EVALUATION OF RECEIVING WATER-BASED TOXICS CONTROL INITIATIVES: FINAL REPORT

Volume One: Findings and Recommendations

prepared for:

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EXECUTIVE SUMMARY

Purpose

MISA is a commitment to a fundamental review and revision of Ontario's approach to water pollution control based on the understanding that Ontario's water pollution control system must deliver an enhanced level of environmental quality in a publicly acceptable manner.

MISA presents the opportunity of designing a coherent, consistent, comprehensive and effective pollution control approach for Ontario which meets the current and anticipated needs of the province.

This study is part of the MISA initiative. Its focus is a review of the receiving water-based "track". Its objective is to provide the Ministry of the Environment with recommendations for a suitable receiving water-based effluent control system, consistent with MISA's overall objectives and complementary to the control technology BAT(EA) approach.

Scope

The report addresses all aspects of Water quality-based toxics control, including:

- water quality standards
- receiving water considerations
- effluent limit definition, and
- compliance

The investigation focussed on a number of initiatives currently being pursued in the U.S. Specifically, the procedures being used in Regions II, IV and V of the U.S. EPA and the states of Michigan, New Jersey, North Carolina and Florida were examined.

Water quality standards and the available mechanisms for deriving them are discussed. Their application is also reviewed.

The appropriateness of water quality standards depends on the characteristics of the receiving waterbody. Three aspects of the receiving waterbody are reviewed: mixing zones, design flows, and water use/biological characteristics.

Various ways of defining effluent limits are explored. These include 'best available technology (economically achievable)", chemical-based limits and limits based on the toxicity of the whole effluent.

Ways of measuring and achieving compliance are considered by reviewing legal and administrative mechanisms, and the need for and appropriate means of monitoring.

Alternatives for each of these four aspects are evaluated using a set of criteria, and based on this evaluation, a recommended system is proposed. Procedures and guidelines for implementing the recommended approach are set out based on the U.S. experience.

Approach

An initial review of U.S. toxics control programs led to the preparation of a "synthesis" report. This document was designed for discussion at a workshop attended by provincial and federal government staff with invited experts from several U.S. state and federal government organizations with experience implementing toxics control programs.

Concurrently, case studies were selected for detailed investigation. The case studies were designed to obtain specific implementation details regarding the setting and enforcement of toxic effluent limits using receiving water considerations. Each case study consisted of documenting the approval of, and compliance with, an individual effluent discharge permit.

The results of the workshop and case studies raised a number of supplementary points requiring investigation, these were examined in the second phase of the study. This report documents the results of the first and second phases of the project and the conclusions and recommendations resulting therefrom.

Main Findings and Conclusions

Major changes are currently underway in the U.S. in terms of the methods used to control toxic discharges to their aquatic environment. It is concluded that Ontario can benefit significantly by building the MISA toxics control program on the experience and technology available in the U.S.

The review covered all components of the toxic control programs in several states and U.S. EPA regions. Some procedures are reasonably well tested through actual application (e.g., their procedures for setting water quality standards) and some new techniques are being developed and applied. Perhaps the most significant recent development is a major new initiative to use whole effluent toxicity limits to control complex discharges. It was concluded that Ontario should use whole effluent control limits in its MISA program but that refinement in the future should be expected as practical experience is gained.

In the U.S., water quality standards are defined in chemical-based and "total toxicity" terms. It is concluded that both types of standards are required to meet the objectives of MISA to be comprehensive in terms of both pollutant types and impact types.

Significant weaknesses exist with the definition of design flows and mixing zones. Work is underway in the U.S. to develop estimating procedures for design flows that better reflect their importance from a biological perspective rather than strictly in hydrological terms. Several additional refinements are suggested that warrant further attention and are not being actively researched in the U.S. at the present time.

A somewhat radical departure from the current practice in the U.S. is recommended to deal with the matter of mixing zones. No system comparable to that recommended is known to be in use currently or to be under research. However, the proposed system is consistent with the overall thrust of the MISA initiative.

The U.S. EPA has developed a use classification system for their waters that is used to assist in the derivation of effluent limits. A conceptually similar approach is recommended for Ontario to ensure maintenance of the wide diversity in aquatic systems present in the province and particularly to ensure highly significant water systems are given due consideration in water resource planning and management.

Several significant departures from the past system of compliance and enforcement in the province are suggested. The use of fixed term licences rather than Certificates of Approval to control toxic effluents is recommended. Also, a number of recommendations are made to develop a more quantitative, structured and efficient water quality standards and effluent limits setting system . This will make the process more "open and accessible" to the public.

Following is a summary of the major recommendations emanating from this study.

Recommendations

Water Quality Standards

It is recommended that:

- total toxicity standards be set for acute and chronic effects to aquatic ecosystems and that they be referenced to a standard analytical method of determination.

- a controlled and detailed comparative analysis of a cross-section of standards developed by the Ontario and U.S. systems be undertaken to determine sources of discrepancy and to modify the U.S. system to overcome any deficiencies uncovered as a result of the analysis.

- Ontario adopt an explicit standard setting procedure along the lines of that used by the U.S. EPA and the State of Michigan.

- human health considerations be explicitly incorporated in the standard setting procedure to account for both direct and indirect effects.

Receiving Water Considerations

It is recommended that:

- Ontario formally adopt a probability distribution technique to predict extreme event drought flows. A significant constraint faced in some circumstances will be the lack of an adequate historical flow record. Accordingly, it is recommended that formal procedures be developed to estimate design flows based on records from appropriate gauged systems.

- a uniform level of protection for estimating design flows not be used throughout the province; instead, the level of protection should be related to the tolerance of the receiving aquatic ecosystem and its use and value.

- design flows be based on variable time intervals according to prescribed levels of environmental protection and the ability of the discharger to regulate its effluent volume and concentration.

- regulatory mixing zones be defined for both flowing and non-flowing waterbodies in areal terms that are a function of the physical characteristics and significance of the receiving waterbody.

Effluent Limits

It is recommended that:

- whole effluent toxicity limits be used to control contaminants with direct acute and chronic toxicity effects on aquatic resources. Ontario should adopt the U.S. EPA toxicity testing protocol immediately.

- chemical-specific effluent limits be set for contaminants with bioaccumulation potential and/or human health effects.

- Ontario adopt acute and chronic toxicity testing protocols that are comparable in terms of comprehensiveness, efficiency and reliability to those being used in the U.S. Also, these standard tests should be used to define compliance of discharges with specified toxicity limits.

- effluent limits be defined in terms of both concentration and load for several time intervals particularly for persistent and/or bioaccumulative contaminants.

- regulations be used to define the procedures to be used to set water quality standards and that the resultant values be binding in determining acceptable environmental performance.

- specific, legally-enforceable"end-of-pipe"effluent limits for individual discharges be set out in discharge licenses or Certificates of Approval.

- sampling frequency be intensified and that greater reliance be placed on composite samples and continuous whole effluent testing procedures.

- independent audit sampling be regularly undertaken to a level adequate to demonstrate clearly that accurate and representative samples and results are being obtained.

- Ontario continue to require dischargers to sample their effluent and to report the analytical results to the Ministry.

- a representative group of discharges be selected and intensively monitored to assess the degree of contaminant quality variation and how well this is reflected in routine monitoring results.

- a sample group of ecosystems be selected for intensive performance assessment monitoring over a period of 10 years or more before and following implementation of a toxics control program.

Implementation

It is recommended that:

- priority be given to accelerating the water quality track program to the schedule of BAT(EA).

- the regulations controlling toxic effluents under MISA embody both BAT(EA) and water quality considerations.

- the design standards and process to be used by Ministry staff for estimating acceptable mixing zones and design flows be embodied in regulation and the Ministry periodically issue technical manuals clearly setting out the calculational and modelling procedures to be used.

- a public water use planning system be developed for Ontario that sets out individual goals and objectives for specific waterbodies or sections thereof according to the capability of water systems to satisfy the requirements and aspiration of the people of Ontario.

- the Ministry establish interim guidelines for establishing appropriate uses for waterbodies on a case-by-case basis during preparation of a comprehensive water use plan.

- thecurrent Certificate of Approval process be replaced by a licensing system that would issue discharge licenses for fixed periods of time that would set out specific effluent concentrations and total loads.

- if the preceding recommendation is not accepted, effluent limits be defined in all Certificates of Approval for toxic contaminants and that a system be instituted to periodically review and reissue Certificates with appropriate modifications to the effluent limits.

- a regular updating process be institutionalized within the administrative structure and procedures of the Ministry to revise water quality standards for specific contaminants.

- a series of regional and provincial seminars be convened to address some of the key topics pertaining to receiving water-based toxics control and to publicize the technical aspects of the program, in particular the whole effluent component

- effluent limits be specified in the short term based on both whole effluent toxicity and specific chemicals and that in the longer term, the chemical-specific limits be eliminated where they pertain only to acute or chronic aquatic ecosystem impacts, particularly in cases involving complex effluents.

- a laboratory certification program be initiated concurrently with the introduction of whole effluent toxicity limits.

- MOE undertake a formal review process under the auspices of the Environmental Assessment Board to confirm key public policy decisions identified relating to acceptable levels of protection and allocation of aquatic resources for mixing zones.

SOMMAIRE

Objectif

Par la SMID, le Ministère s'engage à réviser fondamentalement sa manière d'envisager la dépollution de l'eau, en prenant pour principe que les mécanismes de dépollution de l'eau en Ontario doivent améliorer la qualité de l'environnement à l'aide de méthodes acceptables pour le public.

La SMID fournit l'occasion de mettre au point une méthode cohérente, logique, complète et efficace de la dépollution de l'eau en Ontario afin de répondre aux besoins présents et futurs de la province.

La présente étude fait partie du programme SMID. Il s'agit d'une révision de la méthode d'étude des eaux réceptrices. Son but est de fournir des recommandations au ministère de l'Environnement sur un système approprié de dépollution de l'effluent agissant sur les eaux réceptrices, en accord avec les objectifs généraux de la SMID, et qui complète la méthode de la meilleure technique et la plus économique qui soit.

Portée

Le rapport traite de tous les aspects de la réduction des produits toxiques touchant la qualité de l'eau, y compris :

- les normes sur la qualité de l'eau
- les données concernant le milieu récepteur
- la définition de la limite de l'effluent
- le respect des limites

L'étude a porté sur un certain nombre de projets présentement en cours aux États-Unis. Plus précisément, sur les méthodes utilisées dans les régions II, IV et V de l'agence de protection de l'environnement des États-Unis et dans les états suivants : le Michigan, le Nouveau Jersey, la Caroline du Nord et la Floride.

Il y est question des normes sur la qualité de l'eau et des mécanismes qui permettent de les établir. On fait aussi mention de l'application de ces normes.

L'opportunité des normes sur la qualité de l'eau dépend des caractéristiques du milieu récepteur. On passe en revue trois aspects du milieu récepteur : zones de mélange, débit nominal, et caractéristiques biologiques et usage de l'eau.

On présente diverses façons de définir les limites des effluents. Parmi celles-ci, il y a <la meilleure technique (et la plus économique qui soit)>, les limites portant sur les produits chimiques et celles basées sur la toxicité de l'effluent global.

Il est aussi question des façons de vérifier dans quelle mesure et comment les limites sont respectées, en passant en revue les mécanismes juridiques et administratifs, ainsi que du besoin d'un moyen de surveillance adéquat.

On évalue les solutions de rechange de ces quatre aspects en tenant compte de certains critères et, à partir de cela, on propose une ligne de conduite à suivre. Les méthodes et directives permettant de suivre cette ligne de conduite sont fondées sur l'expérience acquise aux États-Unis.

Ligne de conduite à suivre

Après avoir passé en revue les programmes de réduction des produits toxiques aux États-Unis, on a pu préparer un rapport de <synthèse>. Ce document a été soumis à un groupe de travail comprenant des membres du gouvernement fédéral et du gouvernement provincial, ainsi que des experts invités provenant de plusieurs États américains et d'organismes du gouvernement fédéral, et ayant tous une expérience au niveau de l'exécution des programmes de réduction des produits toxiques.

On a aussi sélectionné certains cas pratiques pour en faire une étude poussée. On a choisi ces cas de façon à obtenir des détails précis sur la mise en place et l'application de limites concernant les produits toxiques d'un effluent, en tenant compte des caractéristiques du milieu récepteur. Dans chaque cas, ils' agissait de donner les détails sur l'approbation d'un permis individuel de déversement dans un effluent, ou sur la conformité à un tel permis.

Les résultats du groupe de travail et des études de cas pratiques ont soulevé un certain nombre de points exigeant une étude plus approfondie. On a examiné ces points dans la deuxième phase. Le présent rapport donne les résultats des première et deuxième phases du projet, ainsi que les conclusions et recommandations qui en résultent.

Principaux résultats et conclusions

Des changements majeurs sont présentement en cours aux États-Unis quant aux méthodes de contrôle des déversements de produits. toxiques dans l'environnement aquatique. On est arrivé à laconclusion qu'il est tout à l'avantage de l'Ontario de fonder les programmes de réduction des substances toxiques de la SMID sur l'expérience acquise et la technologie qui existe aux États-Unis.

Tous les aspects des programmes de réduction des produits toxiques de plusieurs États américains et de plusieurs régions de l'EPA ont été passés en revue. Certaines méthodes sont déjà utilisées et, de ce fait, éprouvées (méthodes permettant d'établir les normes sur la qualité de l'eau par exemple), tandis que certaines techniques nouvelles en sont au stade de la mise au point ou de l'application. L'amélioration récente la plus importante est peut-être l'utilisation des limites de la toxicité de l'effluent global afin de contrôler les déversements complexes. Les conclusions indiquent que l'Ontario devrait utiliser dans la SMID, des limites portant sur l'effluent global, pour ensuite raffiner les méthodes à mesure qu'on gagne en expérience.

Aux États-Unis, les normes sur la qualité de l'eau sont définies en termes de produits chimiques et de <toxicité totale>. On a conclu que ces deux types de normes sont nécessaires pour atteindre les objectifs de la SMID et comprendre à la fois le type des polluants et le type des répercussions.

On note certaines faiblesses dans les définitions de débit nominal et de zones de mélange. On tente présentement aux États-Unis de mettre au point des méthodes d'évaluation du débit nominal qui reflètent mieux son importance du point de vue biologique, plutôt que du simple point de vue hydrologique. On préconise plusieurs améliorations qui devront être examinées plus à fond; pour l'instant, elles ne font pas l'objet de recherches intensives aux États-Unis.

On recommande de se dissocier de la pratique courante aux États-Unis dans la façon de traiter les zones de mélange.On ne connaît aucun système semblable à celui proposé qui soit présentement utilisé ou à l'étude. Cependant, le système proposé est conforme aux objectifs généraux de la SMID.

L'Agence de protection de l'environnement des États-Unis a mis au point un système de classification des eaux selon leur usage qui est utile pour établir les limites des effluents. On recommande une méthode semblable pour l'Ontario, afin de maintenir la grande variété des réseaux aquatiques de la province, et surtout pour que les voies d'eau importantes reçoivent l'attention qui leur est due à l'étape de la planification et de la gestion des ressources en eau.

On préconise plusieurs changements par rapport à l'ancien système du respect et de l'application. On recommande l'utilisation de permis définis plutôt que de certificats d'autorisation pour réduire les effluents toxiques. On fait aussi certaines recommandations relatives à la mise au point d'une méthode plus quantitative, plus structurée et plus efficace pour déterminer les normes sur la qualité de l'eau et les limites des effluents. Le procédé serait donc plus accessible au public.

Voici en résumé les recommandations principales de l'étude.

Recommandations

Normes sur la qualité de l'eau

On recommande :

- d'établir des normes de toxicité totale pour les effets aigus et chroniques sur les écosystèmes aquatiques, et d'utiliser pour ce faire une méthode analytique standard.

- d'effectuer une analyse comparative détaillée d'un certain nombre de normes mises au point en Ontario et aux États-Unis, afin de déterminer les différences et de pouvoir modifier le système américain, pour éliminer toute contradiction relevée au cours de l'analyse.

- à l'Ontario d'adopter une méthode explicite de détermination des normes dans le même genre que celle utilisée par l'EPA et l'État du Michigan.

- d'incorporer explicitement les facteurs de la santé de la population dans la méthode de détermination des normes, afin d'inclure les effets directs et indirects.

En ce qui concerne les eaux réceptrices,

on recommande :

- à l'Ontario d'adopter une technique de distribution basée sur les probabilités pour prévoir le débit *en* cas d'épisodes de sécheresse extrême. Dans certains cas, le manque dedonnées passées sur le débit peut poser un problème. Par conséquent, on recommande de mettre au point des modalités formelles pour évaluer les débits nominaux, à partir des données passées de systèmes étalonnés correctement.

- de ne pas utiliser un niveau de protection uniforme dans toute la province pour évaluer les débits nominaux; le niveau de protection devrait plutôt reposer sur la tolérance de l'écosystème aquatique récepteur ainsi que sur son utilisation et son importance.

- de fonder les débits nominaux sur des intervalles de temps variables, selon les niveaux de protection de l'environnement indiqués, et sur la capacité du pollueur de régulariser le volume et la concentration de son effluent.

- de définir des zones de mélange obligatoires pour les masses d'eau courantes ou stagnantes, selon des termes spatiaux qui sont fonction des caractéristiques physiques et de l'importance des eaux réceptrices.

Limites des effluents

On recommande :

- d'utiliser les limites de la toxicité de l'effluent global à l'égard des contaminants ayant des effets toxiques directs, aigus ou chroniques, sur les ressources aquatiques. L'Ontario devrait adopter immédiatement le protocole d'évaluation de la toxicité adopté par l'EPA des É.-U.

- d'établir des limites de l'effluent en termes de produits chimiques spécifiques dans le cas des contaminants présentant un risque de bioaccumulation ou pouvant affecter la santé de la population.

- à l'Ontario d'adopter des protocoles de vérification de la toxicité aiguë et chronique d'une portée, d'une efficacité et d'une fiabilité comparables à celles des protocoles utilisés aux États-Unis. De plus, ces analyses standard devraient aussi servir à déterminer si les déversements respectent les limites de toxicité fixées.

- de définir les limites des effluents en termes de concentration et de charge pour plusieurs intervalles de temps, surtout pour les contaminants persistants ou sujets à la bioaccumulation.

- d'utiliser des règlements pour définir les modalités servant à déterminer les normes sur la qualité de l'eau, et d'utiliser obligatoirement ces valeurs pour déterminer si les résultats sont acceptables pour l'environnement.

- d'établir des limites spécifiques exécutoires de l'effluent final des sources de rejet particulières dans les permis ou certificats d'autorisation des déversements.

- d'augmenter la fréquence de l'échantillonnage et d'accorder plus d'importance aux échantillons composés et aux méthodes de vérification continue de l'effluent global.

- d'effectuer régulièrement un échantillonnage de vérification indépendant, de façon à prouver clairement que l'on obtient des échantillons et résultats précis et représentatifs.

- à l'Ontario de continuer d'exiger des pollueurs qu'ils prélèvent des échantillons de leur effluent et qu'ils présentent au Ministère les résultats des analyses.

- de sélectionner un groupe représentatif de déversements et de le soumettre à une surveillance étroite, afin d'évaluer la variation de la qualité des contaminants et jusqu'à quel point les résultats des vérifications de routine en font état.

- de sélectionner un groupe-témoin d'écosystèmes afin d'y effectuer une surveillance très étroite pendant une période de 10 ans ou plus, avant et après la mise en application d'un programme de réduction des produits toxiques.

Mise en application

On recommande :

- d'accélérer en priorité le programme sur la qualité de l'eau pour respecter le calendrier de la technique la meilleure et la plus économique qui soit (BAT EA).

- de tenir compte dans les règlements prévus par la SMID pour réduire les effluents toxiques aussi bien de la technique la meilleure et la plus économique qui soit, que de la qualité de l'eau.

- d'inclure dans les règlements les normes et processus théoriques utilisés par le personnel du Ministère pour évaluer les zones de mélange et les débits nominaux acceptables, et de faire publier périodiquement par le Ministère des manuels techniques indiquant clairement les calculs et modèles à utiliser.

- d'élaborer un plan pour l'utilisation des eaux par la population de l'Ontario, précisant les objectifs et buts particuliers à des masses d'eau précises ou à des sections de ces masses d'eau, selon la capacité des réseaux hydrographiques de répondre aux exigences et aux attentes de la population ontarienne.

- au Ministère d'établir, pendant l'élaboration d'un plan complet de l'utilisation des eaux, des directives intérimaires définissant l'utilisation adéquate des masses d'eau particulières.

- de remplacer le procédé actuel de délivrance de certificats d'autorisation par un système qui délivrerait des permis de déversement pour une période fixe, mentionnant les charges totales et les concentrations précises de l'effluent.

- si la recommandation précédente est refusée, de définir dans tous les certificats d'autorisation les limites des effluents en termes de contaminants toxiques, et d'instituer un système visant à revoir périodiquement les certificats et à en délivrer de nouveaux comprenant les modifications appropriées aux limites des effluents.

- de mettre sur pied un processus de mise à jour régulière dans la structure administrative et les modalités du Ministère afin de réviser les normes sur la qualité de l'eau en rapport avec des contaminants précis.

- de tenir une série de réunions régionales et provinciales pour examiner des points importants de la réduction des produits toxiques dans les eaux réceptrices, et de rendre publics les aspects techniques du programme, surtout la partie sur l'effluent global.

- de préciser, dans un premier temps, les limites des effluents en fonction de la toxicité de l'effluent et des produits chimiques spécifiques, et, dans un deuxième temps, d'éliminer les limites fondées sur les produits chimiques spécifiques lorsqu'elles se rapportent seulement aux répercussions aiguës ou chroniques sur les écosystèmes aquatiques, surtout dans les cas d'effluents complexes.

- d'instaurer en même temps que les limites de la toxicité de l'effluent global un programme de certificat d'agrément des laboratoires.

- au ministère de l'Environnement de l'Ontario d'entreprendre un processus formel de révision sous les auspices de la Commission des évaluations environnementales, pour confirmer les décisions politiques importantes pour le public en ce qui concerne les niveaux acceptables de protection et l'affectation des ressources aquatiques pour les zones de mélange.

ACKNOWLEDGEMENTS

This report is the result of the effort and input of a number of individuals. The project liaison officer was Mr. Peter Dennis, Ontario Ministry of the Environment. He effectively expedited the administrative aspects of the contract plus he provided important technical comments and coordinated those of other members of the Ministry.

The work was carried out under the auspices of "Blue Book Working Group H" whose membership comprises.

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D. Veal		Southwestern Region

All members of the working group took an active role in the critical review and discussion of the evaluation and recommendations contained in this report.

A workshop was held from the afternoon of Friday April 4, 1987 to the afternoon of Sunday April 6, 1987 to provide an opportunity for an open exchange of information and ideas among Ministry staff and external experts familiar with, or with an interest in, receiving water-based effluent control systems. In addition to the members of Working Group II, the workshop was attended by

R. Brandes,	U.S. EPA, Washington, D.C.
M. Hyatt,	Region IV, U.S. EPA, Atlanta, Georgia
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[1] Did not attend workshop.

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Particular mention is due to the U.S. participants. They gave freely of their personal time on the weekend to attend the meeting and their knowledge and insights were pivotal to the success of the workshop and many of the results of the overall study. Similar time commitments were made by Ministry and Environment Canada attendees and this was essential for the timely completion of the study.

A number of U.S. state agencies freely gave access to information in their files and their time during our case study investigations. A considerable number of individuals were involved and acknowledgement of their full cooperation is given. The specific agencies involved in the case studies were:

Michigan Department of Natural Resources. Lansing
New Jersey Department of Environmental Protection
North Carolina Department of Natural Resources and Community Development. Raleigh

The case study analyses for each state were undertaken by the following consultants.

Florida	D. Heeney, Heeney Associates
Michigan	E. Hanna, JE Hanna Associates inc.
Ness Jersey	C. Montgomery. Environmental Law Institute
North Carolina	B. Baetz. JE. Hanna Associates Inc.

Mr. Rick Scroggins, Environment Canada, greatly facilitated the contract through the provision of a large volume of information he has compiled regarding whole effluent approaches to toxics control. He also provided material on the Florida permits used in the case study evaluation.

Mr. Edward Hanna, JE Hanna Associates Inc., was the primary author of the report.

Mr. David Heeney, Heeney Associates, authored much of Chapter 7 and contributed to Chapters 4, 6 and 9 and Appendix D.

Mr. Terry Burrell, Victor & Burrell, prepared portions of Chapters 1 and 2.

Mr. Perry Graham, JE Hanna Associates Inc., contributed to part of Chapter 5 and to Appendix A.

Other members of the consulting team Who attended the workshop also provided comments on drafts of the report. In addition, Mr. Steve Washburn of Environ Inc. supplied useful suggestions for modifications to the report.

Inputs from this large member of individuals and agencies was essential to the completion of the work and is gratefully acknowledged. However, their involvement should not be construed as endorsement or as shared responsibility for the contents of this report. Responsibility for the information, conclusions and recommendations contained herein rests solely with JE Hanna Associates Inc. The Ontario Ministry of the Environment has not accepted or rejected any or all of the conclusions or recommendations in this report. The document is being circulated for information and discussion only.

CHAPTER 1 INTRODUCTION

This chapter sets out the context within which this study was prepared and in particular, its role within the MISA initiative. The scope and approach to the study are described.

1.1 The MISA Challenge

On June 24, 1986 Environment Minister Jim Bradley tabled in the Legislature a White Paper entitled *Municipal-Industrial Strategy for Abatement (MISA) - A Policy and Program Statement of the Government of Ontario on Controlling Municipal and Industrial Discharges into Surface Waters.* MISA constitutes a major commitment on the part of the Ontario government to upgrade Ontario's approach to water pollution control with particular reference to toxic substances.

1.1.1 MISA's Concerns

The MISA initiative is based on the conviction that Ontario's current approach to water pollution control can be substantially improved to provide a higher level of environmental quality.

MISA states that Ontario's present approach to water pollution control is outdated, that the present system focuses mostly on conventional pollutants and consequently deals inadequately with pollutants of concern such as toxic metals and toxic organics:

> "Water pollution control efforts in Ontario have been hampered by outdated control concepts. Until now, controls were aimed at the conventional pollutants such as biodegradable wastes, suspended solids. ammonia, phosphorus. some metals. oils, grease and phenols. The newer more complex pollutants have escaped specific control and present a threat to our drinking water, fisheries, and wildlife. There are two main groups of toxic contaminants of concern: toxic metals, such as mercury, lead and arsenic: and toxic organics such as dioxins. PCBs and chlorinated benzenes." (MOE, 1986: p.1).

MISA also identifies the enforcement provisions of the current approach as being of major concern. Unlike air pollution and toxic waste management, water pollution control is not based to the same extent on legally enforceable regulations specifying acceptable water quality standards or allowable discharge levels.

1.1.2 MISA's Objectives

MISA's long range goal for the Ontario environment is set out in the following terms:

> **MISA's ultimate goal is the virtual elimination of toxic contaminants in municipal and industrial discharges in to waterways. (MOE, 1986: p.7)**

This goal and MISA's subsidiary objectives are embodied in the benefits identified for MISA's implementation. These include:

- Reduction of total toxic loadings
- Uniform application of standards
- Increase in economic and administrative efficiency
- Clear specification of regulatory requirements and procedures "allowing industries and municipalities to know what will be required of them, and the public to know what is being done to protect water quality." (MOE, 1986: p.10 and 11).

1.1.3 MISA'S Approach

MISA proposes to accomplish these objectives through three interrelated initiatives:

1.1.3.1 A "Two Track" Approach to Control

- BAT(EA). Increased emphasis will be placed on control technology. BAT(EA)(Best available technology economically achievable) effluent limits will be set "for each industrial sector and the municipal sector as the minimum pollution control requirement for each discharger in that sector." (MOE, 1986: p.7).
- Receiving Water-based Approach. The current approach to control via water quality impact requires "strengthening and expanding... This approach will complement the BAT(EA) approach, with the more stringent effluent limit of the two applying to each discharger." (MOE,1986: p.8).

1.1.3.2 Enhanced Enforcement

- Monitoring and effluent regulations will be established under Section 136 of the Environmental Protection Act.

- Stiffer penalties will be established for violations.

- Effluent limits regulations will specify abatement responsibilities and steps to follow when violations occur.

- A number of other steps will be taken including revision of control documents and streamlining of procedures for monitoring and enforcement action. (MOE, 1986: pp. 23-4)

1.1.3.3 Public Participation

- Municipalities and industry will be involved to "ensure maximum technological and economic efficiency." (MOE, 1986: p.8).

- General public and public interest groups will be involved "to promote awareness and to gain widespread comment and advice." (MOE. 1986: p.S).

1.1.4 The MISA Challenge - Implications for this Project

MISA is a commitment to a fundamental review and revision of Ontario's approach to water pollution control based on the understanding that Ontario's water pollution control system must deliver an enhanced level of environmental quality in a publicly acceptable manner.

MISA presents the opportunity of designing a coherent. consistent. comprehensive and effective water pollution control approach for Ontario which meets the current and anticipated needs of the province.

This study is part of the MISA initiative. Its focus is a review of the "receiving water-based track". Its objective is to provide the Ministry of the Environment with recommendations for a suitable receiving water-based effluent control system, consistent with MISA's overall objectives and complementary to the control technology BAT(EA) approach.

1.2 Study Context

This study is part of an overall effort to update Ontario's procedures for setting and achieving water quality objectives. Currently, the "Blue Book" (MOE, 1984) establishes the framework for Ontario's water quality policy. However, deficiencies are recognized in particular with regards to organic toxics and revisions to the policies and objectives are currently underway. The results of this study will feed into this process.

Various other investigations are concurrently being conducted. A review of the application of "Policies 1 and 2" in the "Blue Book" (MOE, 1986: p.14) is directed at assessing the strengths and limitations of these policies. A series of "Pilot Site" watershed studies are designed to develop technologies suitable for setting effluent limits based on receiving waterbody conditions and for assessing the effectiveness of toxic effluent control programs in protecting aquatic resources. These various efforts are closely interrelated and together will form a foundation for development of the receiving water-based component of the overall MISA toxics control program.

1.3 Terms of Reference

1.3.1 Objectives

The primary study objective is:

To develop a technically sound, practical and publicly acceptable procedure to establish toxic effluent limits based on ecological and use characteristics of receiving waterbodies.

In order to achieve this objective, a number of secondary objectives need to be accomplished, namely:

i) to prepare a comprehensive description and critical analysis of existing and proposed U.S. initiatives to regulate toxic effluent discharges;

ii) to provide an evaluation of the appropriateness of these initiatives for Ontario and to recommend the best approach; and

iii) to set out procedures and guidelines for implementing the recommended approach.

1.3.2 Scope

The study examined all components of toxic control programs from the setting of broad water quality standards to the definition and enforcement of specific effluent limits. The investigation focussed on a number of initiatives currently being pursued in the U.S. Specifically, the procedures being used in Regions II, IV and V of the U.S. EPA and the states of Michigan, New Jersey, North Carolina and Florida were examined.

The investigation did not consider the setting of drinking water standards but instead focussed on setting water quality standards and effluent limits primarily with respect to protection of the natural environment. At the direction of MOE, human health considerations were reported but specific recommendations for developing a human health standards setting procedure were given secondary priority. This direction reflected the dominant role of the federal government and other provincial ministries in this matter.

1.3.3 Approach

An initial review of U.S. toxics control programs led to the preparation of a "synthesis" report. This document was designed for discussion at a workshop attended by provincial and federal government staff and by invited experts from several U.S. state and federal government organizations with experience implementing toxics control programs.

Concurrently, case studies were selected for detailed investigation. The case studies were designed to obtain specific implementation details regarding the setting and enforcement of toxic effluent limits using receiving water considerations. Each case study consisted of documenting the application, approval and compliance monitoring process of an individual effluent discharge permit.

The results of the workshop and case studies raised a number of supplementary points requiring investigation; these were examined in the second phase of the study. This report documents the results of the first and second phases of the project and the conclusions and recommendations resulting therefrom.

1.3.4 Terminology

There is significant potential for misinterpretation of parts of this report due to possible semantical differences. This is particularly the case with a number of technical terms used throughout. Generally. where new terms are introduced they are defined in the main body of the report. However, a glossary of terms and definitions has been included on page 59 to 60 for easy reference and to reinforce the precise meanings intended for the various terms.

Readers are suggested to carefully read the glossary before proceeding with the main body of this report.

CHAPTER 2 EVALUATION CRITERIA

This chapter presents a series of criteria used to evaluate alternative approaches to receiving water-based toxics control. The need for and application of these criteria in this study are first discussed. Following, the criteria are defined.

2.1 Need for Criteria

The study's purpose is to develop a set of recommendations for a receiving water-based toxics control program for Ontario. These recommendations need to be based on a thorough evaluation of alternatives open to the province. The evaluation of alternatives must in turn be grounded on a clear conception of what the desirable characteristics of a receiving water-based control system are.

In cooperation with Ministry staff, the study team developed the following set of criteria to aid in the development of a preferred option. These criteria are based on the outline of MISA's concerns and objectives discussed in Section 1.1 and on the study team's understanding of desirable characteristics for any pollution control system.

As discussed in Chapter 3, a receiving water-based toxics control program consists of several elements. The following criteria have been applied in the evaluation of each of these components: however, in some cases, not all criteria are appropriate and in these instances, certain criteria have been excluded. The recommendations in Chapter 8 are rationalized on the basis of the evaluation criteria.

In developing these criteria, a conscious effort was made to make them as unambiguous and discrete as possible. In this way, the rationale for the conclusions is most evident. Also, double counting in the evaluation is minimized.

Several higher level criteria were intentionally omitted since they comprised two or more "base" criteria. For example. a primary requirement for any recommended system is public acceptability. Public acceptability depends on characteristics such as consistency, clarity and simplicity, and comprehensiveness; these are all included as "base" criteria. If the following "base" criteria are satisfied, the higher level requirements will be met also.

2.2 Comprehensiveness

One of MISA's central concerns is that the present system inadequately deals with a number of "non-traditional" pollutants. The recommended receiving water-based approach should deal with the full range of:

- pollutant types, in particular the toxic organics and metals identified by MISA as being of special concern

- pollutant impacts including both long and short term impacts on the aquatic environment, wildlife and human health.

2.3 Flexibility

Knowledge of pollutants and their impacts is constantly expanding. The control system should have the flexibility to incorporate new knowledge so that comprehensiveness can be maintained over time.

Flexibility also refers to the ability of a system to deal with a broad range of environmental setting. The recommended system must be able to cope with the environmental diversity inherent to Ontario.

2.4 Complementarity

Preference is given to systems that will be compatible with the BAT (EA) component of MISA and with pertinent provincial legislation, regulations and procedures. Alternatives that are complementary both administratively and philosophically are superior.

2.5 Enforceability

One of MISA's primary concerns is to ensure that the increased level of environmental performance is not just formally mandated, but is actually delivered. Enhanced enforcement mechanisms, including the embodiment of technology-based effluent limits in legally enforceable regulations, are a central part of the program.

This criterion includes the ease of enforcement and the strength of the legal basis available for enforcement. The preferred alternative should be easily enforceable with a clear and defensible definition of noncompliance.

2.6 Consistency

MISA's concern for "uniform application of standards" (MOE, 1986; p. 11) and elementary considerations of fairness demand consistency in the system. It is important that all of the receiving water-based regulatory decisions - from overall standard setting to establishing permissible effluent levels for individual firms - are made in keeping with the province's environmental objectives, regardless of pollutant type, geographic location, regulated industry, etc. Consistency does not imply necessarily uniform effluent limits but rather, for example, uniform levels of protection for comparable receivers.

Consistency with the province's overall environmental regulatory efforts such as air and waste management objectives is also desirable.

2.7 Cost effectiveness

The system should achieve its environmental objectives at least economic cost. This includes minimizing both the cost of implementing the system and of operating it over time. A cost effective system minimizes disruption and is practical in its implementation requirements.

2.8 Technical Soundness

The effectiveness of the system and its credibility with the public demand that those elements dependent on technical factors or decisions be based on the best scientific and technical principles and information. Also, proven effective alternatives are considered more sound than, and hence preferable to, those in the developmental stages.

2.9 Clarity and Simplicity

One of the anticipated benefits of MISA is a clear specification of regulatory requirements and procedures" allowing industries and municipalities to know shat will be required of them, and the public to know what is being done to protect water quality" (MOE, 1986: p.11). Acceptability of the system will be dependent in large part on the degree to which the system and the decisions made under it are known and clearly understood.

CHAPTER 3 RECEIVING WATER-BASED TOXICS CONTROL PROGRAM - KEY ELEMENTS

This chapter reviews what is .meant by a "receiving water-based toxics control program". A general overview of the system components is followed by a discussion of the purpose, derivation, application and alternative methods available for each. The purpose of the chapter is to briefly lay out the alternatives considered for inclusion in the approach recommended for Ontario. The following chapter evaluates the alternative methods in terms of the criteria set out in Chapter 2.

3.1 System Overview

A toxics control program consists of various levels of decisions and information. Following is a brief overview of the significant elements of the hierarchy. This provides a perspective for the interpretation of the remainder of this report.

A schematic conceptualization of a toxics control system is presented in Figure 1. Each of the components and their interrelationships are discussed in the following sections.

3.2 Water Quality Standards

Standards (see Glossary for definition. p.60) reflect a minimum acceptable level of protection and/or quality at the mixing zone boundary. Standards may be defined in many ways and need not necessarily be uniform across the province, but the nature of. and basis for, any variations need to be clearly defined.

3.3 Receiving Water-specific Characteristics

This discussion of toxics control applies specifically to point-source discharges. Defined discharge points are the focus of control. The site-specific ecological, physical and chemical conditions of the receiving waterbody at the point of discharge can greatly influence the nature and extent of environmental effects resulting from toxic discharges.

This component of the system sets out how these site-specific characteristics are incorporated in determining toxic limits. The primary receiving water considerations are waterbody hydrology mixing characteristics and its biological and chemical status and associated uses.

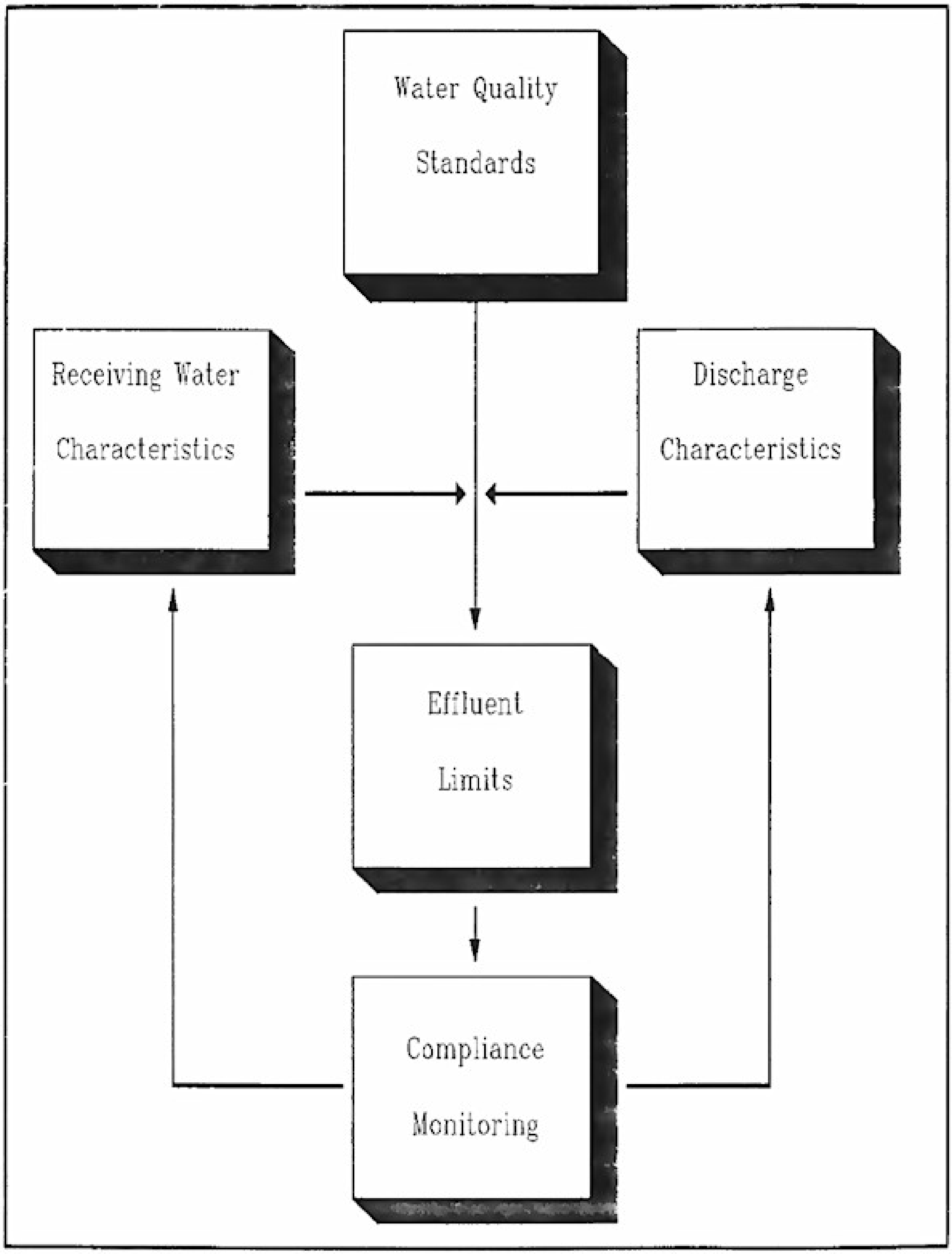

Figure 1: Schematic Outline of Significant Components of Receiving water—based Toxics Control Program

3.4 Discharge Characteristics

The nature of the effluent itself is fundamental to developing appropriate control strategies. The primary considerations are the quantity of effluent and concentrations of tonics in the discharge. The quantity and quality of individual effluents often vary greatly over time due to many factors (e.g., level of production output, process upsets, maintenance activities). As a result, discharge characteristics such as concentration, composition and quantity in terms of duration and frequency are often as or more important than average conditions in predicting impacts and setting effluent limits and sampling frequencies.

3.5 Effluent Limits

A primary point of environmental control is the issuance of approval of effluent limits for individual discharges. The limits are derived based on water quality standards, receiving water characteristics and the nature of the discharge. Limits may be described in various Ways and their definition has significant implications for compliance monitoring and enforcement.

3.6 Compliance Monitoring

Compliance monitoring ensures that the effluent limits specified and overall water quality standards are being achieved. Monitoring may consist of tracking i) discharge characteristics and ii) the receiving waterbody itself in terms of water quality conditions and the overall health of the aquatic ecosystem.

3.7 Summary

Each of these elements of a toxic control program are closely interrelated and are essential for an integrated and effective control strategy. Following is a discussion of the alternative methods of constructing each of these components and an evaluation of current systems being used.

CHAPTER 4 WATER QUALITY STANDARDS

This chapter reviews procedures for setting water quality standards and evaluates these using the criteria set out in Chapter 2.

4.1 Purpose

The term "water quality standards", is used in this report (see Glossary, p.60) to reflect a minimum acceptable level of water quality. They are viewed as being different than water quality goals. These latter measures represent ideal quality levels that may not be practically achievable currently in all circumstances but are statements of long term directions for evaluation and planning purposes. Standards are designed to be used as the basis for setting effluent limits and are expected to be modified in the direction of the goal as technology improves and/or new scientific information regarding effect levels comes available.

4.2 Derivation

The basic information used for deriving standards may vary somewhat; however, the procedure whereby information is used to arrive at a standard can vary greatly. These differences have been separated into the following categories.

A) Decision Processes
   1) Qualitative
   2) Structured

B) Decision Measures
   1) Benefit/Cost
   2) No Effect
   3) Affordability

The "decision process" is the method used to arrive at a conclusion. These two categories represent extreme choices; in reality, a great number of intermediate options are available. Ontario's system of deciding on ambient water quality standards (ie. objectives) in the past, has tended more toward the qualitative end of the spectrum. Although quantitative scientific data were used to derive water quality standards. the method of using the information was based primarily on the judgement of technical experts. The Ontario system is currently undergoing fairly major changes as discussed in Section 4.4 and is moving toward a more structured decision process.

Michigan's Rule 57 (MDNR, 1985) is nearer the other extreme. It consists of a quite highly structured decision process. Expert judgement is restricted to well defined points in the decision process.

The "decision measures" are the performance indicators or objectives. "Benefit/cost" measures imply an optimization of environmental benefits (ie, avoided environmental impacts) and costs (ie, the pollution control costs required to achieve a given level of quality). The standard represents the level at which the net benefits are maximized.

"No effect" measures consider only potential environmental damages. The standard is set at the level at which no effect is expected to occur. Many standards in Ontario are based to a large extent on this type of measure.

The final measure, affordability, considers primarily the costs to dischargers. In this case, limits are set based on perceptions of economic impact or affordability.

In most cases, standards are set based on some intermediate combination of these measures; each of the three measures represents an extreme option, somewhat like the decision process categories.

The selection of a decision process/measure combination can greatly influence the resultant standards. Once a decision framework is selected, the derivation of standards is performed by compiling relevant scientific literature and using the decision process and decision measure to determine an acceptable level. The systems reviewed in this chapter comprise various combinations of these processes and measures.

4.3 Application

Standards may be set for specific contaminants and/or for specific effect levels. An example of the former would be a maximum concentration of copper in a waterbody and of the latter, a maximum acute toxicity of 100% 96 hour LC_{50}[1]. There are also various means to define limits (e.g., annual, daily and hourly loads and maximum and average concentrations for specific periods of time). The definition of a water quality standard has a direct effect on i) effluent limit definitions and ii) the effectiveness and ease of compliance monitoring and enforcement.

4.4 Alternative Systems

Appendix C provides a detailed discussion of the various systems reviewed. This section draws on this appendix and presents some of the significant results of the analysis.

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[1] A 100% 96 hr LC_{50} is a technical term referring to the results of a controlled toxicity test to estimate lethal concentrations (LC). This test would be run using 100% pure effluent for a period of 96 hours. At the end of this time, a maximum of 50% of the test organisms would either have died or shown mortal symptoms.

4.4.1 Current Ontario System

Water quality standards in Ontario are synonymous with the term "objectives" as currently utilized in the "Blue Book" (MOE, 1984). The "Blue Book" levels are based on aquatic life and aesthetic considerations. Modifications to the objectives (e.g., see p. 58-64, MOE, 1984) are made to account for certain specific uses (e.g., livestock watering). Human health is considered in setting ambient water quality standards by means of fish consumption guidelines developed by Health and Welfare Canada and the ambient water concentrations associated with the acceptable contaminant loads (Ralston, 1987). Incidental ingestion and dermal uptake are generally considered to be relatively insignificant exposure mechanisms. The basic premise is that if an adequate level of protection is achieved to maintain healthy aquatic ecosystems, human health effects resulting from incidental exposures will be sufficiently avoided. A separate set of standards are published for drinking water, but these only apply after treatment (MOE, 1983).

4.4.1.1 Standard Definition All the water quality standards except dissolved oxygen and hydrogen sulfide, in the current version of the "Blue Book' are expressed as concentrations with no statement of duration (ie, no reference is made to instantaneous maximum, daily average, monthly average). Based on discussions with MOE staff, total loadings are often considered in setting the standards, in particular those with biomagnification potential, but maximum loading rates are not included as part of the water quality standard definition.

Objectives are set for specific chemicals on the basis of their acute and chronic toxicity. The acute toxicity objective used in the past was 0.1 of the 100% 96 hr LC_{50} for all contaminants at any time or place except persistent and/or cumulative substances for which the objective is 0.05 of the 100% 96 hr LC_{50} at any time or place (MOE, 1984: p.11). The 0.1 and 0.05 are termed application factors and are intended to provide protection from both acute and chronic toxicity effects. Currently, greater reliance is being placed directly on chronic toxicity data where available (e.g.. Trotter, 1987).

4.4.1.2 Derivation Process The Ministry has developed a standard procedure for deriving water quality objectives for specific contaminants (Ralston, 1987). The first step is an extensive literature review. Resulting from such work a provisional objective level is suggested. World experts familiar with the substance being examined critically review the study results and make suggested revisions. Finally, a panel of experts in toxicology review the provisional level and reach a consensus as to an appropriate objective.

The decision process is primarily qualitative and depends on expert judgement and interpretation of the available scientific literature. Objectives are derived by means of consensus.

This process is being continually refined and there is a strong trend to defining a more structured decision process. There are several factors influencing this trend.

i) The large number of contaminants for which standards are required to be set demands an efficient standards derivation process. A structured decision process can streamline the standard setting procedure.

ii) In the past, water quality standards were adopted with little or no public input. The trend is toward greater public involvement prior to finalizing standards. Accordingly, the demand for a clear and consistent rationale for each standard favours a structured decision process.

The decision measures applied in these deliberations is not specified but the "Blue Book" states that "...water quality objectives should be established based on 'no negative effect' data...". In general, a "no effect threshold" concept is used to set water quality objectives in Ontario.

4.4.2 Michigan's Rule 57

Rule 57 is a state regulation that prescribes the procedure for calculating water quality standards (MDNR,1985). A comparable system in many respects is used by the U.S. Environmental Protection Agency (U.S. EPA, 1983c; Stephen *et al*, 1955). These systems take account of aquatic and terrestrial life considerations plus human health and aesthetic considerations in setting standards for individual contaminants.

4.4.2.1 Standard Definition Standards are defined as concentrations with no specification of duration or frequency. Where total loadings are a concern (e.g., bioaccumulative contaminants). bioconcentration factors are used to derive corresponding ambient concentrations.

As in Ontario, general toxicity standards are set for acute toxicity and implicitly for chronic toxicity via application factors and acute/chronic ratios.

4.4.2.2 Derivation Process There are several major differences between the Michigan approach and that used historically in Ontario. A highly structured decision process is set out in the Michigan regulations and supporting guidances (see Appendix B). A comprehensive set of contingencies are described according to available scientific data. A systematic sorting and analysis procedure is prescribed leading to a water quality standard based on one of four factors (ie., acute or chronic aquatic toxicity, wildlife toxicity or human health).

Of particular importance is the treatment of uncertainty. Uncertainty factors are included as specific parameters in the standards derivation equation: these factors may range over 3 orders of magnitude. Broad guidelines for their application are given; however, considerable variation in the final standard value is possible based on expert judgement of the uncertainty associated with the supporting scientific data.

The levels established for aquatic toxicity and wildlife use the no effect level as the decision measure whereas with human health effects a risk analysis measure is used. Risk analysis can be viewed as an intermediate option between benefit/cost and no effect measures. Human health standards for "non-threshold" contaminants[1] are set at the level below which an acceptable level of risk prevails. Standards for "threshold" contaminants are set at the no-effect level.

4.4.3 U.S. EPA System

The U.S. EPA procedures for setting chemical-specific standards are structured quite similarly to those of Michigan's Rule 57. The major differences relate to information requirements and the treatment of uncertainty. The Michigan system is designed to encourage industry to undertake primary toxicological research; the results of which will lead directly to a reduction in the magnitude of the safety (e.g., uncertainty) factor used to set the standard for a specific chemical where limited toxicological information had previously been available.

The U.S. EPA is actively pursuing, in addition to their conventional chemical-specific toxics control program, a quite different approach called "whole-effluent" toxics control (see Glossary p.60). This system is complementary to "chemical-specific" standards. Currently, the "whole effluent" program applies only to acute and chronic aquatic toxicity effects. National toxicity standards have been set based on a "no-effect" philosophy. Unlike the case of chemical-specific standards, the "no-effect" level is not deduced from the scientific literature but rather is defined in analytical terms (e.g., 100% 96 hr LC1). "Whole effluent" standards do not require a deductive decision process and can be defined on the basis of the decision measure only if a "no-effect" standard is adopted.

4.4.4 Comparative Evaluation of Systems

This section summarizes the evaluation of the three systems just described for setting water quality standards. The evaluation criteria described in Chapter 2 were used in the analysis. The results are summarized in Table 4.1.

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[1] Considerable debate currently exists among toxicologists regarding no-effect threshold concentrations of certain contaminants particularly those with carcinogenic, mutagenic and teratogenic properties. The Michigan and U.S. EPA systems are based on the conception that there is no no-effect concentration for some compounds.

TABLE 4.1. EVALUATION OF WATER QUALITY STANDARD SETTING.

	Past Ontario System	U. S. Chemical-based Standards (Rule 57)	U.S. Total Toxicity Standards
Comprehensiveness	Although work is underway to improve the contaminants covered, the breadth of the standards is limited. Impacts on human health are partially and/or implicitly addressed.	Coverage is broader than for Ontario, but many contaminants are still not addressed. Human health effects are addressed. Treatment of bioaccumulation and wildlife effects weak.	ALL contaminants are covered. Impact types currently restricted to acute and chronic toxicity to aquatic organisms.
Flexibility	Relatively inflexible: difficult to adapt to different waterbody characteristics or to capture synergism	Same as Ontario	Very flexible: capable of addressing different water characteristics and synergistic effects.
Complementarity	Complements technology track.	Complements technology track.	Complements technology track.
Enforceability	Subject to challenge due to qualitative nature of the decision process.	Less challengeable than Ontario system.	Enforceable: difficult to challenge.
Consistency	Potential exists for major inconsistencies.	Limited potential for inconsistencies.	Consistent.
Cost effectiveness	Places high demand on the time of experts.	Streamlines demands on experts.	Highly cost-effective.
Technical soundness	Varies with the staff developing the standards.	High, but may mask subtle points of the results or lead to artifacts due to the structure of the system.	Technically sound.
Clarity and simplicity	The decision process is hard to retrace. Use of data is complex.	The explicitness of the process increases clarity, but the technical nature of the process is quite complex.	Clear and simple compared to the alternatives.

Overall the "total toxicity" standards approach embodied by the whole effluent system is superior with respect to each of the criteria except for comprehensiveness of impact types. Specifically, no adequate technology currently exists to adequately define "total" effect levels for human health and bioaccumulation impacts.

Some of the major strengths of the total toxicity approach are its ability to deal with:

i) the total combined acute and chronic toxic effects of complex effluents; and

ii) all contaminant types.

Also since the standard setting procedure involves a very limited number of values (ie, one for acute and chronic toxicity, respectively) and does not require an elaborate scientific research data, it is highly cost effective.

The structured process used by Michigan and the U.S. EPA is superior, regarding each of the evaluation criteria, to the system used historically in Ontario except with respect to technical soundness; both systems have weaknesses in this regard. The Ontario system is vulnerable to inconsistencies resulting from differences among expert panels for specific compounds. Their interpretation of acceptable safety factors, treatment of uncertainty and appropriate decision measures can significantly influence the final standard value. On the other hand, the structured decision process used by Michigan and the U.S. EPA restricts intuitive inputs by experts regarding subtle interpretations of supporting scientific data. This can force conclusions to be reached for some contaminants that are contrary to the intuitive conclusions developed by some experts.

CHAPTER 5 RECEIVING WATER CHARACTERISTICS

This chapter examines approaches for incorporating receiving water characteristics in toxics control programs. The approaches are evaluated in terms of the criteria set out in Chapter 2.

5.1 Mixing Zones

The concept and definition of mixing zones has been, and is today, a highly contentious issue. "The mixing zone mainly represents a loss of habitat but it must not be allowed to become an area where aquatic life is killed or seriously damaged." (MOE, 1984: p.11). It is "...the zone surrounding, or downstream from, a discharge location [and] is an `allocated impact zone' where numeric water quality criteria can be exceeded as long as acutely toxic conditions are prevented." (U.S. EPA, 1983: p.2-7).

Mixing zones are sections of waterbodies allocated for waste assimilation and dilution. The use of mixing zones is often a much more cost effective solution to removing toxic effects of effluents than elaborate and extensive treatment. In effect, mixing zones represent a tradeoff between the resource benefits that would be realized if the zones were not degraded against the increased costs of treatment that would be faced without a mixing zone provision.

The contentious points associated with mixing zones are:

a) it is an area in which water quality standards are not met and limited impact on aquatic resources is permitted; and
b) inadequate criteria often have been used to define mixing zone limits making their enforcement difficult if not impossible.

Little can be done to relieve concern, associated with the first point except to keep the mixing zone to a minimum and to ensure that the decision process as to the amount of the aquatic resource allocated for this purpose is reached collectively and openly. Better definitions of mixing zones can greatly reduce contention relating to the second point.

5.1.1 Regulatory and Physical Mixing Zones

A central issue in defining a mixing zone is whether one adopts the perspective of the mixing zone being a physical feature or a regulatory "allocation' as suggested in the U.S. EPA definition preceding. Two types of mixing zones are referred to in the following discussion.

a) Regulatory Mixing Zone (RMZ) is specified according to one or more waterbody characteristics (e.g., a proportion of the drought flow volume, surface area).

The allowable size of the RMZ is determined by a public policy decision to allocate a proportion of the aquatic resource for waste assimilation purposes. This decision is more or less independent of the actual physical mixing phenomenon of a waterbody and instead should be based to a large extent on the value of the aquatic resource being impacted.

b) Physical Mixing Zone (PMZ) is predicted using hydrologic/diffusion/ dispersion models or it can be measured directly under various hydrologic conditions. The boundaries of the PMZ are controlled by a variety of factors such as the volume, concentration and type of contaminants in the discharge, the design of the outfall and diffuser and the volume, turbulence and flow velocity of the waterbody.

Clearly the RMZ should be defined by the public and elected representatives based on the amount of aquatic resource that they are willing to allocate for mixing purposes. In our view, the most appropriate measure to define mixing zones is the area of a waterbody affected. Area is the common measure used by most states to define mixing zones in lakes but in flowing waters, usually a proportion of the design flow is allocated (see Appendix C). While the allocated design flow volume can readily be converted to area this is not normally done and the area corresponding to the volumetric RMZ depends significantly on the hydrologic and physical characteristics of the receiving waterbody.

5.1.2 Mixing Zone Boundaries

A primary weakness with current regulatory approaches to dealing with mixing zones is the lack of a quantitative definition that can be used to determine the precise limits of the PMZ. To be practically applicable, the definition must specify at what point or concentration complete, or the acceptable level of, mixing has occurred. For the definition to be operative, the PMZ boundaries must be measurable.

The differentiation between the RMZ and PMZ has not been made in the policies of any of the jurisdictions reviewed in this study or for which information is available. Understandably given these limitations, there is an aversion to focussing enforcement efforts on regulating mixing zones *per se.* Rather, enforcement attention has been directed to the end-of-pipe with the implicit assumption that if compliance with specified effluent limits is achieved, mixing zone requirements will be met. A primary reason for this strategy is the lack of precise definitions of i) the acceptable dimensions of the RMZ and ii) the boundaries of the PMZ.

A PMZ boundary definition has been developed to deal with this problem. Normally, on the basis of the RMZ volume (in addition to other factors), an acceptable end-of-pipe effluent contaminant concentration is derived. Also predicted either explicitly or implicitly is a contaminant concentration at the edge of the mixing zone (ie, after complete or acceptable mixing). If the volume of the RMZ and the effluent flow and the background and effluent contaminant concentrations are known, the boundary of the PMZ can be calculated and expressed in terms of contaminant concentration.

For example, consider a discharge with the following characteristics.

	Volume	Contaminant X Concentration (mg/L)
Effluent	1	30
RMZ	100	2 (background)

At the edge the mixing zone, the concentration of contaminant X would be estimated as (1*30+100*2)/(100+1) = 2.3 mg/L.

If an acceptable level of measurement precision of say 10% were deemed appropriate for this contaminant, a series of Water samples could be collected to plot the 2.53 mg/L (ie. 2.3+2.3) boundary or isopleth. By comparing the dimensions of the measured or predicted (if a mixing model were used) PMZ with the regulated RMZ, a precise determination of compliance can be made.

5.1.3 Conditions Within Mixing Zones

Ontario and the U.S. have similar qualitative requirements regulating water quality within the RMZ (see MOE, 1984: p.22-23; U.S. EPA, 1983c: p.2-8 - 2-9). These narrative conditions could be, but currently are not, supported by quantitative definitions. For example, "rapidly lethal" conditions could be defined as being able to meet a 100% 96 hr. LC_{50}. This would reduce the possibility of inconsistent qualitative interpretations of the conditions.

5.1.4 Relationship to Receiving Waterbody

RMZs in the U.S. are related to receiving waterbody characteristics via the design flow. However, in lakes no comparable link is made and a uniform RMZ is often specified in the regulations and guidelines. Or as is the case with Michigan, a case-by-case approach is used to setting effluent limits for non-flowing waterbodies. In Ontario, a qualitative requirement is set out to establish mixing zones "...by the Ministry on a case-by-case basis, where `case' refers to both local considerations and the waterbody as a whole or segments of the waterbody." (MOE, 1984; p.23). Needless to say, this narrative is left open to wide interpretation. Accordingly, it is difficult, if not impossible, to predetermine what the approved mixing zone will be. This conveys to the public the sense that the definition of mixing zones is highly arbitrary.

Since the designation of a RMZ is essentially a public policy decision, each "case", in essence, should require a high level decision and/or extensive public discussion to ensure that it accurately reflects collective aspirations. Without more definitive guidance, it is understandable that mixing zones are contentious and their determination is laborious, inefficient and has the appearance of being potentially capricious.

5.1.5 Proposed Procedures

Improvements on the U.S. systems for defining and applying mixing zones are possible. Following is a proposed modified procedure.

5.1.5.1 Mixing Zone Definition An overall guiding policy that can be consistently, clearly and simply applied in all cases is required. The policy therefore must be generalizable yet connected to site specific characteristics. By defining the mixing zone in terms relative to the site, this can be accomplished. The proposed system is designed to apply equally well to flowing and non-flowing waterbodies and to those of differing quality and significance.

The following examples indicate how the proposed system would operate. The RMZ for flowing waterbodies would be a function of the width. Say "x" is equal to the stream width, then the acceptable mixing zone would be calculated as a.x * b.x = RMZ area (eg., if a=0.5[1], b=20 and x= 15 m, then RMZ = 2250 m^2). The coefficients, a and b, would be set by a public policy decision.

For lakes, the equation might take the form of 0.5 ($\pi * r^2$) = RMZ area. The public policy variable in the equation is the acceptable size of the radius, r. To more adequately capture the effects of size and resource significance, the public policy variable, r, could be established as a function of lake size and use (see Section 5.4). For example, for lakes <10,000 ha, "r" might equal 20 m and for larger lakes, a value of 30 m might be deemed acceptable.

Within the RMZ, the mean depth would be calculated and the total dilution volume estimated. In some cases, where outfalls are located in deep waters, an excessive dilution volume could be present. A maximum acceptable depth for the RMZ in terms of calculating the dilution volume could be added to the system. However, caution must be exercised not to discourage outfalls in deep water sites. This would generally be counter to achieving overall environmental protection objectives.

Another key element to an effective system is the definition of the mixing zone boundary. As described in Section 5.1.2, a clear definition needs to be adopted. The primary decision that needs to be made is the acceptable level of sampling and measurement precision and hence, the upper concentration used to define the mixing

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1 The numbers in this section are for illustrative purposes only and are not intended in any way to represent suggested values. The values for these coefficients must be determined on the basis of a thorough review and discussion by all affected parties.

zone boundary. The acceptable precision may vary somewhat by the parameter being considered.

5.1.5.2 Maximum Dimensions The RMZ definition procedure leads to a measure of the allocated area for dilution/assimilation, but it is conceivable that certain configurations of the acceptable RMZ total area would be undesirable. For example, "shore hugging" plumes are expected to have a greater aquatic ecosystem impact than mid-water plumes. Likewise a narrow but greatly extended plume is more likely to interfere with adjacent uses.

The following limitations are advised:

a) set a maximum limit for longitudinal extent
b) set a maximum limit for lateral extent
c) set a maximum limit for length of shoreline impacted (i.e., length of shoreline contacted).
d) restrict boundary to prevent overlap with adjacent sensitive water uses (e.g., water supply intakes).

The first two conditions can be made a function of the waterbody characteristic variable used to estimate the RMZ. For example, in a stream, the maximum longitudinal dimension might be 20 times the stream width, x. Figure 2 illustrates these concepts.

5.1.5.3 Use of Mixing Zone for Approval

For evaluating a specific discharge, the allocated RMZ width coefficient (eg., a=0.5) would represent the proportion of the design flow available for mixing. This dilution volume would be used to set effluent limits at the point of discharge.

A subsequent step in the process would be to predict the extent of the physical mixing zone using physical dispersion, diffusion models and to confirm that the predicted shape met the dimensional requirements of the RMZ. (A number of mixing models are available, for example see Hamdy. 1981; Kohli, 1981; Gowda, 1980). If the predicted PMZ did not meet the RMZ conditions, modifications to the design would be required. For example, the effluent strength/quantity and/or the location and design of the outfall would need to be redesigned or modified. This process would be repeated until an acceptable predicted PMZ configuration is achieved.

In issuing approval, the conditions would specify effluent concentrations and quantity and allowable dimensions of the PMZ. The discharger would be responsible for ensuring adequate mixing such that compliance with the approval conditions is achieved.

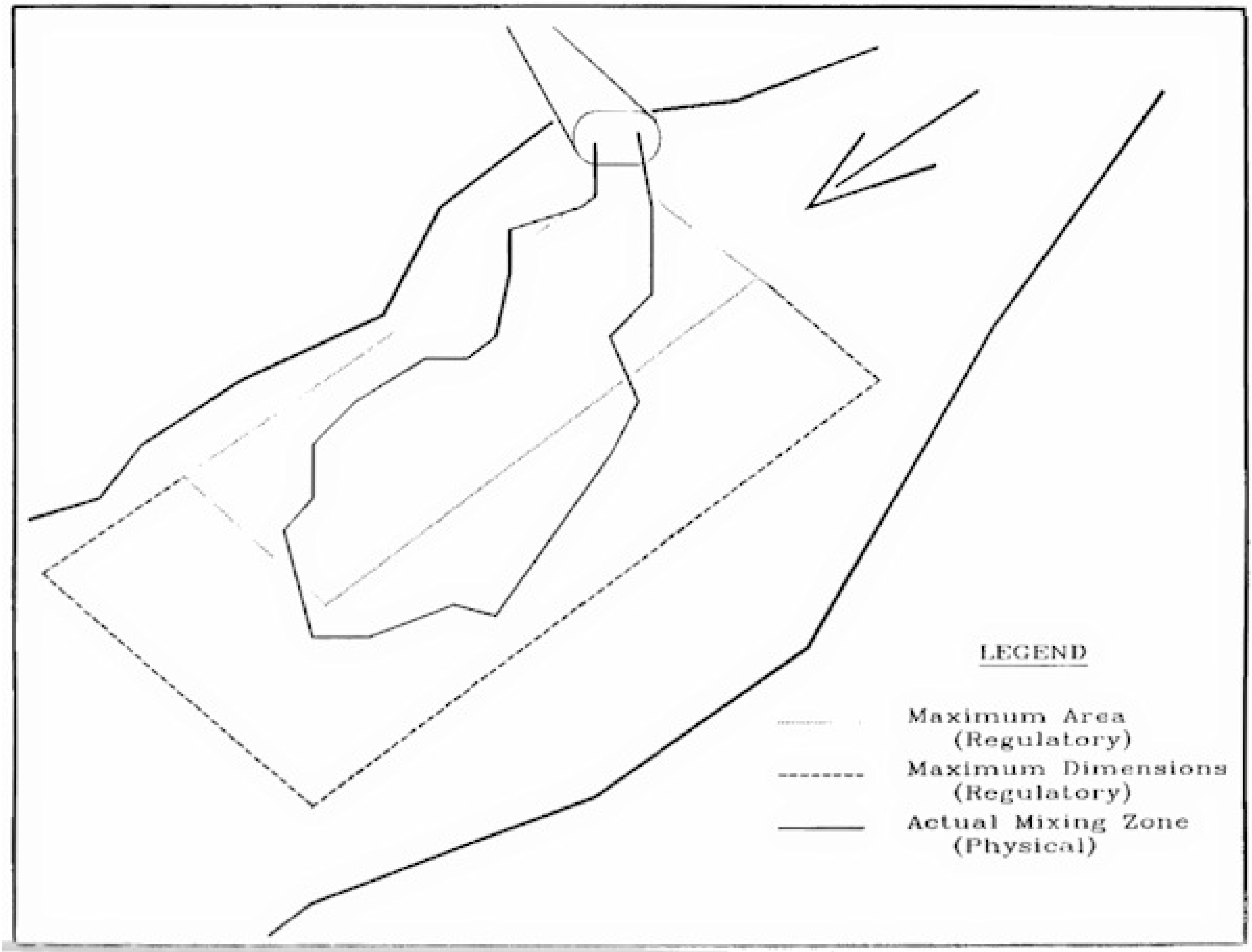

Fig. 2. Illustrative Definition of Mixing Zones.

5.1.5.4 Monitoring

The dimensions of the PMZ can be defined by field sampling given a quantitative definition of the mixing zone boundary contaminant concentration. Longitudinal and lateral sampling transects around the discharge would permit the mixing 2one boundary to be mapped. The configuration would be checked against the PMZ dimension conditions to ensure compliance.

5.1.5.5 Summary

Ontario currently lacks an adequately definitive mixing zone policy and while more definitive policies are being used in the U.S., they suffer from several major weaknesses. The mixing zone is an area of controlled degradation of water quality and the RMZ needs to be defined in areal terms and in terms of maximum dimensions. Also the definition of the RMZ boundary in chemical terms is essential. By setting out the permissible characteristics of the RMZ in quantitative terms, many of the underlying principles of MISA can be satisfied.

5.2 Design Flows

Aquatic communities in flowing waterbodies experience the greatest stress from toxic effluents during low flow periods, the primary reason being reduced dilution, but other factors may also play significant roles. For example, refugia may be limited, preventing avoidance of toxic plumes; mixing zones are more extensive; and predation and food competition are usually greatest. The use of low flow conditions to set effluent limits provides protection under "worst case" conditions.

There are a number of considerations associated with the derivation of design flows.

5.2.1 Return Period

The return or recurrence frequency is, in a sense, the desired level of protection. If a design frequency of 1 in 20 years is accepted; this is comparable to a risk of 1 in 20 per year. In other words, on average. every 20 years the waterbody will experience a period during which the toxic loads and associated aquatic impacts may exceed prescribed levels. The consequences of these exceedances will depend on their temporal distribution and magnitude, and the preventative actions taken in response by government agencies and dischargers to these occurrences.

As with regulatory mixing zones, the selection of an acceptable level of protection associated with a design flow is a public policy decision. Technical experts can provide information as to the potential environmental consequences of accepting different return periods but the ultimate selection cannot be made on technical grounds.

Design flows are generally uniform within jurisdictions in the U.S. However, there is reason for specifying the level of protection in relation to the significance of the water resource being protected. Normally, higher levels of protection (ie, longer return frequencies) would be assigned to Water systems with greater significance. This is comparable in concept to taking out insurance proportional to the value of the item being insured.

5.2.2 Duration

Duration is the length of the time over which the design flow persists. As the duration becomes shorter, the design flow volume tends to decrease. Therefore, short duration (e.g., 1 day) design flows are more restrictive and provide a higher level of environmental protection than do longer flow durations (e.g., 7 days).

In Ontario, a "7Q20" (ie, the 1 in 20 year drought flow that lasts for 7 days or more) design flow has been used. In the U.S., there is considerable variation with from 1Q3 to 7Q10 being used.

The appropriate design duration is similar to return frequency in that its choice ultimately comes down to a public policy decision. However, technical experts can provide meaningful interpretations in aquatic biology terms of the potential impact of varying durations.

As with return frequency, the length of duration specified does represent, to a degree, a level of protection. Therefore, duration also should be based partly on the significance of the receiving waterbody.

5.2.3 Statistical Methods

Logan (1986: p.9) advocates the use of the Gumbel (Fisher-Tippett Type I) distribution. The U.S. EPA method is based on the log-Pearson Type III flow estimating technique. The selection of an appropriate distribution is a technical issue which may have significant impact on the design flow.

To minimize confusion and challenge, an acceptable estimating procedure should be adopted by the Ministry. As part of this process, the rationale and application of the method should be published.

Another related issue pertains to bounded distributions. Statistical analysis techniques are limited somewhat by the length of record available for a water system. This is a pervasive difficulty in probability analysis of extreme events (e.g., flood prediction and nuclear accident risk analysis). If a high level of protection is desired (e.g., 10^{-6} as is the case with human health in some. jurisdictions), it is unlikely that an event corresponding to that return frequency is available in the flow records. While 10^{-6} is certainly an "extreme" value, the limitation is present also for lesser levels of protection. Many of the probability analysis issues raised by Adams and Howard (1986) regarding design storms and flood flows pertain equally to establishing drought flows.

5.2.4 Hydrological vs Biological Design Flows

As mentioned, the selection of design drought flows is ultimately a public policy decision. However, technical evaluations of alternative levels of protection have tended to focus almost exclusively on hydrological performance measures to select an appropriate design flow.

For example, Logan (1986) defined streamflow performance in hydrologic terms according to:

i) reliability - the likelihood that the design flow will be exceeded;

ii) resiliency - the time required for the system (hydrologically) to recover (ie, the duration of the low flow); and

iii) vulnerability - the volumetric shortage of flow below the design flow in a drought event.

Unfortunately, these terms have ecological connotations that are misleading. The analysis presented is based solely on hydrological characteristics of waterbodies and does not integrate associated biological effects or the notion of a "socially acceptable" level of protection.

The U.S. EPA is currently investigating the development of a biological design flow procedure (Biswas *et al*, 1986). Given that a central objective of controlling toxic discharges is to protect aquatic resources, it follows that an appropriate design flow performance criterion should be the level of stress expected to be experienced by the aquatic ecosystem. At the present time, appropriate biological performance criteria have not be devised and fully tested. Further work in this area is required to develop accurate procedures to establish biological design flows.

5.2.5 Flow Data Availability

Not all waterbodies in Ontario are gauged. For those that are, the length of record is often relatively short. This lack of data demands that procedures be developed to extrapolate from gauged rivers to effluent discharge points. A variety of procedures are available and the Ministry needs to formally adopt standard procedures that it feels are appropriate for Ontario.

If a biological design flow procedure eventually is adopted, procedures will be required to estimate certain site specific biological and use inputs (eg., productivity, resiliency).

5.2.6 Seasonal Flow Variability

Most design flows are derived by taking the records for each full year and estimating the corresponding minimum weekly low flow. By failing to recognize the annual periodicity of the flows according to season, inefficient use of the assimilation capacity of the waterbody is likely to result.

Michigan has recognized this in its Rule 90 (MDNR,1985). This rule permits effluent limits to be specified on a seasonal basis using the corresponding seasonal 7Q10 flow. Consideration should be given to similar mechanisms to optimize i) the use of the assimilative capacity of streams and ii) waste treatment costs.

5.2.7 Non-compliance During Low Flow

On occasions where the stream flow is less than the design flow, noncompliance is expected to occur. While permits may include provisions for dischargers to reduce effluent quantity and/or strength during low flow, it will be difficult to prosecute non-compliance during these events. This is not expected to be a major problem since these stresses will generally be accounted for in the biological design flow and the impacts likely to occur should be within the tolerance range of the receiving aquatic ecosystem.

5.3 Waste Load Allocation

The issue of waste load allocation arises where there are multiple discharges to a waterbody whose effects are overlapping. In these cases, the definition of the PMZ of a discrete discharge using direct sampling procedures may be difficult, if not impossible. As a result, specific procedures are required to deal with the allocation of the available assimilative capacity among dischargers, and for defining the RMZ.

Brandes *et. al.* (1985: p.40-42) describe 3 procedures to undertake waste load allocation modelling. They consist of:

a) steady state models
b) dynamic models
c) continuous simulation models.

The latter two approaches attempt to model the combined probabilities of stream flow and effluent variability. However, the dearth of reliable, effluent quality and, to a lesser extent, quantity data for most discharges make these approaches difficult, leaving steady state modelling as the only viable alternative. The key point is the need to consider the combined influence of stream flow and effluent variability in deriving appropriate toxic limits.

A related point is the ability of some dischargers to respond to stream flow rates in terms of effluent quantity and quality. Steady state modelling techniques used to set effluent limits for receiving waterbodies implicitly assume that effluent flows and concentrations remain constant, or at least, no reactive response to low flow conditions is made. This assumption can lead to overly protective effluent limits and may discourage dischargers to take mitigative actions during low flows.

For example, in a recent study prepared by JE Hanna Associates Inc. (1986) on a municipal sewage discharge. a discharge strategy based on stream flow was designed. Accordingly, the instream dilution realized even under drought flow conditions was much greater than if the discharge was constant.

In many cases. dischargers have some control over the quality and/or quantity of their effluent for short durations. During drought conditions, regular maintenance and clean-out procedures could be deferred reducing effluent strength. If treatment lagoons are used, storage capacity may be used to partly or totally reduce discharges for short periods of time.

No specific provision or encouragement within the regulatory system is made at the present time for these types of considerations in most U.S. systems reviewed. Michigan has recognized the potential of utilizing temporal flow variations (e.g., Michigan's Rule 90) but they do not have provision for a fulls controlled effluent-to-streamflow system in setting effluent limits.

Rule 90 makes provision to set seasonal effluent standards; in this way, utilization of the assimilative/dilution capacity can be effectively increased without compromising environmental protection objectives. This approach would be substantially facilitated if a minimum level of protection were set out rather than specifying a design flow *per se.* Design flows could then be computed for appropriate time intervals reflecting the variations in the flow of both the receiving waterbody and the discharge.

5.4 Water Uses

In the U.S.. waterbodies are classified into designated use classes. Several guidances have been prepared outlining the procedures to evaluate and designate water uses (U.S. EPA 1984a, 1984c, 1983a, 1983b). The applicable water quality criteria for discharges to waterbody sections or reaches may be modified by the designated use.

Ontario does not have a comparable system. The water quality objectives are uniform across the province. The only exception is "Policy 2" (ie, degraded) waterbodies where an antidegradation policy is applied and efforts are made to upgrade the system. However, given the wide diversity of waterbodies, aquatic communities, water user groups and environmental settings, and the resource planning and management systems adopted in related areas (e.g., forestry, parks, wildlife, land use planning), uniform water quality objectives and the lack of use classification are inconsistent with the overall resource management philosophy of Ontario and do not appear to be justified. Higher quality standards are required for more significant and better quality waterbodies than for those with less value and use potential.

The application of use and/or quality categories underlies a number of recommendations that have been made in the preceding sections of this report with respect to water quality standards, mixing zones and design flows. Water use/quality classes are an overt and important recognition of the diversity of water types and uses in the province and they offer a means to maintain this diversity and, in particular, to provide adequate protection for high quality waterbodies.

5.4.1 Water Use Planning System

The advantages of a systematic water use/quality plan for the province are similar to those afforded by other comparable planning systems (e.g.. Official Plans, MNR District Land Use Plans) in terms of achieving long term objectives and in allowing the public to actively participate in making these important decisions. By developing a systematic plan, direction is given to potential future dischargers regarding the level of control they can expect at different sites. This will tend to minimize future conflicts among environmental objectives and those of dischargers.

The major disadvantage is the time and effort required to develop such plans. If such a water use planning program were initiated, it would be a relatively long term endeavour. However, the benefits of a provincial water use/quality plan would, in our view, greatly outweigh the effort required to prepare it.

5.4.2 Interim Measures

In the interim during which comprehensive water use/quality plans are being prepared, decisions on approval of discharge applications need to be made. A case-by-case decision process, as is currently the practice, should be used but guidelines should be developed to provide direction on how to explicitly take into consideration significance of the waterbody for different Water uses. In keeping with the MISA objectives of clarity, simplicity and consistency, these procedures need to be formally documented. Also, the Ministry should announce, if our recommendation is accepted, its intention of proceeding with a comprehensive water use/quality planning system and begin fostering the public support necessary to make such a system effective.

CHAPTER 6 EFFLUENT LIMITS

This chapter evaluates alternative means of defining and measuring effluent limits. An effluent limit is the specified acceptable level of contamination in a discharge as measured either by concentration or load.

Two alternatives for setting effluent limits were evaluated:

a) chemical-specific limits
b) whole-effluent toxicity limits

6.1 Chemical-specific Limits

This has been the primary approach to controlling toxic discharges historically in North America and elsewhere. The approach is to define acceptable effluent concentrations or loads in a discharge for each specific contaminant of concern present. Acceptable concentrations are derived i) by referring to the designated provincial standards for the contaminants present and ii) by considering the dilution/assimilation capacity of the receiving waterbody.

Various shortcomings in the approach are known.

a) There may be contaminants in the effluent for which either the Ministry has no knowledge and/or no standard exists.

b) The combined effect of contaminants in complex effluents may be substantially different than the sum of their individual effects and adherence to individual chemical-specific standards may be significantly over- or underprotective.

c) Analysis costs can be prohibitive if frequent sampling for a wide range of contaminants in complex effluents is required.

6.2 Whole Effluent Toxicity Limits

This approach has been developed in the U.S. over the last 5 to 10 years and whole effluent limits are being introduced into discharge permits on a regular basis in some states. Historically, toxicity monitoring has been required of discharges in Ontario on occasion but in the case of exceedances, dischargers could not be prosecuted since toxicity limits had not been specified. The exception in Canada is the federal pulp and paper effluent regulation promulgated in 1971 (Environment Canada, 1971) but for various reason, this has only rarely been enforced.

The approach being promulgated by the U.S. EPA (Brandes *et. al.,* 1985) is designed to prescribe enforceable, whole-effluent toxicity limits for individual discharges. Central to the approach is the development of a series of technical support documents, procedures and guidelines in particular standardized analytical procedures to ensure reliable, replicable test results (Horning and Weber, 1985; Peltier and Weber, 1985).

While the method captures the net (ie, total combined) toxicity of complex effluents, there are some shortcomings, namely:

i) No reliable test procedures are available to measure impacts due to bioaccumulation or on human health.

ii) The system has only recently been introduced and has not had time yet to establish a good "track record" (see Appendix D).

6.3 Effluent Limit Estimation Procedure

The estimation procedure for setting effluent limits is clearly set out (U.S. EPA, 1986) and similar procedures have been developed by individual states. The basic steps are as follows:

1) Determine appropriate water quality standard at edge of mixing zone.
2) Determine available mixing zone.
3) Estimate design flow.
4) Calculate available dilution volume.
5) Back-calculate maximum concentration at "end-of-pipe" assuming complete mixing.

If the procedure proposed for defining mixing zones is adopted, several steps would be added to the process.

6) Model dimensions of mixing zone.
7) Check for compliance with regulated configuration.
8) If unsuitable, reduce effluent concentration or quantity and/or modify outlet design. Repeat steps 6, 7 and 8 until suitable design is achieved.

This type of comprehensive procedure would satisfy many of the MISA goals reflected in the evaluation criteria.

6.4 Evaluation of Alternatives

Table 6.1 summarizes the evaluation of the two alternatives. Both have certain strengths and weaknesses. The systems do not need to be mutually exclusive; in fact, they are quite complementary. The whole effluent approach provides excellent measures of acute and chronic toxicity but is not capable of dealing with bioaccumulation and human health impacts. Chemical-specific limits can deal with these latter two types of impacts reasonably effectively. As a result, a combined system would be optimal if it consisted of whole effluent toxicity limits being used to control acute and chronic toxicity and chemical-specific limits being used to control bioaccumulation and human health impacts.

TABLE 6.1. EVALUATION OF EFFLUENT LIMITS.

	Chemical-specific	Whole-effluent
Comprehensiveness	There may be contaminants for which there is not a standard.	Comprehensive, but techniques to regulate human health and bioaccumulation impacts are not available (see Table 4.1).
Flexibility	Relatively inflexible: cannot capture synergism	Very flexible
Complementarity	Complements the technology-track	Complements the technology-track
Enforceability	Depends on implementation strategy	Depends on implementation strategy
Consistency	Due to a lack of information, some discharges maybe regulated for a contaminant and others not	Good
Cost-effectiveness	Depends on the number and types of tests	Depends on the number and types of tests
Technical soundness	Good	Good
Clarity and simplicity	It may be quite complicated to derive and specify limits for individual contaminants	Clear and simple

CHAPTER 7 COMPLIANCE

This chapter examines the various mechanisms available to ensure compliance with toxic control . programs. The methods are assessed in terms of the evaluation criteria set out in Chapter 2.

7.1 Definition of Compliance

The purpose of all measures and procedures to control water quality is to ensure that water quality objectives are being met. Meeting these objectives is what is meant by compliance. In some cases, this is brought about by enforcement: the taking of administrative actions to force dischargers to adopt a new technology or operating procedures in order to reduce contaminant releases to aquatic systems. To some extent, compliance is brought about by the threat of enforcement or punishment. However, compliance is concerned with more than just punishment or threats of punishment, it is concerned with meeting water quality objectives. If these can be met without punishment or threat of punishment, all the better.

7.2 Legal and Administrative Options

There are a number of legal and administrative options available to the regulator to secure compliance. Among these are approval of works, licenses or permits, and regulation of either discharge limits or the process for determining limits. In practice, an effective control regime will require a combination of these options.

7.2.1 Approval of Works

Historically in Ontario, Certificates of Approval were approvals of works. The proponent's plans would be reviewed and if the Ministry felt that the proposed technologies would be adequately protective of the environment, then a certificate would be issued. Because the approval was based on a review of the technology, the certificate did not usually have a fixed term. The proponent would only need to seek re-approval if some change was being made to the technology.

Comprehensiveness This option is comprehensive to the extent that all discharges are required under the Ontario Water Resources Act (rarely under the Environmental Protection Act) to acquire a Certificate of Approval. However, the approach does not necessarily ensure that all types of pollutants and impacts are addressed. Further, without an expiry date, there is limited capability for updating as knowledge of the toxicity and impacts of various contaminants improves.

Complementarily Much of what this approach achieves will be superceded by the "technology track" of MISA rather than complementing it. Both focus on works. This type of approach is seen as superfluous with the adoption of the proposed MISA technology regulations.

Enforceability Without regulations specifying effluent limits or water quality standards, an approval of works does not provide much opportunity for enforcement if the technology is installed according to plans. To successfully prosecute a discharge made by approved works, the Ministry must demonstrate environmental impairment or contravention of a provision of the Certificate. The only point of control within this system is when works are operated without approval.

Consistency Under this option, it is possible to address special technological and economic situations and ensure that all dischargers are treated in a fair way. However, without formalized procedures to be followed, this is unlikely to result. Further, because there is no regular renewal period, it is likely that applications made at different times will be inconsistent as a result of differences in data and requirements current at the time of application.

Cost effectiveness Individual review of each discharge is required, which is resource intensive. However, the enabling legislation is relatively straight-forward (it already exists under the Ontario Water Resources and Environmental Protection Acts).

Technical soundness Part of the technical integrity of the approach comes from its ability to deal with special circumstances; however, the connection between works approval and water quality may be difficult to clearly establish and, even more importantly, to ensure. There is limited opportunity for post-approval monitoring to ensure that objectives are being met by the works.

Clarity & Simplicity Although relatively simple in concept, the option is not as clear as others in making the connection between operations and environmental protection.

7.2.2 Licensing

Licensing is a powerful tool to allocate use of public property, such as natural resources and the air waves (LRCC, 1986: p.41).

National Pollutant Discharge Elimination System (NPDES) permits are a primary operational tool used in the United States to regulate effluent discharges. These permits are issued by states with delegated authority or by regional offices of EPA and are required for any effluent discharge, either new or existing. to the natural environment. The permits are renewed on a regular basis, usually every 5 years, at which time, the permitted effluent limits may be adjusted in keeping with developments in technology and knowledge of environmental impacts. To help ensure consistency and the meeting of water quality objectives, there is an effort by some jurisdictions to have coincident expiry dates on all permits within a watershed.

In recent years, the Ministry's use of Certificates of Approval has become more and more like a licensing process, with the exception that licenses are usually for a fixed term. Inclusion of such provisions as requirements for monitoring and reporting quantities and types of discharges, and for performance measures is much closer to the concept of a licence than to an approval of works.

In both the U.S. and the Ontario situation, there is provision for issuing orders where there is non-compliance with the legislation or permits. In the U.S. these are Final Orders, in Ontario, Control Orders or Requirement and Directions. These are intended to develop a schedule of compliance, and to avoid prosecution where efforts are underway by the discharger to rectify the situation.

Comprehensiveness A licensing scheme can be comprehensive, if all dischargers are required to obtain a permit and if there are whole-effluent and chemical-specific limits to ensure all constituents are covered.

Complernentarity The permitting option complements the regulatory approach being proposed for the technology track.

Enforceability Control of licensees can be exercised in a number of ways. In most situations, this operates by threat of licence suspension or revocation if there is not adherence to the conditions of the licence. Another sanction that can be applied is the shortening of the licence term, a technique often used by the CRTC to promote compliance. The Ontario Water Resources Act identifies non-compliance with the terms of a Certificate of Approval or licence as an offence which can be prosecuted.

A proponent who is given a licence is governed by the specific conditions included in the licence, and may also be governed by generally applicable legislated standards. In some licensing schemes, compliance with regulations is made a condition of licensing, so that their breach can give rise to licensing action, prosecution for regulatory offence, or both.

Consistency As for "approvals of works", it is possible to address special technological and economic situations and ensure that all dischargers are treated in a fair way. However, without formalized procedures to be followed. this is unlikely to result. The regular renewal term associated with licensing schemes enables revisions of allowable limits in response to new information.

Cost effectiveness Individual review of each discharge is required with each renewal. This is resource intensive. As for approval of works, the enabling legislation is relatively straight-forward.

Technical soundness Properly and impartially executed, a licensing scheme is technically sound.

Clarity and simplicity A licence is applicable when the nature of compliance can be clearly specified. Enforcement is difficult if conditions of the permit or licence are vague or ambiguous (Franson *et al*, 1982: p.186). However, there is good reason for including non-enforceable conditions, as well as enforceable ones, in a licence. Including these conditions advises the licensee of government intention, and thus helps reduce the grounds for complaints about preemptory rule changing (Franson *et al.* 1982: p.187).

7.2.3 Regulated discharge limits

Although control of discharges can be exercised by regulating discharge limits themselves, this approach has not yet been used in Ontario for aquatic discharges. However, under Regulation 308, such an approach is used for atmospheric discharges. Ambient criteria are developed by the Environmental Air Standards Setting Committee (EASSC) taking into account sampling timed differentials, background contaminant concentrations. technological considerations, and other factors such as synergistic reactions, air reactions, and special health considerations which may affect the time dosage (Martin & Kupa, 1977).

In the United States. discharge limits are specified in regulation under the federal Clean Water Act and supporting regulations (e.g., water quality criteria). This leads to a "strict liability" situation whereby any effluent containing a compound in excess of the limit is in violation and the discharge is susceptible to prosecution by federal or state governments or a third party.

Comprehensiveness Unless there is a whole-effluent toxicity criterion, regulating discharge limits alone cannot be comprehensive: there will always be compounds for which there are not limits. New regulations will need to be added on a regular basis. Also they will not capture synergistic/antagonistic interactions in complex effluents.

Complementarity MOE has indicated that regulations will be introduced on the technology side. Introducing regulations governing discharge limits would be quite complementary in philosophy and practice.

Enforceability In theory, regulating discharge limits makes it possible to take legal action if the limits are exceeded. In practice. it is not always so simple. In the case of Regulation 308, the standards are measured at the point of impingement, and although there is a specific model for calculating the concentration from a particular source at the point of impingement, actual concentrations at an individual point may be the result of contributions from numerous sources. Further, although the dispersion model predicts where the point of impingement will occur, there is a considerable degree of uncertainty associated with the actual location of this point. Given that there is no requirement in the regulation *per se.* or in the Act to monitor, record and report emissions at the point of discharge, it is difficult to enforce these "enforceable" standards.

Consistency Providing a consistent level of protection of water quality may be difficult using this approach because of differences in the characteristics of the receiving waterbody. The potential difficulty in updating the limits regulation may mean that there is not consistency across compounds for which limits were set at different times.

Cost effectiveness The effort required to establish discharge limits is significant, though probably unavoidable under all legal and administrative options. The EASSC has the capability of establishing about 25 to 30 criteria a year (Nagy, 1987). However, as of 27 April 1987, there were 133 outstanding requests for medical advice for the development of ambient air standards, some of these requests dating back as far as 1979 and 1980 (MOE, 1987c). The Ministry also sets tentative air quality design standards, guidelines and provisional guidelines Where full data are not available to support setting a criterion for a particular compound (MOE, 1987b). These can only be enforced under the approval process for individual applications.

Technical soundness Assuming that the limits are specified in such a way as to enable consideration of the characteristics of the receiving environment, regulating the limits is technically sound. However, it may be impractical to include the range of significant receiving environment factors and variations thereof in regulation.

Clarity and simplicity This option is simple and easy to understand. Assessing whether or not water quality objectives are met, or whether a particular discharge exceeds the allowable limit is straightforward.

7.2.4 Regulated process

An alternative to regulating discharge limits is to regulate the process by which limits are determined, and compliance is assessed. This is the approach used in Michigan under Rule 57. With this approach, there may be an incentive for dischargers to provide new toxicologic studies to the regulator to demonstrate that a less stringent standard would achieve the desired environmental objectives. This incentive is likely to be used primarily by larger dischargers, but it will benefit all dischargers.

Comprehensiveness By specifying an appropriate procedure for deriving limits, all types of pollutants can be covered as information on their impacts comes available. Although all discharges would be covered by the regulation, the cumulative effect of multiple discharges cannot be readily incorporated.

Complementarity Regulating the process is complementary to the technology track.

Enforceability This option is as enforceable as the regulated discharge standards options.

Consistency The major benefit of this approach is that it clearly delineates the basis on which discharge limits are set, and therefore assures that consistency is provided across criteria. Because the process and not the discharge limits are regulated, regular updating of limits in response to new information is possible without making any changes in the regulation.

Cost effectiveness Although specifying the process is initially difficult, determining limits for particular criteria is simplified and streamlined by the explicitness of the process. The option is relatively simple to implement.

Technical soundness The technical soundness of the option is dependent on the technical integrity of the standard setting process utilised.

Clarity and simplicity The explicitness of the procedure means that it is necessarily clear how discharge limits will be and are determined. Although the approach is conceptually simple, the process itself is likely to be complex if it is capable of dealing with the required range of potential circumstances that can occur.

7.2.5 Combinations

The four options outlined above each have various advantages and disadvantages when evaluated against the criteria described in Chapter 2. In order to build on the advantages, an effective control scheme is likely to consist of combinations of these options. Table 7.1 considers combinations involving licenses.

Table 7.1. Comparison of licensing combinations.

Criteria	Licensing (no regulation)	Licensing with Criteria Regulation	Licensing with Process Regulation
Comprehensiveness	In principle, the licence can be comprehensive.	Provided that the licensing process is not Limited to contaminants with regulated criteria, comprehensiveness is possible.	Comprehensivity is a major attraction of this option.
Complementarity	Complements the technology track	Complements the technology track	Complements the technology track
Enforcement	A licence requiring monitoring and reporting, and with clear conditions which were negotiated with the licensee is likely to be followed and/or enforceable.	If the Licensee was not involved in the setting of the criteria, it maybe more difficult to ensure compliance. Violation of the criteria may be defended on the grounds of due diligence.	Violation of the criteria which emerge from the application of the process may be defended on the grounds of due diligence if the licensee was not involved in the development of the process and there resulting criteria.

Consistency	Unless a formalized procedure is followed for determining the conditions of the permit, it is not possible to ensure consistency.	Consistent application of criteria is ensured under this option. However, although the criteria are consistent, the degree of protection they offer may not be. Criteria may provide more or less protection depending on the characteristic of the local receiving body. In setting criteria for existing operations, application of uniform criteria is fair, but in setting criterion for new operations, it is desirable to aim for a consistent degree of environmental protection, rather than consistent criteria.	If the procedure is properly defined to account for the relevant factors, then this option offers the greatest degree of consistency, if properly applied.
Cost effectiveness	Requires case-by-case review. Only regulation required is to get a license.	As for licensing alone plus the need for regulations for criteria.	As for licensing alone with the need for regulations for the process.
Flexibility	Very flexible. Capable of dealing with special circumstances, both economic and environmental.	Less flexibility. Criteria may not be adaptable to site-specific circumstances.	Less flexibility. Any flexibility must be specifically identified in the process regulation.

CHAPTER 8 RECOMMENDED SYSTEM

This chapter draws on the evaluation of alternatives presented in Chapters 4 to 7 and makes specific recommendations as to the preferred alternative for each component in a receiving Water-based toxics control program for Ontario.

8.1 Water Quality Standards

Of the three alternative systems reviewed for setting water quality standards for toxic contaminants, the "total toxicity" approach is clearly superior with respect to all evaluation criteria except for comprehensiveness in terms of impact types. The absence of good whole effluent analytical measures for bioaccumulation and human health is a serious deficiency. As a result, it is recommended that toxicity standards be set for acute and chronic effects to aquatic ecosystems.

As part of the standard setting procedure, it is recommended that the definition of the toxicity standards be referenced to a standard analytical method of determination.

The structured standard setting procedure used by the State of Michigan and the U.S. EPA is superior, with respect to the evaluation criteria used, to the current Ontario system for all criteria except technical soundness. Neither system is clearly dominant from this perspective. The technical soundness of the Ontario system is vulnerable to the composition of the expert panel used to establish a standard and the implicit decision rules they use to deal with uncertainty and the scientific data before them. The Michigan system may obscure or preclude intuitive interpretation of the scientific data such that incorrect conclusions are reached. The relative importance of these two types of errors could not be established in this study. As a result, it is recommended that a controlled and detailed comparative analysis of a cross-section of standards developed by the two systems be undertaken to determine sources of discrepancy and to modify the U.S. system to overcome any deficiencies uncovered as a result of the analysis.

If no major deficiencies are identified in the U.S. system or those that are uncovered can be mitigated, then it is recommended that Ontario adopt an explicit standard setting procedure along the lines of those used by the State of Michigan and the U.S. EPA. If this recommendation is enacted, consideration should be given to addressing some of the technical weaknesses identified in Appendix B such as the limited amount of guidance provided on the selection of uncertainty factors.

Currently, human health considerations are partially and indirectly assessed by the Ministry of the Environment in setting ambient water quality standards. It is recommended that human health considerations be explicitly incorporated in the standard setting procedure for ambient water quality to account for both direct and indirect effects. This recommendation may require the involvement of other government agencies (e.g., Ministry of Labour, Health and Welfare Canada, Environment Canada) in setting ambient water quality standards.

8.2 Receiving Water Characteristics

Three factors pertain to receiving waterbody characteristics:

a) design flow
b) mixing zones
c) water use.

Recommendations are made for each.

8.2.1 Design Flow

Design flows must be formally established. The questions are: by what procedure? and what is an acceptable level of protection?

Procedural alternatives include various statistical and hydrological techniques. It is recommended that Ontario formally adopt a probability distribution technique to predict extreme event drought flows. A significant constraint faced in some circumstances will be the lack of an adequate historical flow record. Accordingly, it is recommended that formal procedures be developed to estimate design flows for ungauged waterbodies based on records from comparable gauged systems.

Design flows in Ontario and elsewhere have been specified in hydrologic terms which are often totally independent of the aquatic resources that are to be protected. Efforts are underway in the U.S. to develop a design flow estimating procedure based on a desired level of protection and the biological characteristics of the receiving waterbody. It is recommended that **a uniform level of protection for estimating design flows <u>not</u> be used throughout the province; instead, the level of protection should be related to the tolerance of the receiving aquatic ecosystem and its use and value**. Higher protection should be afforded to more sensitive and/or valuable waterbodies. For practical reasons, it is not anticipated that more than 5 or 6 water use categories would be defined.

Design flows are normally specified on an annual basis. This tends to underutilise the assimilation capacity of receiving waterbodies. It is recommended that **design flows be permitted for variable intervals according to prescribed levels of environmental protection and the ability of the discharger to regulate its effluent volume and concentration.**

8.2.2 Mixing Zones

Permitting mixing zones represents a decision to allow limited local environmental degradation to facilitate assimilation of toxics by receiving waterbodies. As such, the definition of the permissible extent of a regulatory mixing zone is strictly a public policy decision which cannot be resolved by technical analysis and modelling. However, by strictly defining the acceptable physical dimensions and chemical characteristics of regulatory mixing zones, they can be employed in a manner consistent with prescribed policy and compliance can be estimated using technical analysis and monitoring tools.

In the U.S., regulatory mixing zones in flowing waterbodies are typically defined in volumetric terms; mixing zones in non-flowing lotic systems are defined in areal terms. It is recommended that **regulatory mixing zones be defined for both flowing and non-flowing waterbodies in areal terms that are a function of the physical characteristics of the receiving waterbody**. For example, a mixing zone for a stream might be expressed as $2*(\text{stream width})^2$ with a maximum width of 50% of the stream width and a maximum length of 6*stream width. The boundary of the physical mixing zone should be defined in quantitative terms (e.g., the limit at which the estimated completely mixed concentration is measured in the receiving waterbody). This system will ensure that adherence to a regulatory mixing zone can be confirmed by predicting and/or measuring the physical mixing zone.

Within individual jurisdictions in the U.S., regulatory mixing zones are generally uniformly defined throughout according to design flow. The rationale for this uniformity is obscure and poorly founded. It is recommended that regulatory mixing zones be defined on the basis of the physical characteristics and significance of the receiving waterbody, rather than be uniform throughout the province. The size of the regulatory mixing zone should be related to the size and significance of the waterbody.

8.2.3 Water Use

Currently in Ontario, no differentiation, in terms of water quality objectives, is made among waterbodies that affects their relative significance or use potential. Throughout the U.S., water quality standards related to "designated uses" and detailed use assessment procedures have been instituted. The preceding recommendations pertaining to design flows and mixing zones imply an assessment of significance and use. Based on discussions with Ministry staff, biological significance assessments are currently used in setting priorities and level of protection. It is recommended that **formal significance/potential use assessment procedures be developed and be broadly applied across the province**. These procedures should be sufficiently explicit so that non-government organizations can apply them to establish the significance/use category relevant for estimating design flows and mixing zones when making or reviewing applications for approval from the Ministry.

8.3 Effluent Limits

Two alternative systems were reviewed for setting effluent limits, namely

a) whole effluent toxicity
b) chemical-specific concentrations.

The whole effluent approach is superior to a chemical-specific system; however. suitable whole effluent analytical procedures are not available for contaminants that bioaccumulate or that are carcinogenic or mutagenic. Until adequate protocols for carcinogens and contaminants that biomagnify are available, a combination of the two systems is required. It is recommended that **whole effluent toxicity limits be used to control contaminants with direct acute and chronic toxicity effects on aquatic resources and that chemical-specific effluent limits be set for contaminants with bioaccumulation potential and/or human health effects**. If suitable whole effluent techniques for bioaccumulation and human health effects are developed, these should be used to eventually replace chemical-specific limits.

Considerable progress in perfecting accurate techniques to measure effluent toxicity has been made in the U.S., and elsewhere; standard procedures for acute and chronic tests have been published. It is recommended that **Ontario adopt acute and chronic toxicity testing protocols that are comparable in terms of comprehensiveness, efficiency and reliability to those being used in the U.S.** It is also recommended that these standard tests be used to define compliance of discharges with specified toxicity limits.

The definition of effluent limits is of primary importance. It is recommended that **effluent limits be defined in terms of both concentration and load over several time periods**. For example, an effluent limit for total toxicity might specify a maximum acute lethality for a single grab sample. a 24 hour composite sample and a total toxicity load for a month which would be calculated as the discharge volume times the corresponding toxicity. By providing various "levels of definition" in the effluent limits, maximum protection of the environment is provided while permitting successful prosecution of violations.

8.4 Compliance

Compliance consists of several components, namely

a) effluent monitoring
b) enforcement
c) performance assessment

The term "compliance" is used to mean the successful achievement of environmental objectives by whatever means. It therefore consists both of measures of performance and mechanisms to regulate performance.

8.4.1 Effluent Monitoring

A major weakness in all toxics control programs reviewed is the difficulty of measuring periodic large variations in effluent characteristics. Based on information collected in U.S. studies, effluent variability is of major importance in determining aquatic impacts of toxic effluents. A number of compliance monitoring strategies for recording this variability are available (e.g., short-interval, regular sampling: composite samples).Inadequate data are generally available for many Ontario discharges to anticipate temporal characteristics of effluent quality and to strategically determine appropriate monitoring program characteristics. It is recommended that **sampling frequency generally be intensified and that greater reliance be placed on composite samples and continuous whole effluent testing procedures.** Sampling frequency might be relaxed for an individual discharge after a sufficient record has been compiled to reasonably determine a suitable sampling frequency and the range in effluent toxicity.

8.4.2 Enforcement

The expectation by dischargers of effective enforcement of environmental regulations is a central element to ensuring compliance. Effective enforcement depends on a reasonable likelihood of i) detection of noncompliance occurrences, ii) successful prosecution of detected cases and iii) adequate penalties on conviction to act as deterrents. Detection and successful prosecution can he significantly affected by the nature of the toxics control program adopted and the definition of associated effluent limits for individual discharges. Penalties are controlled by legislation and the courts, and will not be dealt with further.

Various administrative mechanisms for controlling compliance were examined. It is recommended that **regulations be used to define the procedures to be used to set water quality standards and that the resultant values be binding in determining acceptable environmental performance**. The embodiment of water quality standard setting procedures in regulation will assist in successful prosecution. Rather than the need to demonstrate impairment to the environment, the Ministry will *need* only to prove that one or more standards, derived according to a regulated procedure, were violated.

Effective prosecution can be aided also by the mechanism for controlling individual discharges and the definition of effluent limits therein. It is recommended that specific legally-enforceable "end-of-pipe" effluent limits for individual discharges be set out in discharge licenses or Certificates of Approval. Such a system will permit environmental officers to achieve compliance directly by means of sampling discharges rather than ambient water quality.

These recommendations all will assist in successful prosecution but will not ensure detection. Two principal mechanisms for detection are available i) frequent controlled sampling with mandatory reporting and ii) periodic independent audit sampling.

It is recommended that **Ontario continue to demand dischargers to sample their effluent and to report the analytical results to the Ministry**. The frequency of sampling and the timing of sample collection should be related to the variability of the discharge as discussed. It is also recommended that **independent audit sampling be regularly undertaken to a level adequate to demonstrate clearly that accurate and representative samples and results are being obtained**. Significant public skepticism of the validity of samples collected by dischargers exists. Inadequate data are available to prove or disprove this contention at a general level. Accordingly, it is recommended that **a representative group of discharges be selected and intensively monitored to assess the degree of contaminant quality variation and how well this is reflected in routine monitoring results.**

8.4.3 Performance Assessment

Performance assessment consists of evaluating the status or health of the receiving aquatic ecosystem to determine if the desired level of environmental quality and/or .protection is being achieved. Such assessments have been routine practice within the Ministry for some time and efforts are underway with the "Pilot Site" studies to improve techniques for conducting these surveys. It is recommended that **a sample group of ecosystems be selected for intensive performance assessment monitoring over a period of 10 years or more before and following implementation of a toxics control program**. Aggregate data for the province are available but since none are derived from intensive examinations of specific sites, they all suffer from common weaknesses of representativeness and accuracy. Intensively evaluated examples in combination with more gross provincial statistics will provide the necessary information to assess the performance of toxics control initiatives. Care, however, is warranted in the selection of the ecosystems to be intensively studied. The sample should contain ecosystems with a range of environmental characteristics and various types and quantities of discharges. In practice, the ecosystems will be chosen primarily on the basis of the discharges, with preference being given to ecosystems receiving single source discharges so that a connection can be made with the effluent limits being used.

CHAPTER 9 IMPLEMENTATION STRATEGY

Chapter 8 describes the components of the recommended receiving Water-based toxics control program. This chapter recommends a strategy for implementing this program in Ontario.

9.1 BAT(EA) and Receiving Water-based Controls

The "technology" and "water quality" tracks of MISA are intended to be complementary; however, the scheduling of the "technology" track is ahead of the other. If receiving water-based controls are implemented following BAT(EA), there are a number of potential consequences.

i) The importance of receiving water-based controls may be viewed as being secondary, rather than complementary, to BAT(EA) and may not be treated with the same *degree* of priority.

ii) Many dischargers will be faced with making substantial investments to modify their waste management practices to comply with BAT(EA). Further investments may be required to meet receiving water-based limits. More efficient systems and investments will result if the dischargers are given as clear an indication as early as possible of the level of performance expected for the foreseeable future.

iii) There is a minimum "lead time" required to implement a new program which is determined by various public and private factors. The implementation of BAT(EA) is, and will continue to, preoccupy staff of government and dischargers for at least the next three to four years and likely much longer. If receiving water-based limits are introduced during the adjustment period to BAT(EA). it is highly unlikely that they will be implemented until the "technology track" limits are fully dealt with. As a result. the implementation of receiving water-based limits could be delayed significantly by a phased introduction after BAT(EA).

It is recommended that **priority be given to accelerating the water quality track program to the schedule of BAT(EA) and that the anticipated regulations controlling toxic effluents under MISA embody simultaneously both BAT(EA) and water quality considerations.**

9.2 Receiving Water Design Standards

Three receiving water characteristics for setting effluent limits have been identified; namely

a) mixing zones
b) design flow
c) water use

Specific recommendations have been made defining mixing zones and design flows and it has been recommended that the acceptable values be a function partially of water use. It is recommended that **the design standards and process to be used by Ministry staff for estimating acceptable mixing zones, design flows and water use classes be embodied in regulation and that the Ministry be required to issue periodically technical manuals clearly setting out the analytical and modelling procedures to be used**.

9.3 Water Use

Fundamental to the concept of environmental planning and management is the allocation of resources for desired uses and ends. Without this concept, one is driven to uniformity and inefficiencies. It is recommended that **a public water use planning system be developed for Ontario that sets out individual goals and objectives for specific waterbodies or sections thereof according to the capability of water systems to satisfy the requirements and aspirations of the people of Ontario**. The potential scope and scale of this undertaking is large and is expected to require a number of years to implement. Until a province-wide system is operational, it is recommended that **the Ministry establish interim guidelines for determining appropriate uses for waterbodies on a case-by-case basis**. These guidelines could be constructed along the lines of the use attainability manuals prepared by the U.S. EPA (1983a, 1984a, 1984b). The water use classes arising from the analysis should be integrated with mixing zone and design flow procedures and standards.

9.4 Discharge Control Mechanism

Effluent limits are currently being incorporated in Certificates of Approval on a regular basis in Ontario. However, this administrative mechanism has a number of serious weakness for implementing an effective toxics control program as discussed in Chapter 7. Accordingly, it is recommended that the current Certificate of Approval process be replaced by a licensing system that would issue discharge licenses for fixed periods of time that would set out specific effluent concentrations and total loads. By limiting the term of the licence, discharge performance criteria can be updated on a regular basis.

If the preceding recommendation is not adopted, it is recommended that **effluent limits be defined in all Certificates of Approval for toxic contaminants and that a system be instituted to periodically review and reissue Certificates with appropriate modifications to the effluent limits**. Implicit in these recommendation is a shift from "approval of works" to approval of effluent discharges. By approving Works, there is the potential for the Ministry to compromise its future position to demand changes to an operation in terms of effluent characteristics. Also, with contaminant concentrations in effluents being regulated, little or no benefit is realised from the approval of the works themselves; as a result, the practice should be discontinued eventually.

These recommendations will mean processing significantly more applications. However, conducting the approval process for each should be simpler than the current system due to i) clearly specified procedures for setting effluent limits, ii) a more limited scope of review (ie, detailed designs of works do not need to be reviewed), and iii) the future availability of monitoring data. Where a discharger seeking renewal has a good compliance record and monitoring data indicate adequate protection of the environment, renewal will be a simple and straightforward process.

9.5 Updating Process

A requisite to satisfying requirements such as comprehensiveness, consistency and technical soundness is to regularly update the toxics control system. A major limitation of the existing Ontario system is the lack of provision for updating in response to new information. Several of the recommendations made in this study are designed to facilitate updating (e.g, use of a regulated structured decision process to set water quality standards; fixed period discharge licenses rather than Certificates of Approval). It is recommended that **a regular updating process he institutionalized within the administrative structure and procedures of the Ministry to revise water quality standards for specific contaminants**. The revised standards should be published. A review interval for specific contaminants of 3 to 5 years is suggested as being reasonable and should *be* related to i) the level of uncertainty associated with the existing standard, ii) the level of research undertaken during the interval relating to the contaminant and iii) the magnitude of the potential hazard posed by the contaminant. The use of a structured standard setting procedure will significantly expedite the water quality standard derivation process.

9.6 Public Review and Input

Central to the success of a receiving water-based toxics control program will be public acceptance. There are a number of steps which can be taken to facilitate this acceptance.

9.6.1 Publicize Intentions

The perceived primary focus within and outside the Ministry, at least in the short term, is the BAT(EA) "technology track". Implementation schedules have been built around this portion of MISA. Notice has been given of the eventual use of site-specific receiving water limits but elaboration of the types of controls envisaged has not been widely disseminated.

If the approach recommended herein is adopted by the Ministry, it is essential that the basic concepts are immediately publicly laid out. As recommended, the procedures should be introduced contemporaneously with BAT(EA) both for environmental protection reasons and to maintain the perspective that receiving water limits are not a secondary or subsequent consideration. The sooner that the full scope of MISA can be publicly enunciated the better in terms of public acceptance and the ability of dischargers to deal with the combined requirements.

9.6.2 Scientific Review

The strengths and limitations of the receiving water-based approach will lead to extensive discussion in Ontario. Given its potential extent and significance and the variety of topics of scientific interest, it is expected much attention will be focussed on the procedures. It is recommended that **a series of regional and provincial seminars be convened to address some of the key topics and to publicize the technical aspects of the program, in particular the whole effluent component**.

9.6.3 Public Hearings

Once i) the intentions have been publicised, ii) input has been sought through the regional and provincial seminars, and iii) the Ministry has developed a more specific and formal program framework, it is recommend that the program be subjected to thorough review by means of a public hearing either before the Environmental Assessment Board or a specially appointed panel. The scope of this hearing would he three-fold:

- critical review of the proposed procedures and models.

- broad consultation on aspects of the program based on decisions such as the level of environmental protection to be incorporated in the regulations.

- procedures and mechanisms for seeking public input on specific issues (e.g., individual standards for licence applications).

9.7 Administrative Resources

Staff requirements for implementing toxics control programs in U.S. jurisdictions were discussed with representatives of U.S. agencies. The U.S. experience has been used as the basis for estimating staff requirements in Ontario. To some extent, the needs can be accommodated by reallocating existing staff, but some new staff will be required. There is a one-time staff requirement to set-up the system, and then there is an on-going requirement for professional services of various types:

- permit writers
- technical support groups who provide water quality criteria for the permit writers
- field officers
- laboratory services

Representatives of the U.S. EPA indicated that the initial effort involved in establishing procedures and applying them to the toxicity data to develop standards required about 150 persons at a cost of 350 million U.S. dollars. The cost to implement a comparable system in Ontario will be considerably less. since the U.S. experience can be drawn upon. About 10% of the effort required in the U.S. or up to $35 million may be necessary. Ontario should explore opportunities for sharing this development cost with the federal government and other provincial governments. Considerable work in this regard is already underway within the Ministry and an informal information-sharing arrangement with the State of Michigan has been established.

Once established, maintaining the system can be expected to require in the order of 20 to 40 persons, based on the experiences reported elsewhere. This presumes little or no involvement of Environment Canada in the program.

Michigan has about 20 permit writers for 1300 permits; New Jersey has about 14 permit writers for 1000 direct dischargers. Ontario will require discharge licenses or revised Certificates of Approval for about 650 dischargers (250 industries and 400 sewage treatment plants). It follows that Ontario should require about 15 permit writers. Many of these individuals would come from the existing Approvals Branch of the Ministry.

Technical support groups who provide water quality criteria for the permit writers are required. In the U.S., these groups typically consist of 8 to 10 persons:

- Michigan-- about 8, with toxic organics group to be included in the near future
- Florida- - about 10
- Georgia -- 7 to 10

New Jersey's group is considerably larger at 20 to 30 persons, but some of these are scheduled to be moved into permit writing shortly. Staff requirements depend on the diversity of industry types in a jurisdiction in addition to the total number of dischargers. Consequently, a team of about 12 is required in Ontario. Existing personnel in the Water Resources Branch and the Regional offices might fill some of these positions.

Field officers are required for the inspection and monitoring provisions of the proposed system. This is an extension of the existing MOE field activity. Michigan (1300 permits) has 9 district offices with 3 or 4 Water quality staff in each office. Although Ontario has about one half as many direct dischargers as Michigan. Ontario's larger area means its demands will be nearly comparable. It is suggested that on average about 4 person years will be needed in each of the six regions. Thus Ontario will require in the order of 20 to 25 field staff, including existing staff, to implement a province-wide receiving water-based toxics control program.

Laboratory services will be required. Michigan currently bas 4 laboratory technicians: Florida requires 3 to 4. Ontario's needs are likely to be comparable. This need may rise if there is a major increase in the use of toxicity testing.

9.8 Phasing

Currently, chemical-based toxic limits constitute the primary toxics control mechanism in Ontario. As recommended, whole effluent toxicity measures are proposed to replace chemical-specific limits as the primary basis to control acute or chronic toxicity impacts. A key issue is the rate and means whereby this is carried out. It is recommended that **effluent limits be specified in the short term based on both whole effluent toxicity and specific chemicals and that in the longer term, the chemical-specific limits be eliminated where they pertain only to acute or chronic aquatic ecosystem impacts particularly in cases involving complex effluents.**

Central to this recommendation is the need to undertake whole effluent toxicity sampling on a frequent basis to deal with problems of effluent variability. There are several implications to this recommended change. First, adequate capacity to undertake the toxicity tests will need to be made available in Ontario. The experience in the U.S. has been that the private sector will and can respond fairly quickly to the demand for analytical services as it materializes.

With the expansion in laboratory capacity and the need for controlled conditions to perform accurate toxicity tests, care must be taken to ensure accurate analytical results. Accordingly, it is recommended that **a laboratory certification program be initiated concurrently with the introduction of whole effluent toxicity limits**. As part of this process, standard testing procedures need to be adopted. The U.S. EPA and a number of individual states have made considerable progress in this regard and this experience is a valuable base on which Ontario can construct its procedures.

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GLOSSARY

Chemical-specific Effluent Limits - Limits in terms concentration and/or load for variable periods of time may be defined for a given discharge for specific contaminants. The chemical-specific limits may be set to avoid various types of impacts including acute and chronic toxicity, bioaccumulation and human health effects. The limits for each chemical are usually derived on the basis of water quality standards and available dilution volume.

Compliance - Compliance is the achievement of water quality standards- Embodied in the term is enforcement of effluent limits and water quality standards but it is not limited to these actions and includes performance monitoring and related efforts to control effluent quantities, contaminants and concentrations.

Design Flow - It is a defined drought flow rate in a flowing waterbody. The flow rate is expressed as a return frequency in years for a specified duration typically in days. For example, a "7Q20" design flow would be the minimum average 7 day flow estimated to occur in a given waterbody on average once every 20 years. The design flow is used to estimate the dilution volume available for toxic effluents and to "back-calculate" the allowable concentrations at the end-of-pipe.

Physical Mixing Zone (PMZ) - The PMZ is the actual zone of environmental degradation in a receiving waterbody resulting from assimilation of a contaminated effluent. It can be predicted using hydrologic/diffusion/ dispersion models or it can be measured directly under various hydrologic conditions. The boundaries of the PMZ are controlled by a variety of factors such as the volume, concentration and type of contaminants in the discharge, the design of the outfall and diffuser and the volume. turbulence and flow velocity of the waterbody.

Regulatory Mixing Zone (RMZ) - The RMZ is a zone of controlled environmental degradation in a receiving waterbody allocated for waste assimilation- It is specified according to one or more waterbody characteristics (e.g., a proportion of the drought flow volume, surface area). The allowable size of the RMZ should be determined by a public policy decision with consideration given to the value of the aquatic resource and the incremental waste treatment costs as the dilution volume is reduced. This decision is more or less independent of the actual physical mixing phenomenon of a waterbody.

Total Toxicity - This term is used to describe ambient water quality standards that define acceptable toxicity in total of all contaminants present in a waterbody. The definition of total toxicity is related to standardised toxicity tests and includes standards for acute and chronic effects.

Water-based Effluent Limits - This term relates to the setting of effluent limits based on the specific characteristics of the receiving waterbody. This is in contrast to industrial sector effluent limits that are based on best available technology that is economically achievable (ie, BAT(EA)). The receiving waterbody characteristics normally considered included design flow, mixing zone and water uses and significance.

Water Quality Goals - Goals are long-term targets designed to provide direction for the periodic modification of short-term water quality standards. MISA has set a goal to "virtually eliminate" toxics from effluents.

Water Quality Standards -Standards are the minimum acceptable level for specific water quality parameters- They are set by the government and are used to define maximum concentrations of contaminants in effluents. Standards are different than water quality goals but are comparable to the term "water quality objectives" as defined and used in some applications in Ontario. The term "standards" does not necessarily imply that they are set out in regulations but it does imply that they are used to set legally enforceable effluent limits.

Whole Effluent Toxicity - This term is related to that of total toxicity. Whole effluent toxicity refers to the combined toxicity of contaminants in effluents. Standardised tests are used to define toxicity units that describe maximum toxicity concentrations in contaminated effluents. Limits for both acute and chronic toxicity effects may be defined. These limits are separate from chemical-specific limits: they reflect the net effect of all contaminants in the chemical environment of the effluent.