities under the Clean Water Act. Conditions requiring zero discharge from some portions of several industrial categories, regulated under the technology-based requirements of the CWA, have been established by EPA. Conditions for zero discharge have been included for some portion of twenty-three of fifty industrial categories regulated by means of Best Available Technology (BAT) or other technology-based regulatory controls. EPA has included zero discharge requirements for at least some subcategories, based on product substitution or complete reuse of process wastes. However, where zero discharge, implemented through technology-based controls, is enforced by a level of detection or quantitation and not through **discharge elimination**, the process will suffer the same failings as water quality-based controls, limited by analytical detection capabilities, discussed below.

Over 280 individual requirements for zero discharge in approximately 100 subcategories have been established. For example, 40 CFR 466.22(a) establishes a zero discharge requirement in the BAT guidelines for metal preparation operations within the Cast Iron Basis Material subcategory of the Porcelain Enameling category (J.D. Rankin, U.S. EPA Region V, Personal communication).

Immediate prohibition of dilution for direct discharges into the Great Lakes is strongly recommended for at least two reasons. First, unlike streams, the Great Lakes do not disperse contaminants rapidly. Thus, any discharge of a persistent pollutant is likely to cause local contamination problems. Second, most of the Great Lakes already have limited or nonexistent assimilative capacity, that is, tissues of Great Lakes fish and sediments in many areas are contaminated with many persistent toxicants. Thus, any discharge of persistent pollutants will contribute to existing loads and existing contamination problems.

Analytical Levels of Detection

The use of the LOD or other analytical detection limits, such as the compliance point in NPDES permits, is critical for regulating the mass of persistent toxic pollutants discharged into the Great Lakes Ecosystem. A possible solution to problems associated with detection capabilities is the implementation of a policy that requires the WQBEL to be used as the permit limit, when it is below the analytical detection limit. In such cases, the permit's language should state that the discharger is required to comply with this limit by using innovative techniques for detecting the toxicant. Techniques may include sampling at a point in the wastestream where the toxicant is more concentrated than in the final effluent or using caged biota or other in situ studies. Some flexibility can be incorporated into this policy by allowing a specific timetable for improving detection capabilities until they reach the WQBEL concentration. However, the elimination of the **discharge** of persistent toxicants, through chemical ban, product substitution, or complete reuse or recycling, that results in the total elimination of effluent, is the only method both to assure that these substances do not end up in the Great Lakes and their tributaries and to circumvent unavoidable problems associated with detection capabilities.

Background Concentrations

State policies on the background concentration of pollutants currently exist in two forms: 1) When the background concentration of a pollutant is above the WQC and the receiving stream serves as the source of intake, most states do not allow a net increase in the pollutant to be discharged and 2) When the background concentration of a pollutant in an intake source which is not the receiving stream is above the WQC, most states require that the WQC be met at the point of discharge, a condition which results in the discharge of additional loads of pollutants to a receiving stream which is already polluted. This issue is important where water quality problems such as fish tissue or sediment contamination exist or where a polluted system contributes large loads of persistent toxicants to the Great Lakes.

The philosophies of virtual elimination of persistent toxic materials expressed in the Clean Water Act and the Great Lakes Water Quality Agreement support the position that increases in pollutant loads should be prohibited in systems that are already polluted. Jurisdictions should not allow a net increase in pollutant discharges to an already polluted system, either when the source of discharge water is the receiving stream or when a non-receiving stream serves as the intake source. In the latter case, prohibition of **any** discharge of a pollutant is the only mechanism that will not contribute additional loads of pollutant to the polluted system.

The Ontario Program

Discharges of toxic pollutants from industries in the Canadian portion of the Great Lakes basin are regulated differently and perhaps much less stringently than their counterparts in the U.S. We were not able to compare the loads of persistent pollutants discharged from the hypothetical industry, if it had been located in Canada, since the Canadian regulatory program is not amenable to this type of analysis. The development of MISA should, for the first time, provide a comprehensive mechanism to regulate the discharge of persistent toxic pollutants from Canadian industries into the Great Lakes basin. However, a technology-based program, particularly one which considers economic feasibility and relies on analytical detection capabilities, may not adequately control those substances which pose the greatest threat to the Great Lakes ecosystem.

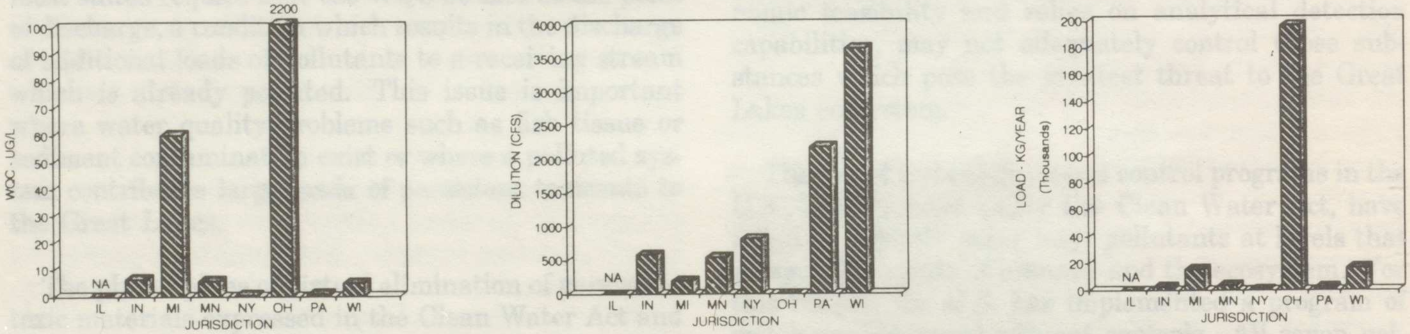
The use of technology-based control programs in the U.S., as mandated under the Clean Water Act, have failed to regulate many toxic pollutants at levels that protect the health of humans and the ecosystem. For this reason, the U.S. has implemented a program of water quality-based effluent controls. All seven pollutants analyzed in this study are regulated by WQBELs as technology-based limits for these pollutants do not adequately protect water quality. The use of technology-based controls under MISA may face the same failures, with the outcome a continuation of the impairment of Great Lakes water quality and its impacts on human and ecosystem health.

Figures

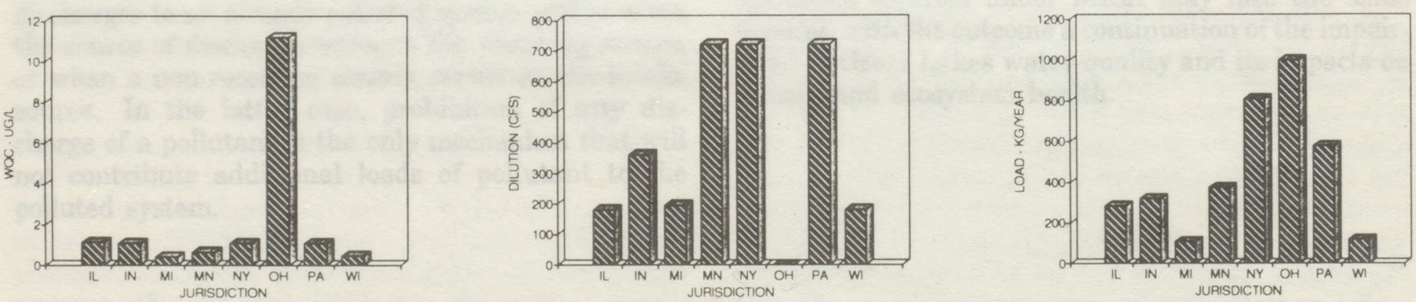
Figure 1

State-specific water quality criteria (WQC - first graph) and dilution flows (second graph) used to calculate annual loads (third graph) of seven pollutants (benzene, cadmium, chromium, lead, mercury, PCB and TCDD) discharged by a hypothetical industry with an effluent flow of 100 cfs. State-specific WQC are those used in the most stringent WLA and indicated in Tables 5-11 with an *. Dilution flows are specific to criteria in the first graph (see text for a discussion of the use of numeric criteria and dilution in the calculation of the WLA). NA indicates that a state does not have a WQC for that substance.

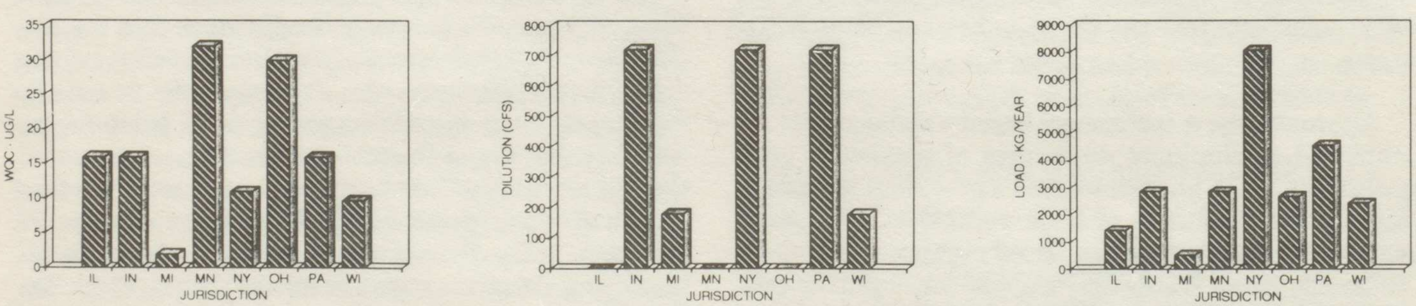
Benzene



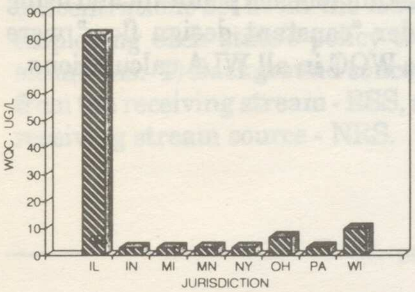
Cadmium

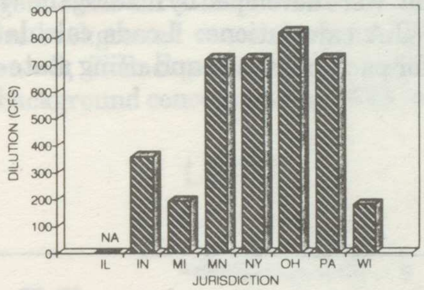


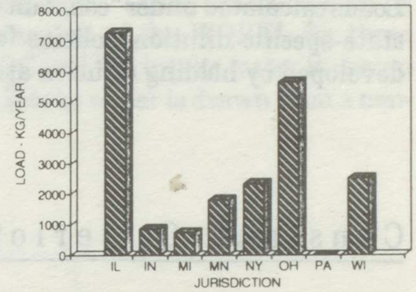
Chromium



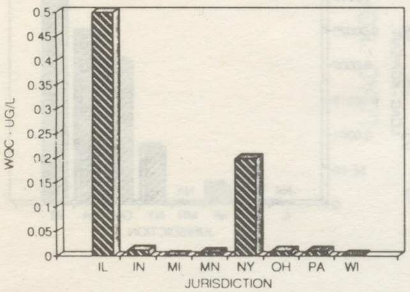
Lead

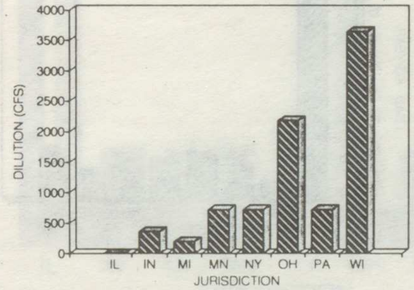


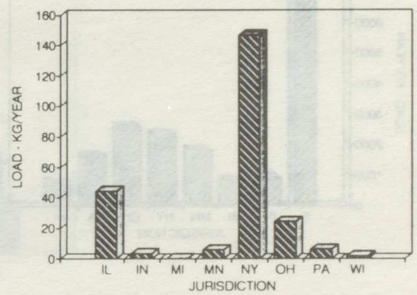




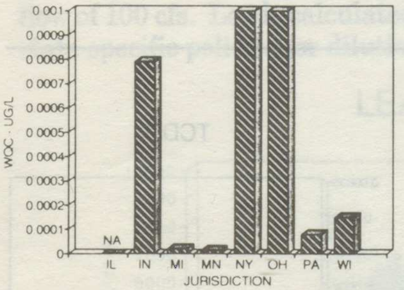
Mercury

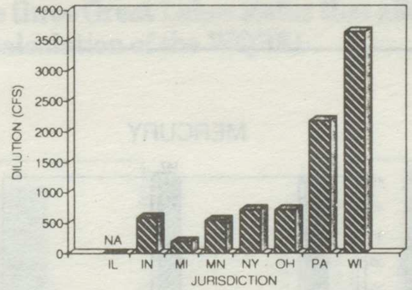


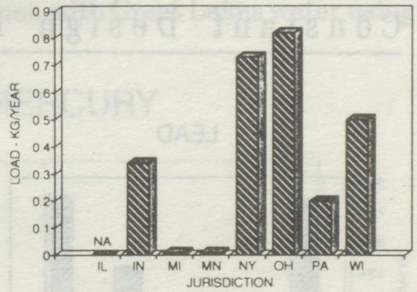




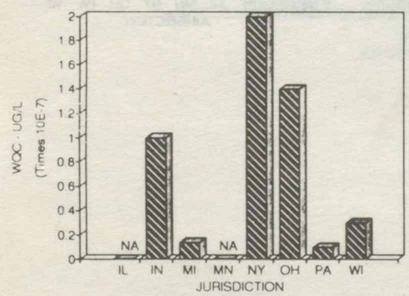
PCB

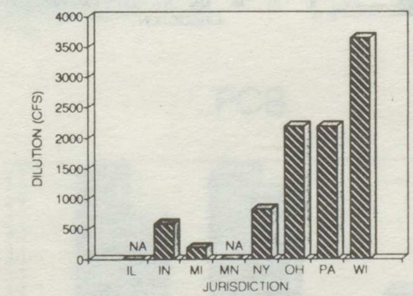






TCDD





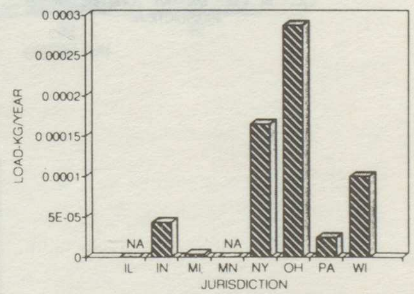
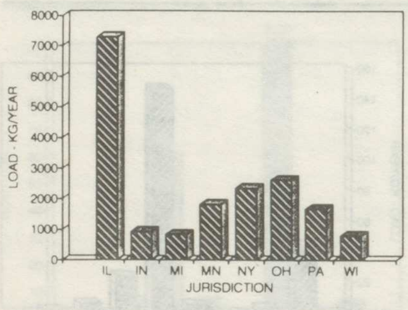


Figure 2

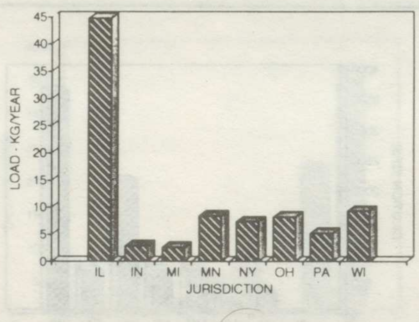
Annual loads of lead, mercury and TCDD discharged by a hypothetical industry with an effluent flow of 100 cfs. Loads calculated under "constant criterion" were developed by holding the WQC constant for each pollutant and using state-specific dilution policies for all WLA calculations. Loads calculated under "constant design flow" were developed by holding dilution at 7Q10 for each pollutant and using state-specific WQC in all WLA calculations.

Constant Criterion

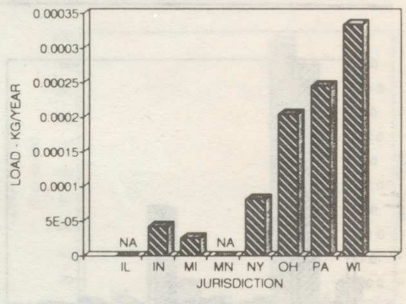
LEAD



MERCURY

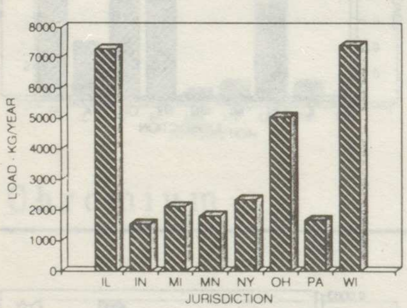


TCDD

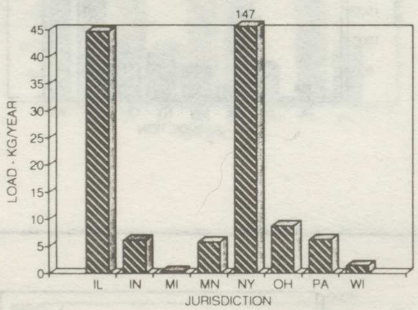


Constant Design Flow

LEAD



MERCURY



TCDD

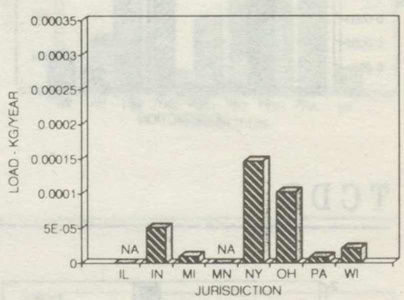


Figure 3

Annual load of lead discharged by a hypothetical industry with an effluent flow of 100 cfs and stream background concentrations set at 2X the least stringent state chronic criterion (see Table 8 and text). Loads are calculated by employing each state's policy to address background concentrations in the derivation of the WQBEL for three situations: 1) Background concentration = 0; 2) Background concentration > WQC and the intake water is drawn from the receiving stream - RSS, and 3) background concentration > WQC and the intake water is drawn from a non-receiving stream source - NRS.

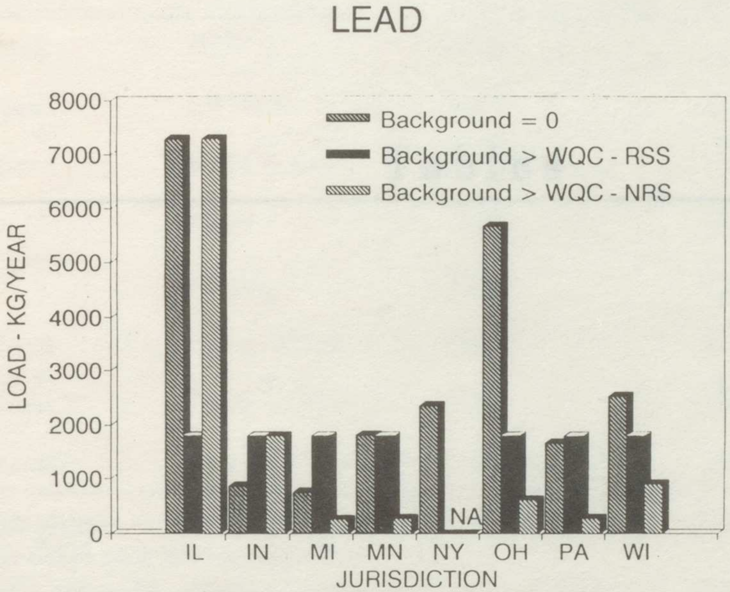


Figure 4

Annual loads of lead, mercury and PCB discharged directly into the Great Lakes (Lake Load) and into the receiving stream presented in this study (Stream Load - for comparison purposes) by a hypothetical industry with an effluent flow of 100 cfs. Loads calculated for the three Great Lakes states that allow dilution with Great Lakes water using state specific policies for dilution and calculation of the WQBEL.

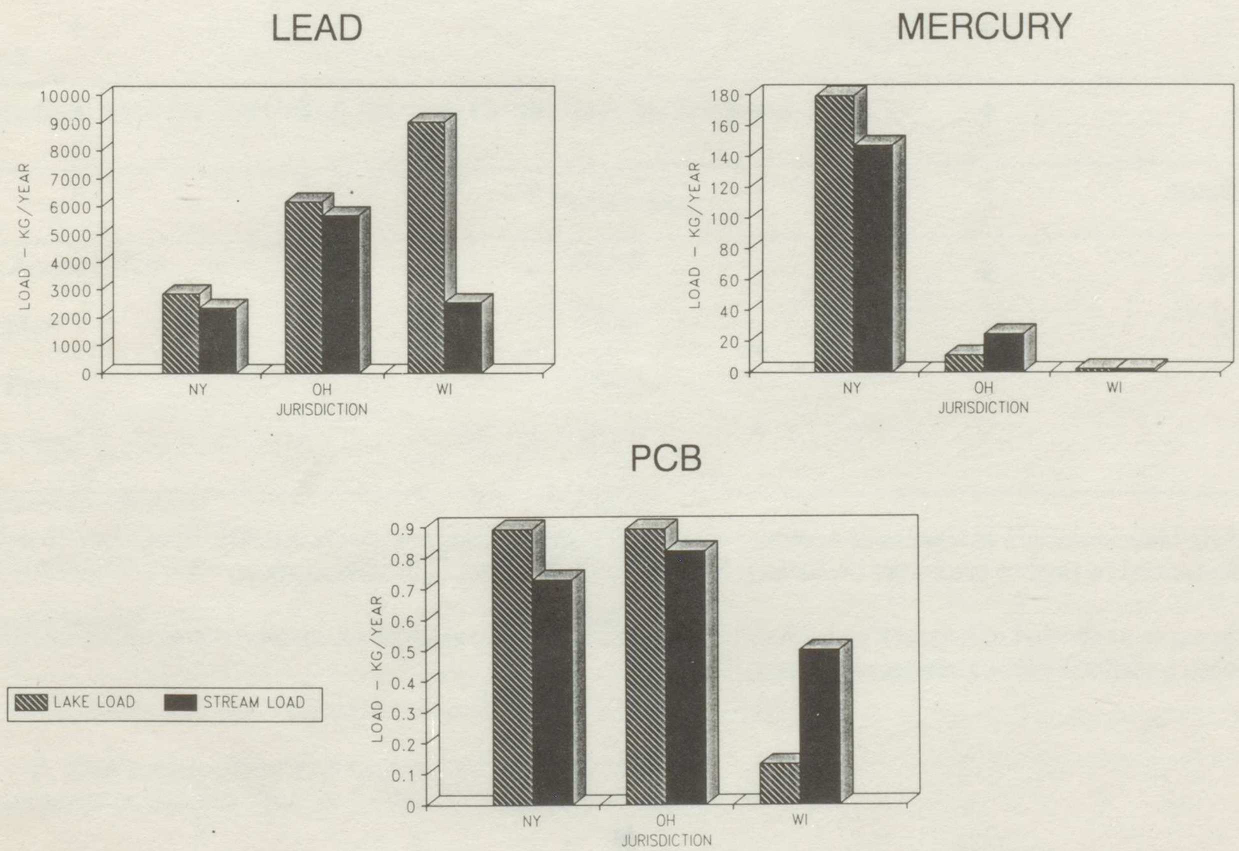
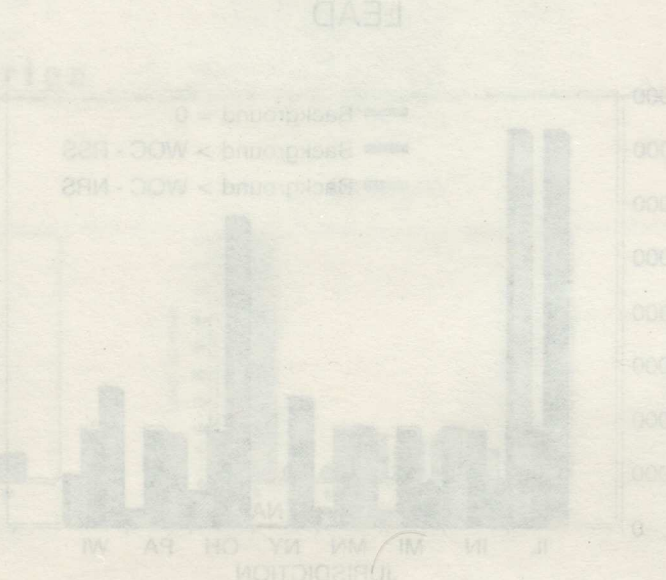


Figure 3

Annual load of lead discharged by a hypothetical industry with an effluent flow of 100 cfs and stream background concentrations set at [illegible] the [illegible] state chronic criterion (see Table 8 and text). Loads are calculated by employing each state's policy to address background concentrations in the derivation of the WQBEL for three situations: 1) Background concentration = 0, 2) Background concentration > WQC and the intake water is drawn from the receiving stream - RSS, and 3) background concentration > WQC and the intake water is drawn from a non-receiving stream source - NRS.



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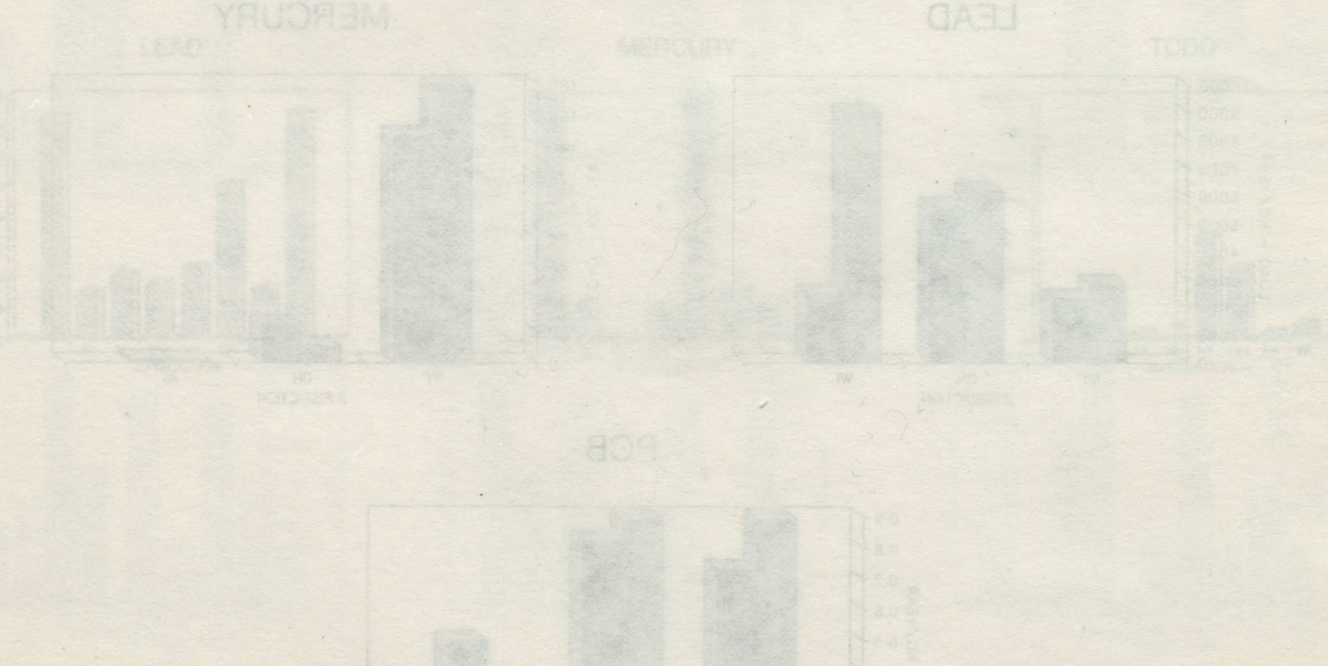
Annual loads of lead, mercury and PCB discharged directly into the Great Lakes (Lake Load) and into the receiving stream presented in this study (Stream Load - for comparison purposes) by a hypothetical industry with an effluent flow of 100 cfs. Loads calculated for the three Great Lakes states that allow dilution with Great Lakes water using state specific policies for dilution and calculation of the WQBEL.



Tables

Table 1

Pollutants selected for analysis with associated characteristics serving as rationale for selection

CHEMICAL	IJC LIST	DISCHARGED FROM PS	PERSISTENT/ BIOACCUMU-LATIVE	POTENTIAL INTERACTION [1]	SELECTED FOR EFFLUENT ANALYSIS
TCDD	+	+	+	+	+
TCDF	+	+	+	+	-
PCB	+	+	+	+	+
Hg	+	+	+	?	+
Cd	+	+	+	+	+
Cr	-	+	-	+	+
Benzene/ HCB	-	+	-	+	+
PAH (BaP)	+	+	+*	+	-
DDT	+	-	+	+	-
Pb	+	+	+	?	+
Mirex	+	-	+	?	-
Toxaphene	+	-	+	?	-
Dieldrin	+	-	+	+	-
TCE	-	+	-	-	-
2,4-D	-	+	-	?	-

* PAHs bioaccumulate in tissues of aquatic biota but are metabolized relatively quickly; thus, they do not pose a substantial hazard to predators (including humans) as a result of fish consumption.

1 Known or suspected of interacting with other chemicals to produce additive, synergistic or antagonistic effects (acute toxicity/death, carcinogenicity and others).

Table 2

Criterion-specific dilution flows used by the eight Great Lakes states for WLA and effluent limit development for toxic pollutants

STATE	Cancer Criterion	Threshold Criterion	Acute Aquatic Criterion	Chronic Aquatic Criterion	FAV
IL	Harm. Mean	7Q10	EOP	1/4 7Q10	#
IN[1]	1/4 50th pctl.	1/2 7Q10	7Q10	1/2 7Q10	EOP
MI	1/4 95% Excd.	1/4 95% Excd.	1/4 95% Excd.	1/4 95% Excd.	EOP
MN	1/4 Harm. Mean	7Q10	7Q10	7Q10	EOP
NY	30Q10	30Q10	7Q10	7Q10	NA
OH	Harm. Mean	Harm. Mean	7Q10	30Q10	EOP
PA	Harm. Mean	7Q10	7Q10	7Q10	NA
WI	Mean Annual	Mean Annual	1/4 7Q10*	1/4 7Q10*	EOP

* Wisconsin allows other stream design flows, including the 4-day/3-year biological flow, 85% of the 7Q2, or the 30Q5 on a case-by-case basis.

1 Indiana's procedures for allowable dilution are proposed in 327 IAC 5.

\# Illinois applies AAC at EOP

EOP Criterion is applied at the point of discharge (end-of-pipe)

NA State does not develop criterion

Table 3

Stream flow data for the Grand River at Grand Rapids, Michigan

	FLOW (cfs)
Mean Annual Flow	3645.0
7Q10 Flow	722.5
30Q5 Flow	938.0
30Q10 Flow	822.0
50% Exceedance Flow	2350.0
95% Exceedance Flow	782.0
Harmonic Mean*	2186.5

* Harmonic Mean = [1.194 * (Q arith. mean)^0.473] * [(7Q10)^0.552]

From U.S. EPA's *Assessment and Control of Bioconcentratable Contaminants in Surface Waters.* Office of Water, March 1991 draft.

Table 4

U.S. EPA Water Quality Criteria, International Joint Commission Water Quality Objectives, U.S. State Water Quality Criteria and Ontario Water Quality Criteria for the Great Lakes or Connecting Waters. Notation *E refers to numbers expressed in exponential form, such that 1.3*E-8 = 1.3 x 10^{-8}.

***Table 4, Part 1:* EPA, IJC and Ontario: Criteria and Objectives**

CHEMICAL	EPA (HH)	EPA(CAC)	EPA(AAC)
TCDD	1.3*E-8 (HC)	1.0*E-5	1.0*E-2
TCDF	NA	NA	NA
PCB(total)	7.9*E-5 (HC)	1.4*E-2	2.0
Hg	0.14 (HT)	1.2*E-2	2.4
Cr(total)	NA	NA	NA
Cr(tri)	170.0 (HT)	210.0#	1,700#
Cr(hex)	50.0 (HT)	11.0	16.0
Cd	10.0 (HT)	1.1#	3.9#
Benzene	0.66 (HC)	NA	5,300(LOEL)
HCB	7.2*E-4 (HC)	NA	NA
PAH	NA	NA	NA
BaP	2.8*E-4 (HC)	NA	NA
DDT	2.4*E-5 (HC)	1.0*E-3	1.1
Pb	50.0	3.2#	82.0#
Mirex	NA	1.0*E-3	NA
Toxaphene	7.1*E-4 (HC)	2.0*E-4	7.3*E-2
Dieldrin	7.1*E-5 (HC)	1.9*E-3	2.5
TCE	2.7 (HC)	21,900 (LOEL)	45,000 (LOEL)
2,4-D	100.0 (HT)	NA	NA

All values in µg/L, unless stated otherwise.

HH - Human health, HT - Human threshold toxicant, HC - Human carcinogen -(Risk level - EPA = 1*E-6), CAC - Chronic aquatic criterion, AAC - Acute aquatic criterion

EPA numbers are for consumption of water and organisms.

- Water Hardness = 100mg/L.

Table 4, Part 1: **EPA, IJC and Ontario: Criteria and Objectives,** ***cont'd***

CHEMICAL	IJC(objectives)	ONTARIO (AQ)	ONTARIO (HH)
TCDD	NA	1.0*E-7	NA
TCDF	NA	2.0*E-7	NA
PCB(total)	NA	1.0*E-3+	3.0
Hg	0.2 (CA & T)	0.2+	1.0
Cr(total)	50.0 (HT)	100.0	50.0
Cr(tri)	NA	NA	NA
Cr(hex)	NA	NA	NA
Cd	0.2 (CA)	0.2#	5.0
Benzene	NA	NA	NA
HCB	NA	6.5*E-3	NA
PAH	NA	NA	NA
BaP	NA	6.0*E-5	NA
DDT	3.0*E-3 (DDT & mtblts)	3.0*E-3+	30.0
Pb	10.0 - L. Superior; 20.0 - L. Huron; 25.0 - other lakes;(CA)	5.0#	50.0
Mirex	0 (CA & T)	1.0*E-3+	NA
Toxaphene	8.0*E-3 (CA)	8.0*E-3	5.0
Dieldrin	1.0*E-3 (Ald + Dldn)	1.0*E-3	0.7
TCE	NA	3.0	NA
2,4-D	NA	4.0	100.0

All values in µg/L unless stated otherwise.

HT - Human threshold toxicant, CA - Chronic aquatic criterion,
T - Terrestrial

- Water Hardness = 100 mg/L.

+ - These numbers also retain a zero tolerance limit.

Ontario's human health objectives (HH) are based on drinking water.

AQ - Ontario's water quality criteria to protect aquatic life

Table 4, Part 2: **Human Health**

CHEMICAL	INDIANA	MICHIGAN
TCDD	1.0*E-7 (HC)	1.4*E-8 (HC)*
TCDF	NA	2.2*E-5 (HT)
PCB(total)	7.9*E-4 (HC)	2.0*E-5 (HC)*
Hg	0.14 (HT)	6.0*E-4(methyl) (HT)
Cr(tri)	170,000 (HT)	980,000 (HT)
Cr(hex)	50@	NA
Cd	10@	1,900 (HT)
Benzene	6.6 (HC)	68.0 (HC)*
HCB	7.2*E-3 (HC)	1.8*E-3 (HC)
PAH	2.8*E-2 (HC)	NA
BaP	NA	1.18*E-3 (HC)
DDT	2.4*E-4 (HC)	2.3*E-4 (HC)*
Pb	50@	9400 (HT)
Mirex	NA	2.1*E-3 (HC)
Toxaphene	7.1*E-3 (HC)	1.0*E-3 (HC)
Dieldrin	7.1*E-4 (HC)	3.0*E-5 (HC)
TCE	27.0 (HC)	240 (HC)*
2,4-D	NA	860 (HT)

All values in µg/L, unless stated otherwise.

HC - Human carcinogen (Risk Level - Indiana & Michigan = 1*E-5),

HT - Human threshold toxicant

* - Regulated as a carcinogen, risk level not necessarily 1*E-5
Indiana uses a drinking water standard for Lake Michigan.

@ - Specific drinking water standard

Table 4, Part 2: **Human Health,** ***cont'd***

CHEMICAL	MINNESOTA	NEW YORK	PENNSYLVANIA
TCDD	NA	2.0*E-7 (HC)	1.0*E-8 (HC)
TCDF	NA	50.0@	NA
PCB(total)	1.4*E-5 (HC)	1.0*E-2 (HC)	8.0*E-5 (HC)|
Hg	6.9*E-3 (HT)	2.0 (HT)+	0.144 (HT)
Cr(total)	NA	50.0+	170,050 (HT)
Cr(tri)	NA	NA	NA
Cr(hex)	NA	NA	50.0 (HT)
Cd	NA	10.0 (HT)	10.0 (HT)
Benzene	5.9 (HC)	0.7 (HC)	1.0 (HC)
HCB	5.6*E-5 (HC)	2.0*E-2 (HC)	7.0*E-4 (HC)
PAH	NA	NA	3.0*E-3 (HC)
BaP	NA	2.0*E-3 (HC)	3.0*E-3 (HC)
DDT	1.1*E-4 (HC)	1.0*E-2 (HC)	2.0*E-5 (HC)
Pb	NA	50.0+	50.0 (HT)
Mirex	NA	0.04 (HC)	NA
Toxaphene	3.1*E-4 (HC)	1.0*E-2 (HC)	7.0*E-4 (HC)
Dieldrin	6.5*E-6 (HC)	9.0*E-4 (HC)	7.0*E-5 (HC)
TCE	25.0 (HC)	3.0 (HC)	3.0 (HC)
2,4-D	NA	100.0+	0.3|

Values are in µg/L, unless stated otherwise.

HC - Human carcinogen (Risk Level - MN, NY & PA = 1*E-6),

HT - Human threshold toxicant

@ - Nonspecific maximum standard

+ - Regulations for drinking water Maximum Contaminant Levels

| - Aesthetic

Table 4, Part 2: **Human Health,** *cont'd*

CHEMICAL	OHIO	WISCONSIN
TCDD	1.4*E-7 (HC)	3.0*E-8 (HC)
TCDF	NA	NA
PCB(total)	7.9*E-4 (HC)	1.5*E-4 (HC)
Hg	1.2*E-2 (HT)	7.9*E-2 (HT)
Cr(total)	NA	NA
Cr(tri)	NA	140.0 mg/L (HT)
Cr(hex)	NA	50.0 (HT)
Cd	10.0 (HT)@	10.0 (HT)
Benzene	710.0 (HC)	5.0 (HC)
HCB	0.99 (HC)	1.6*E-3 (HC)
PAH	0.31 (HC)	2.3*E-2 (HC)
BaP	0.31 (HC)	NA
DDT	2.4*E-4 (HC)	4.3*E-5 ng/L (HC)
Pb	50.0 (HT)@	50.0 (HT)
Mirex	NA	NA
Toxaphene	7.3*E-3 (HC)	1.7*E-3 (HC)
Dieldrin	7.6*E-4 (HC)	1.7*E-4 (HC)
TCE	807.0 (HC)	5.0 (HC)
2,4-D	100.0 (HT)@	1.4 mg/L (HT)

All values are in µg/L, unless stated otherwise.

HC - Human carcinogen (Risk Level - Ohio & Wisconsin = 1*E-5),

HT - Human threshold toxicant

@ - Standard for drinking water, other Ohio standards are for aquatic habitat.

***Table 4, Part 3:* Chronic Aquatic Criteria**

CHEMICAL	MICHIGAN	INDIANA	NEW YORK
TCDD	NA	NA	1.0*E-6 (B)
TCDF	NA	NA	NA
PCB(total)	0.4	1.4*E-2	1.0*E-3 (B)
Hg	0.13	1.2*E-2	0.2 (B)
Cr(total)	48.0#	NA	207.0#
Cr(tri)	NA	207.0#	NA
Cr(hex)	2.0	11.0	11.0
Cd	0.409#	1.1#	1.1#
Benzene	118.0	NA	6.0(B)
HCB	NA	NA	NA
PAH	NA	NA	NA
BaP	NA	NA	1.2*E-3 (B)
DDT	2.0*E-2	1.0*E-3	1.0*E-3 (B)
Pb	2.88#	3.0#	3.2#
Mirex	NA	NA	1.0*E-3
Toxaphene	4.0*E-2	2.0*E-4	5.0*E-3
Dieldrin	5.0*E-2	1.9*E-3	1.0*E-3+Aldrin (B)
TCE	94.0	NA	11.0 (B)
2,4-D	46.7	NA	NA

All values µg/L, unless stated otherwise.

- Water Hardness = 100 mg/L.

B - Based on bioaccumulation to protect the human and wildlife consumers of fish

Table 4, Part 3: **Chronic Aquatic Criteria,** ***cont'd***

CHEMICAL	PENNSYLVANIA	OHIO	MINNESOTA
TCDD	NA	NA	NA
TCDF	NA	NA	NA
PCB(total)	1.4*E-2	1.0*E-3	NA
Hg	1.2*E-2	0.2	NA
Cr(total)	221.0#	210.0#	NA
Cr(tri)	NA	NA	207.0#
Cr(hex)	11.0	11.0	11.0#
Cd	1.1#	1.4#	0.66#
Benzene	128.0	560.0	NA
HCB	NA	NA	NA
PAH	NA	NA	NA
BaP	NA	NA	NA
DDT	1.0*E-3	1.0*E-3	NA
Pb	3.2#	6.9#	3.2#
Mirex	NA	1.0*E-3	NA
Toxaphene	2.0*E-4	5.0*E-3	NA
Dieldrin	1.9*E-3	5.0*E-3	NA
TCE	450.0	75.0	NA
2,4-D	337.0ǀ	NA	NA

All values are in µg/L, unless stated otherwise.

- Water Hardness = 100 mg/L.

ǀ - Aesthetic

Table 4, Part 3: **Chronic Aquatic Criteria,** ***cont'd***

CHEMICAL	WISCONSIN	ILLINOIS
TCDD	NA	NA
TCDF	NA	NA
PCB(total)	NA	NA
Hg	NA	NA
Cr(total)	NA	NA
Cr(tri)	54.06#	207.0#
Cr(hex)	9.74	11.0
Cd	0.471#	1.13#
Benzene	NA	NA
HCB	NA	NA
PAH	NA	NA
BaP	NA	NA
DDT	NA	NA
Pb	10.09#	NA
Mirex	NA	NA
Toxaphene	1.0*E-2	NA
Dieldrin	NA	NA
TCE	NA	NA
2,4-D	NA	NA

All values are in µg/L, unless stated otherwise.

- Water Hardness = 100 mg/L.

***Table 4, Part 4:* Acute Aquatic Criteria**

CHEMICAL	INDIANA	PENNSYLVANIA	OHIO	NEW YORK*
TCDD	NA	NA	NA	NA
TCDF	NA	NA	NA	NA
PCB(total)	NA	2.0	NA	NA
Hg	2.4	2.4	1.1	NA
Cr(total)	NA	1,716#	1,800#	NA
Cr(tri)	1737#	NA	NA	NA
Cr(hex)	16.0	16.0	15.0	NA
Cd	4.0#	3.9#	5.6#@	NA
Benzene	NA	640.0	1,100	NA
HCB	NA	NA	NA	NA
PAH	NA	NA	NA	NA
BaP	NA	NA	NA	NA
DDT	0.55	1.1	NA	NA
Pb	82.0#	82.0#	130.0#	NA
Mirex	NA	NA	NA	NA
Toxaphene	0.73	0.73	NA	NA
Dieldrin	1.3	2.5	NA	NA
TCE	NA	2,250	1,700	NA
2,4-D	NA	1,685 l	NA	NA

All values are in µg/L, unless stated otherwise.

\# - Water Hardness = 100 mg/L.

@ - Warm water habitat

l - Aesthetic

* - New York does not use acute aquatic criteria for high class waters.

Table 4, Part 4: **Acute Aquatic Criteria,** ***cont'd***

CHEMICAL	MINNESOTA	WISCONSIN	MICHIGAN	ILLINOIS
TCDD	NA	NA	NA	NA
TCDF	NA	NA	NA	NA
PCB(total)	1.0	NA	2.5	NA
Hg	2.4	1.53	1.37	0.5
Cr(total)	NA	NA	1,657#	NA
Cr(tri)	1,735#	1,871#	NA	1,737#
Cr(hex)	16.0	14.2	15.0	16.0
Cd	3.9#	3.92#	32.5#(warm water) 10.5#(cold water)	9.7#
Benzene	4487	NA	2650	NA
HCB	NA	NA	NA	NA
PAH	NA	NA	NA	NA
BaP	NA	NA	NA	NA
DDT	0.55	0.43	0.6	NA
Pb	82#	169.1#	122.0#	81.6#
Mirex	NA	NA	NA	NA
Toxaphene	0.73	0.61	1.1	NA
Dieldrin	1.25	1.33	0.21	NA
TCE	6988	NA	2,120	NA
2,4-D	NA	NA	1,050	NA

All values are in µg/L, unless stated otherwise.

- Water Hardness = 100 mg/L.

Table 4, Part 5: **Wildlife Criteria**

CHEMICAL	MICHIGAN	WISCONSIN
TCDD	NA	NA
TCDF	NA	NA
PCB(total)	NA	3.0*E-3
Hg	NA	2.0*E-3
Cr(total)	NA	NA
Cr(tri)	NA	NA
Cr(hex)	NA	NA
Cd	NA	NA
Benzene	60.0	NA
HCB	NA	NA
PAH	NA	NA
BaP	NA	NA
DDT	NA	1.5*E-4
Pb	NA	NA
Mirex	NA	NA
Toxaphene	NA	NA
Dieldrin	NA	NA
TCE	NA	NA
2,4-D	NA	NA

All values are in µg/L, unless stated otherwise.

Table 4, Part 6: **Non Specific Standards**

CHEMICAL	ILLINOIS
TCDD	NA
TCDF	NA
PCB(total)	NA
Hg	NA*
Cr(total)	50.0
Cr(tri)	NA*
Cr(hex)	NA*
Cd	NA*
Benzene	NA
HCB	NA
PAH	NA
BaP	NA
DDT	50.0
Pb	50.0
Mirex	NA
Toxaphene	5.0
Dieldrin	1.0
TCE	NA
2,4-D	100.0

These standards are applicable only in Lake Michigan proper at public water supply intakes. Their basis is uncertain. They supersede other general use standards where they are more stringent.

All standards designated "NA" are covered by a narrative standard, except those marked - *.

* - Numeric standard (acute or chronic) exists.

Tables 5 - 11

Water Quality Criteria, effluent limits and annual loads of seven pollutants (benzene, cadmium, chromium, lead, mercury, PCB and TCDD) discharged from a hypothetical industry with an effluent flow of 100 cubic feet per second. Effluent limits (EFFLMT - µg/L) calculated using state-specific modifications of equation (A) in text and state- and criterion-specific dilution flows in Table 2 (zero background concentration). Loads (kg/year), calculated by multiplying the daily effluent flow by the effluent limits and by 365. Criteria indicated by an * are those used in the WLA to derive the effluent limit. HCNC = human cancer criterion, HTHR = human threshold criterion, WLDF = wildlife criterion, CHRAQ = chronic aquatic criterion, ACTAQ = acute aquatic criterion, FAV = final acute value (all values in µg/L)

Table 5 Benzene

	CRITERION							
STATE	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
IL	--	--	--	--	--	--	--	--
IN	*6.6	--	--	--	--	--	32.0	2861
MI	68.0	--	*60.0	118.0	2650.0	5300.0	177.3	15,833
MN	*5.9	--	--	--	4487.0	8974.0	43.9	3917
NY	*0.7	--	--	6.0	--	--	6.5	576
OH	710.0	--	--	560.0	1100.0	*2200.0	2200.0	196,460
PA	*1.0	--	--	128.0	640.0	--	27.5	2495
WI	*5.0	--	--	--	--	--	187.3	16,721

Table 6 Cadmium

	CRITERION							
STATE	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
IL	--	--	--	*1.13	9.7	--	3.2	283
IN	10.0	--	--	*1.10	4.0	8.0	3.6	320
MI	--	1900	--	*0.41	32.5	65.0	1.2	108
MN	--	--	--	*0.66	3.9	7.8	4.2	376
NY	--	10.0	--	*1.10	--	--	9.0	808
OH	--	10.0	--	1.40	5.6	*11.2	11.2	1,000
PA	--	10.0	--	*1.10	3.9	--	6.5	578
WI	--	10.0	--	*0.47	3.9	7.8	1.3	118

Table 7 ***Chromium***

STATE	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
	CRITERION							
IL	--	--	--	11.0	*16.0	--	16.0	1429
IN	--	50.0	--	11.0	*16.0	32.0	31.7	2833
MI	--	--	--	*2.0	15.0	30.0	5.9	528
MN	--	--	--	11.0	16.0	*32.0	32.0	2858
NY	--	--	--	*11.0	--	--	90.5	8079
OH	--	--	--	11.0	15.0	*30.0	30.0	2679
PA	--	50 0	--	11.0	*16.0	--	51.2	4571
WI	--	50 0	--	*9 7	14.2	28.4	27.3	2441

Table 8 ***Lead***

STATE	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
	CRITERION							
IL	--	--	--	--	*81.6	--	81.6	7287
IN	--	50.0	--	*3.0	82.0	164.0	9.8	872
MI	--	9400	--	*2.9	122.0	244.0	8.6	765
MN	--	--	--	*3.2	82.0	164.0	20.4	1821
NY	--	50.0	--	*3.2	--	--	26.3	2350
OH	--	50.0	--	*6.9	130.0	260.0	63.6	5681
PA	--	50.0	--	*3.2	82.0	--	18.8	1683
WI	--	50.0	--	*10.1	169.1	338.2	28.3	2529

Table 9 ***Mercury***

STATE	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
	CRITERION							
IL	--	--	--	--	*0.5	--	0.50	45
IN	--	0.14	--	*1.2×10^{-2}	2.4	4.8	0.04	3
MI	--	*6.0×10^{-4}	--	0.13	1.4	2.8	0.002	<1
MN	--	*7.0×10^{-3}	--	--	2.4	4.8	0.07	6
NY	--	2.00	--	*0.2	--	--	1.65	147
OH	--	*1.2×10^{-2}	--	0.2	1.1	2.2	0.28	25
PA	--	0.14	--	*1.2×10^{-2}	2.4	--	0.07	6
WI	--	7.9×10^{-2}	*2.0×10^{-3}	--	1.5	3.0	0.02	2

Table 10 PCB

ST	CRITERION							
	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
IL	--	--	--	--	--	--	--	--
IN	*7.9×10^{-4}	--	--	1.4×10^{-2}	--	--	3.8×10^{-3}	0.34
MI	*2.0×10^{-5}	--	--	0.4	2.5	5.0	5.9×10^{-5}	5.3×10^{-3}
MN	*1.4×10^{-5}	--	--	--	1.0	2.0	1.1×10^{-4}	9.3×10^{-3}
NY	1.0×10^{-2}	--	--	*1.0×10^{-3}	--	--	8.2×10^{-3}	0.73
OH	7.9×10^{-4}	--	--	*1.0×10^{-3}	--	--	9.2×10^{-3}	0.82
PA	*8.0×10^{-5}	--	--	1.4×10^{-2}	2.0	--	2.2×10^{-3}	0.20
WI	*1.5×10^{-4}	--	3.0×10^{-3}	--	--	--	5.6×10^{-3}	0.50

Table 11 TCDD

ST	CRITERION							
	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
IL	--	--	--	--	--	--	--	--
IN	*1.0×10^{-7}	--	--	--	--	--	4.9×10^{-7}	4.3×10^{-5}
MI	*1.4×10^{-8}	--	--	--	--	--	4.1×10^{-8}	3.7×10^{-6}
MN		--	--	--	--	--	--	--
NY	*2.0×10^{-7}	--	--	1.0×10^{-6}	--	--	1.8×10^{-6}	1.6×10^{-4}
OH	*1.4×10^{-7}	--	--	--	--	--	3.2×10^{-6}	2.9×10^{-4}
PA	*1.0×10^{-8}	--	--	--	--	--	2.8×10^{-7}	2.5×10^{-5}
WI	*3.0×10^{-8}	--	--	--	--	--	1.1×10^{-6}	1.0×10^{-4}

Table 12

Loads of PCB, resulting from an effluent limited only by various analytical detection levels used in the Great Lakes states

EFFLUENT CONCENTRATION (µg/L)	LOAD (kg/YEAR)	LOAD (POUNDS/YEAR)
0.6 (LOQ used by WI)	53.6	118.2
0.2 (LOD used by MN)	17.9	39.5
0.1 (LOD used by IL, IN,MI,OH,PA)	8.9	19.6
0.065 (LOD used by NY)	5.8	12.8
0.000079 (EPA WQC)	0.007	0.02

Table 13

Annual load of pollutants discharged directly into the Great Lakes by twenty-one pulp and paper mills in Ontario. Loads calculated from the average daily effluent concentration during the period 1 January 1990 to 30 June 1990. Source - Municipal Industrial Strategy for Abatement: Preliminary Report on the First Six Months of Process Effluent Monitoring in the Pulp and Paper Sector.

POLLUTANT	LOAD (KG/YEAR)	# MILLS DISCHARGING POLLUTANTS
Mercury	1.43	11
Chromium	510.13	20
Lead	230.62	17
Cadmium	97.03	20
Benzene	34.12	16
TCDD	0.02	1
Total Dioxins	0.18	13

Appendix A

Table 1A

Application procedures in the Great Lakes basin to derive Water Quality-based Effluent Limits in NPDES permits

Illinois

Mixing Zones

Streams - Allowed
Lakes - Discouraged

Additivity None

Background Concentrations > WQC

Receiving Stream Intake - No net increase
Non-receiving Stream Intake - WQC at point of discharge

Detection - LOD used to develop the effluent limit when WQBEL < LOD
LOD for PCB = 0.1 µg/L

Criterion Application
Acute Aquatic Criterion at point of discharge
$WQBEL = [WQC * (Qs+Qe) - (Qs*Cs)]/Qe$

Indiana

Mixing Zones

Streams - Allowed
Lakes - Not Allowed

Additivity None

Background Concentrations > WQC

Receiving Stream Intake - Effluent limit = background conc.
Non-receiving Stream Intake - Effluent limit = background conc.

Detection LOD used to develop the effluent limit when WQBEL < LOD
LOD for PCB = 0.1 µg/L

Criterion Application
FAV at point of discharge
LTA mass balance approach, following U.S. EPA TSD for calculation of chronic WLA

Application procedures in the Great Lakes basin to derive Water Quality-based Effluent Limits in NPDES permits

New York

Mixing Zones

Streams - None
Lakes - Used with dilution of 10:1

Additivity none

Background Concentrations > WQC

Receiving Stream Intake - Apply BAT
Non-receiving Stream Intake - No net increase

Detection MDL or PQL used as compliance point when WQBEL < detection
MDL for PCB = 0.065 µg/L

Criterion Application
WQBEL = [WQC * (Qs+Qe) - (Qs*Cs)]/Qe

Ohio

Mixing Zones

Streams - Allowed
Lakes - Allowed with a dilution factor of 10X

Additivity None

Background Concentrations > WQC

Receiving Stream Intake - Previous effluent limit
No new dischargers
Non-receiving Stream Intake - WQC at point of discharge

Detection - MDL used as compliance point when WQBEL < detection
MDL for PCB = 0.1 µg/L

Criterion Application
FAV at point of discharge
WQBEL = [WQC * (Qs+Qe) - (Qs*Cs)]/Qe

Table 1A, cont'd

Application procedures in the Great Lakes basin to derive Water Quality-based Effluent Limits in NPDES permits

Pennsylvania

Mixing Zones

Streams - Not Allowed
Lakes - Case by case

Additivity None

Background Concentrations > WQC

Receiving Stream Intake - Criterion = Background
Non-receiving Stream Intake - WQC at point of discharge

Detection MDL used as compliance point when WQBEL < detection
MDL for PCB = Arochlor specific

Criterion Application
Modified EPA LTA approach

Wisconsin

Mixing Zones

Streams - Allowed
Lakes - (11 * WQC) - (10 * Cs)

Additivity Carcinogens

Background Concentrations > WQC

Receiving Stream Intake - Effluent Limit = Background (w/exceptions)
Non-receiving Stream Intake - WQC at point of discharge (w/ exceptions)

Detection LOD or LOQ as compliance point when WQBEL < LOD or LOQ
LOD for PCB = 0.2 µg/L
LOQ for PCB = 0.6 µg/L

Criterion Application
FAV at point of discharge
WQBEL = [(WQC * (Qs + (1-f) * Qe)) - (Qs*Cs)]/Qe

Tables 2A - 4A.

Water Quality Criteria, effluent limits and annual loads of three pollutants (lead, mercury and TCDD) discharged from a hypothetical industry with an effluent flow of 100 cubic feet per second. Effluent limits (EFFLMT) calculated using the 7Q10 as the dilution flow and state-specific criteria in the WLA calculation (zero background concentration). Loads, expressed in kg/year, calculated by multiplying the annual effluent flow by the effluent limits and by 365. Criteria indicated by an * are those used in the WLA to derive the effluent limit. HCNC = human cancer criterion, HTHR = human threshold criterion, WLDF = wildlife criterion, CHRAQ = chronic aquatic criterion, ACTAQ = acute aquatic criterion, FAV = final acute value.

Table 2A Lead

	CRITERION							
STATE	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
IL	--	--	--	--	81.6	--	81.6	7287
IN	--	50.0	--	3.0	82.0	164.0	17.4	1556
MI	--	9400	--	2.9	122.0	244.0	23.9	2130
MN	--	--	--	3.2	82.0	164.0	20.4	1821
NY	--	50.0	--	3.2	--	--	26.3	2350
OH	--	50.0	--	6.9	130.0	260.0	56.8	5068
PA	--	50.0	--	3.2	82.0	--	18.8	1683
WI	--	50.0	--	10.1	169.1	338.2	83.0	7411

Table 3A Mercury

	CRITERION							
STATE	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
IL	--	--	--	--	0.5	--	0.50	45
IN	--	0.14	--	1.2×10^{-2}	2.4	4.8	0.07	6
MI	--	6.0×10^{-4}	--	0.13	1.4	2.8	0.01	<1
MN	--	6.9×10^{-3}	--	--	2.4	4.8	0.07	6
NY	--	2.0	--	0.2	--	--	1.65	147
OH	--	1.2×10^{-2}	--	0.2	1.1	2.2	0.10	9
PA	--	0.1	--	1.2×10^{-2}	2.4	--	0.07	6
WI	--	7.9×10^{-2}	2.0×10^{-3}	--	1.5	3.1	0.02	1

Table 4A TCDD

ST	CRITERION							
	HCNC	HTHR	WLDF	CHRAQ	ACTAQ	FAV	EFFLMT	LOAD
IL	--	--	--	--	--	--	--	--
IN	1.0×10^{-7}	--	--	--	--	--	5.8×10^{-7}	5.2×10^{-5}
MI	1.4×10^{-8}	--	--	--	--	--	1.2×10^{-7}	1.0×10^{-5}
MN	--	--	--	--	--	--	--	--
NY	2.0×10^{-7}	--	--	1.0×10^{-6}	--	--	1.6×10^{-6}	1.5×10^{-4}
OH	1.4×10^{-7}	--	--	--	--	--	1.2×10^{-6}	1.0×10^{-4}
PA	1.0×10^{-8}	--	--	--	--	--	9.9×10^{-8}	8.8×10^{-6}
WI	3.0×10^{8}	--	--	--	--	--	2.5×10^{-7}	2.2×10^{-5}

Tables 5A and 6A

State-specific Water Quality Criteria (WQC - µg/L), associated endpoints (ENDPT) for those criteria, effluent limits (EFF - g/L) and loads for two pollutants, lead and mercury, generated from a hypothetical industry with an effluent flow of 100 cubic feet per second. EFF1 - effluent limit derived using the state-specific dilution flows and WQC in the WLA with zero background concentration (from Tables 8 and 9). EFF2 - effluent limit developed for a discharger with intake water from the receiving stream with a background pollutant concentration greater than the chronic WQC (Pb - 20.2 µg/L, Hg - 0.4 µg/L). EFF3 - effluent limit developed for a discharger with intake water from a non-receiving stream source and a background pollutant concentration greater than the chronic WQC (as in EFF2). LOADS 1, 2 and 3 (kg/year) calculated for EFF 1, 2 and 3 by multiplying the effluent concentration by the daily effluent flow and by 365.

Table 5A Lead

STATE	WQC	ENDPT	EFF1	EFF2	EFF3	LOAD1	LOAD2	LOAD3
IL	81.6	ACTAQ	81.6	20.2	81.6	7287	1802	7287
IN	3.0	CHRNAQ	9.8	20.2	20.2	872	1802	1802
MI	2.9	CHRNAQ	8.6	20.2	2.9	765	1802	259
MN	3.2	CHRNAQ	20.4	20.2	3.2	1821	1802	286
NY	3.2	CHRNAQ	26.3	BAT	20.2	2350	BAT	BAT
OH	6.9	CHRNAQ	63.6	20.2	6.9	5681	1802	616
PA	3.2	CHRNAQ	18.8	20.2	3.2	1683	1802	286
WI	10.1	CHRNAQ	28.3	20.2	10.1	2529	1802	901

Table 6A Mercury

STATE	WQC	ENDPT	EFF1	EFF2	EFF3	LOAD1	LOAD2	LOAD3
IL	0.5	ACTAQ	0.50	0.50	0.50	45	45	45
IN	1×10^{-2}	CHRNAQ	4×10^{-2}	0.40	0.40	4	36	36
MI	6×10^{-4}	HTHR	2×10^{-3}	0.40	6×10^{-4}	<1	36	<1
MN	7×10^{-3}	HTHR	7×10^{-2}	0.40	7×10^{-3}	6	36	<1
NY	0.2	CHRNAQ	1.65	BAT	0.40	147	BAT	BAT
OH	1×10^{-2}	HTHR	0.28	0.28	1×10^{-2}	25	25	1
PA	1×10^{-2}	CHRNAQ	7×10^{-2}	0.40	1×10^{-2}	6	36	1
WI	2×10^{-3}	WLDF	2×10^{-2}	0.40	2×10^{-3}	2	36	<1