VOLUME IIR
NPDES PERMIT RENEWAL APPLICATION

MIXING ZONE DEMONSTRATION

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FOREWARD

FOREWORD

This report is Volume IIR of the Amoco Oil Company, Whiting Refinery, application to renew NPDES Permit Number IN0000108. This document supplements Volume II submitted to the Indiana Department of Environmental Management in August, 1994.

Volume IIR provides information to demonstrate that a mixing zone can safely be integrated into the renewed Amoco NPDES Permit. This mixing zone demonstration addresses the requirements of state rules and federal law and guidance. Amoco is providing information based on hydrodynamic and biological field studies, chemical and biological laboratory tests, computer modeling, and literature review of the physical, chemical, and biological characteristics of the receiving water, effluent, and the specific areas of the mixing zone. As a replacement for the current Outfall 001 configuration, Amoco proposes to install and operate a multi-port high-rate diffuser to discharge its treated effluent. A multi-port high-rate diffuser will assure rapid and immediate mixing, thus further minimizing potential aquatic organism exposure. Based on the information provided in this report to satisfy Indiana rules (327 IAC 2-1.5-8 and 5-2-11.4, etc.), a mixing zone is appropriate to be included in Amoco's NPDES permit.

The report is organized into the following sections:

- Section 1 introduces background information on the Amoco Whiting facility, the technical and regulatory basis for allowing a regulatory mixing zone in Lake Michigan, and the applicability of a regulatory mixing zone to Amoco's NPDES permit.

- Section 2 analyzes the mixing zone dispersion of the proposed multi-port high-rate diffuser, using a USEPA-accepted and supported computer model.

- Section 3 demonstrates that a mixing zone meets all Indiana mixing zone regulatory requirements as well as federal guidance. The demonstration includes information on the magnitude and extent of the mixing zone, receiving water and effluent characteristics, and the results of a bioassessment field study.

- Section 4 summarizes the findings of this mixing zone demonstration and recommends the specific mixing zone (size and dispersion ratio) to be incorporated into wasteload allocation procedures necessary to derive water quality-based effluent limits for the NPDES Permit renewal process.

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY
VOLUME IIR

INTRODUCTION

In August of 1994, Amoco submitted an application to renew its NPDES permit that authorizes Amoco to discharge treated water into Lake Michigan. Amoco requested that the 1990 ambient water quality standards be applied at the edge of a proposed mixing zone. Amoco's proposed mixing zone would not result in an increase in concentration or mass over currently permitted levels that are discharged into Lake Michigan from Amoco's state-of-the-art wastewater treatment plant.

This document supplements Volume II ("Mixing Zone Demonstration") of the 1994 permit application. This document (referred to as "Volume IIR") reorganizes the information contained in the original Volume II (referred to as "Volume II") to correspond to new mixing zone rules adopted by IDEM in February of 1997. The substance of the mixing zone demonstration has not changed. While Volume II should remain a part of the permitting docket, Volume IIR is a free-standing document that can be relied on without reference to Volume II. Volume I ("NPDES Permit Renewal Application") has not changed and remains an integral component of the overall application. Volume III ("Permit Limits Derivation Report") completes Amoco's NPDES permit application.

In February of 1997, Indiana adopted new water quality standards (WQS)[1]. The 1997 WQS are based on the United States Environmental Protection Agency's (USEPA) Water Quality Guidance for the Great Lakes System (commonly referred to as the GLI), 40 CFR Part 132. The GLI WQS establish numeric criteria for some specific chemicals and a procedure for developing numeric water quality criteria or values for other specific chemicals. In addition, the GLI WQS specify mixing zone criteria for use in converting the numeric water quality criteria or values into water quality-based effluent limits

[1] Water Quality Standards (WQS) include numeric criteria and narrative standards that address designated uses, antidegradation, criteria development methods, and implementation procedures, including mixing zones. Mixing zones are, in fact, part of WQS.

(WQBELs). Table ES-1 sets forth the 1997 mixing zone criteria verbatim. As demonstrated herein, the 1997 water quality criteria or values should be applied at the edge of a small, well-defined mixing zone.

WHAT IS A MIXING ZONE?

A mixing zone is an area contiguous to a discharge where the treated effluent mixes with the receiving waters. Since water quality criteria or values are exposure-based, they do not apply within a mixing zone; the criteria or values are met at the edge of a mixing zone. Compliance is determined by sampling the effluent prior to discharge and comparing the results to permit limits that account for the dispersion which occurs within the mixing zone.

This technique is common for health-based environmental standards. For example, USEPA promulgates national ambient air quality standards (NAAQS) to protect public health and welfare. 42 USC 7408(a), 7409(a). The various states then adopt rules that apply to specific sources to ensure that the ambient air meets the NAAQS. 42 USC 7410 (a). Individual sources are not required to meet the NAAQS. In fact, individual sources may exceed the NAAQS at the end of a smoke stack and remain in compliance with their individual permits as long as the ambient air meets the NAAQS at the point of exposure (e.g., outside the plant's fenceline). The NAAQS, like water quality standards, are set at a level to protect against excessive exposure in the real world. It is not reasonable (or necessary) to assume that an individual will be perched at the top of a smoke stack for eight hours inhaling the emissions. Likewise, it is not reasonable (or necessary) to assume that a fish will take a position at the end of a discharge pipe and remain there for a sufficient duration to result in any harm. Instead, the regulatory procedures for health-based standards allow for demonstrated dispersion to be included and an emissions limit that accounts for that dispersion.

USEPA and the States, including Indiana, have used mixing zones as a tool for implementing water quality criteria or values since the 1960's. USEPA reaffirmed its view that mixing zones are an appropriate tool for implementing water quality criteria or

values in the recently promulgated GLI. IDEM modeled its mixing zone rules on the GLI.[2]

Like the NAAQS, one of the main objectives in applying the water quality standards is to determine a point at which the standards must be met. In the case of the NAAQS, it may be at the fenceline. In the case of the WQS, it is at the edge of a mixing zone. In practice, this means that a dispersion ratio is established at the edge of the mixing zone and is used to translate water quality criteria to an end-of the-pipe limit. For example, with 100:1 dispersion at the edge of a mixing zone, a mass balance of 1 part effluent with 100 parts receiving water (at background concentration) is calculated to develop an end-of-pipe limit, with compliance determined based on samples of the effluent prior to mixing with the receiving water.[3] An end-of-the-pipe limit is necessary because it is often not feasible to obtain compliance samples at the edge of a mixing zone.

WHY ARE MIXING ZONES APPROPRIATE?

USEPA has endorsed mixing zones for four decades. Mixing zones are appropriate given that the water quality criteria are exposure-based and exposure is of very limited duration inside a mixing zone. Water quality criteria include numerical limits based on three principles[4]:

- magnitude of exposure
- duration of exposure, and
- frequency of exposure

Chemical specific and whole effluent toxicity (WET) water quality criteria are based on both the acute (or short-term) effects and the chronic (or long-term) effects on aquatic life. Numeric water quality criteria are developed for specific chemicals and for WET.

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[2] The USEPA GLI and IDEM rules (327 IAC ARTICLE 5) set forth several important limitations on the use of mixing zones.
First, mixing zones are only appropriate if the subject waterbody meets the water quality standards. In other words, there must be assimilative capacity to accommodate the increased loading. Second, mixing zones are not appropriate for substances that bioaccumulate. Third, mixing zones should not be used to adjust any technology-based limits (as opposed to water quality-based limits). Amoco's proposed mixing zone is consistent with these limitations.

[3] Based on a review of approved mixing zones, dispersions can vary significantly from 2:1 to 500:1. The USEPA GLI uses a default mixing zone for lakes of 10:1.

[4] WQS also include narrative standards that address designated uses, antidegradation, and implementation including mixing zones.

This approach prevents impacts from individual chemicals, as well as from the cumulative, additive and/or synergistic effects of the combination of chemicals in the whole effluent.

Acute Aquatic Criteria (AAC) are based on protecting the most sensitive species from acute effects. For instance, Indiana's AAC for chlorides is 860 mg/L *(magnitude)* as a one-hour average *(duration)* concentration, not to be exceeded more than once every three years on average *(frequency).* By contrast, Chronic Aquatic Criteria (CAC) are derived to protect the most sensitive species from chronic effects and are expressed as a specified concentration *(magnitude)* over a four-day average *(duration*), not to be exceeded more than once every three years on average *(frequency).* The Indiana CAC for chlorides is 230 mg/L *(magnitude)* as a four-day average *(duration)* not to be exceeded more than once every three years *(frequency).* Due to the duration and frequency principles underlying the derivation of criteria, the criteria are referred to (by USEPA and others) as "instream criteria", highlighting the fact that these are not to be attained at end-of-pipe. 327 IAC 2-1.5-7.

The numeric water quality criteria are converted into water quality-based effluent limitations (WQBELs) as part of the permitting process. This process considers whether a permit applicant's effluent (as measured at the end-of-pipe) has the reasonable potential to exceed (RPE) an instream water quality criteria. If so, a permit limit should be developed based on a wasteload allocation that accounts for the permittee's discharge, as well as the combined impact of other discharges (point and nonpoint sources) and naturally occurring background concentrations. The permit limit must ensure that the water quality criteria or values will be met in the receiving water.

If a permit applicant demonstrates that it has engineered a mixing zone that meets the regulatory requirements, then, by definition, the mixing zone will not result in exposure for a duration and/or frequency that exceeds a numeric water quality criteria. Thus, permit limits can be developed, taking into account a mixing zone. For example, in many cases the initial momentum from the discharge of effluent into the receiving water minimizes the time organisms would be exposed to concentrations above the magnitude criteria. Though the exposure will exceed the magnitude of the criteria, the duration of exposure can be limited to ensure that there is no adverse effect. USEPA and the

states have developed rules and guidance over the years to determine the limitations on the duration of exposure that are necessary to protect human health, aquatic life, and wildlife. IDEM has adopted these rules as part of the GLI. If an applicant meets the requirements set forth in 327 IAC 5-2-11.4(b)(4) (see Table ES-1), it has by definition established that the duration of exposure within a defined mixing zone will not interfere with the waterbody's designated uses.

IS AMOCO'S PROPOSED MIXING ZONE APPROPRIATE?

Amoco's proposed mixing zone is appropriate because it meets all of the documentation and demonstration requirements set forth in Indiana rules (see Table ES-1). Addressing these regulatory demonstration criteria calls on two different disciplines: hydrodynamics and biology. Amoco's hydrodynamic and biological studies are discussed in this document and summarized below.

The hydrodynamic investigations involve studies of the physical properties of mixing. Amoco has previously demonstrated that its present discharge (Outfall 001) provides significant mixing through the dispersion created by its existing discharge configuration. Nonetheless, Amoco is proposing to install a multi-port submerged high-rate diffuser to enhance mixing and to reduce the size and area of the resulting mixing zone. A diffuser is a structure engineered to enhance mixing by discharging effluent at a relatively high velocity into the water column and directed away from the lake bottom.

Amoco proposes to install the multi-million dollar diffuser at a depth of approximately 30 feet at a location approximately 3,500 feet northeast of the present side-channel outfall. The rationale for this site is to maximize mixing with ambient waters by locating the diffuser in deeper waters where more water volume is available for rapid mixing than is available than the current Outfall 001. After installation of the diffuser, the treated effluent will be pumped through a 3,500-foot feeder pipe and discharged at high velocities (e.g., 10 feet/second) through ten small ports evenly spaced over the last 90 feet of the pipe (the diffuser header).

To determine the dispersion ratio that can be achieved by the proposed diffuser, Amoco researched historical records, conducted its own field measurements, and consulted with widely recognized experts. The data gathered were entered into an USEPA-

endorsed computer model used to project mixing (CORMIX2). Based on the modeling and field studies, Amoco proposes a mixing zone that is equivalent to the discharge-induced mixing zone under Indiana rules. This area encompasses a 50-foot radius around the diffuser. At the edge of this zone, the effluent is dispersed by a 54:1 ratio. Organism exposure inside this mixing zone will be less than the duration component used to derive water quality criteria. In fact, exposure time for free floating organisms in the discharge-induced mixing zone is less than 90 seconds, which is significantly less than the one-hour or four-day exposure duration component used to determine acute or chronic water quality criteria, respectively. Thus, to establish daily maximum and monthly average end-of-pipe limits, a mass balance of one part effluent and 54 parts of background receiving water is applied to the instream water quality criteria.

In addition to the mixing hydrodynamics discussed above, Amoco conducted a series of biological assessments of the present discharge location and the proposed diffuser site. These assessments found no evidence of adverse effects to aquatic life or the designated uses of the receiving water at the present site (presented in 1994 Volume II). Given that the proposed mixing zone includes dispersion enhancements when compared to the current discharge (i.e., a diffuser in deeper water and away from shore), the proposed mixing zone will not adversely impact the designated uses of southern Lake Michigan.

The biological assessments evaluated bottom-dwelling, free-floating, and attached aquatic communities. Species from these particular communities were collected, identified, and counted because they are either (a) the most sensitive aquatic communities in the area where mixing between effluent and receiving water occurs, or (b) the most critical communities in the Great Lakes ecosystem food chain. The overall findings from the biological assessment were that the present discharge has not adversely affected aquatic life or the designated uses of the receiving water. With a submerged multi-port high-rate diffuser located in deeper waters, the dispersion effects are enhanced as effluent will be quickly mixed throughout the deeper water column, further minimizing the exposure time for organisms.

CONCLUSION

The hydrodynamic studies and biological assessment, taken together, make a compelling demonstration that Amoco's proposed mixing zone will not cause harm to human health, aquatic life, or wildlife. In fact, reducing the duration of exposure by using a submerged high-rate diffuser renders Amoco's proposed mixing zone more protective of human health, aquatic life, and wildlife than the existing discharge. Under Indiana law, IDEM must include the mixing zone in Amoco's permit because Amoco has met all of the conditions for approval set forth in 327 IAC 5-2-11.4(b)(4).

TABLE ES-1. INDIANA MIXING ZONE CRITERIA

327 IAC 5-2-11.4(b)(4)(A)(i)	Document the characteristics and location of the outfall structure, including whether technologically enhanced mixing will be utilized.
327 IAC 5-2-11.4(b)(4)(A)(ii)	Document the amount of dilution occurring at the boundaries of the proposed mixing zone and the size, shape and location of the area of mixing, including the manner in which diffusion and dispersion occur.
327 IAC 5-2-11.4(b)(4)(A)(iii)	For sources discharging to the open waters of Lake Michigan, define the location at which discharge-induced mixing ceases.
327 IAC 5-2-11.4(b)(4)(A)(iv)	Document the physical including substrate character and geomorphology, chemical and biological characteristics of the receiving waterbody, including whether the receiving waterbody supports indigenous, endemic or naturally occurring species.
327 IAC 5-2-11.4(b)(4)(A)(v)	Document the physical, chemical, and biological characteristics of the effluent.
327 IAC 5-2-11.4(b)(4)(A)(vi)	Document the synergistic effects of overlapping mixing zones or the aggregate effects of adjacent mixing zones.
327 IAC 5-2-11.4(b)(4)(A)(vii)	Show whether organisms would be attracted to the area of mixing as a result of the effluent character.
327 IAC 5-2-11.4(b)(4)(B)(i)	The mixing zone would not interfere with or block passage of fish or aquatic life.
327 IAC 5-2-11.4(b)(4)(B)(ii)	The level of pollutant permitted in the waterbody would not likely jeopardize the continued existence of any endangered or threatened species listed under Section 4 of the ESA or result in the destruction or adverse modification of such species habitat.
327 IAC 5-2-11.4(b)(4)(B)(iii)	The mixing would not extend to drinking water intakes.
327 IAC 5-2-11.4(b)(4)(B)(iv)	The mixing zone would not impair of otherwise interfere with the designated uses of the receiving water or downstream waters.
327 IAC 5-2-11.4(b)(4)(B)(v)	The mixing zone would not promote undesirable aquatic life or result in a dominance of nuisance species.
327 IAC 5-2-11.4(b)(4)(B)(vi)	By allowing the additional mixing: (AA) substances will not settle to form objectionable deposits; (BB) floating debris, oil, scum, and other matter in concentrations that form nuisances will not be produced; and (CC) objectionable color, odor, taste, or turbidity will not be produced.
327 IAC 5-2-11.4(b)(4)(C)	In no case shall a mixing zone for a discharge into the open waters of Lake Michigan be granted that exceeds the area where discharge induced mixing occurs.

SECTION 1

SECTION 1.0
INTRODUCTION

As part of its comprehensive water quality management program, Amoco Oil Company, Whiting Refinery (Amoco) has performed studies to assess the options available to comply with the Indiana Water Quality Standards (327 IAC 2) promulgated on March 3, 1990, and revised February 13, 1997. These state standards have incorporated the requirements of the federal Clean Water Act of 1987 as well as the Final 1995 Water Quality Guidance for the Great Lakes System (40 CFR Part 132). Part of these requirements include application of water-quality based (chemical-specific and whole effluent toxicity) effluent limits, as well as technology-based limits for direct dischargers.

Based on Amoco's water quality studies and the fact that Lake Michigan is in attainment of water quality standards, Amoco concludes that a mixing zone is appropriate to define a point of application for water quality criteria.

Amoco requests an evaluation of the application of a mixing zone for the discharge of treated effluent into Lake Michigan pursuant to 327 IAC 2-1.5-7 and 327 IAC 5-2-11.4 and federal mixing zone guidance. Results of an effluent dispersion analysis and corresponding mixing zone demonstration as part of this request are presented in this report.

1.1 FACILITY DESCRIPTION

The Amoco Whiting Refinery occupies approximately 1,700 acres near the southern end of Lake Michigan as presented in Figures 1-1 and 1-2. The petroleum refinery includes processes such as distillation, catalytic reforming, hydrodesulfurization, catalytic cracking, alkylation, coking, treating, extraction, dewaxing, grease and lube oil production, asphalt production, sulfur recovery, and power generation. The refining throughput varies with product demand and other market considerations, but its capacity averages 410,000 barrels of crude per day. Amoco produces a variety of products including jet fuel, gasoline, diesel fuel, heating fuel, lubricating oils, asphalt, coke, and waxes.

The refinery generates process waters which are continuously treated on-site at an advanced biological wastewater treatment plant (WWTP) as shown schematically in Figure 1-3. (Volume I NPDES Permit Application, submitted August 29, 1994, presents details of the WWTP). Stormwater run-off and recovered groundwater from refinery areas are also treated at the WWTP. The treated effluent is then discharged to Lake Michigan through a National Pollutant Discharge Elimination System (NPDES) permitted outfall (Outfall 001). The refinery withdraws water from Lake Michigan for use in process units and for once-through cooling. The once-through noncontact cooling water is discharged through NPDES Outfall 002. Both outfalls are regulated by NPDES Permit IN0000108 (the NPDES Permit) which became effective on April 1, 1990. The effluent flow from Outfall 001 ranged from 13 (long-term average) to 23 (maximum monthly average) million gallons per day (mgd) during 1991 to 1994 (Volume I NPDES Permit Application, submitted August 29, 1994). For the same time period, the average flow from Outfall 002 ranged from 110 to 120 mgd.

The NPDES Permit has limits for Outfall 001 derived from technology-based effluent limits, which are presented in Table 1-1. Amoco has consistently attained these permit limits with high quality effluent that meets or is better than "Best Available Technology" (BAT) effluent requirements, as seen by the historical WWTP plant performance also indicated in Table 1-1. It is anticipated that the new permit will contain effluent limits based on the Indiana Water Quality Standards as well as the previously applicable technology-based standards. Amoco is not requesting a mixing zone for technology-based standards. As part of the permit renewal application, Amoco is submitting this report to demonstrate an appropriate implementation of a mixing zone for application of the Indiana water quality standards consistent with 327 IAC 2-1.5-7 and 5-2-11.4.

1.2 WATER QUALITY MANAGEMENT PROGRAM

To meet the goals of the Indiana water quality laws, Amoco developed a comprehensive water quality management program including the elements presented in Table 1-2. For example, wastewater treatment has been optimized by supplementing the aeration system in the bio-tanks (1995) and upgrading the final filters (1996). Details of some of the activities listed in Table 1-2 can be found in Volume I NPDES Permit Application, submitted August 29, 1994. This current report (Volume IIR) presents a discussion of the

program elements relating to defining the point of application for receiving water quality criteria through delineation of a mixing zone in Lake Michigan for Outfall 001.

1.3 APPROPRIATENESS OF MIXING ZONE FOR THE AMOCO WHITING REFINERY

As part of the water quality management program, Amoco considered several factors prior to proceeding with a mixing zone demonstration. There are generic stipulations presented in USEPA guidance[5] to assess the appropriateness of using a mixing zone to define the point of application of criteria and to develop discharge limits. In light of these USEPA stipulations, Amoco presents the following responses to the appropriateness of using a mixing zone for Outfall 001 permitting. As discussed previously, implementation of a mixing zone for the Amoco facility is not a substitute for BAT wastewater treatment. Amoco has demonstrated that based on USEPA test methods the combined effect of constituents discharged from Outfall 001 is not acutely toxic (presented in Volume I NPDES Permit Application, submitted August 29, 1994). Lake Michigan meets the water quality criteria for its designated uses for the constituents listed in Table 1-4, (i.e., background concentrations are less than the most stringent criteria), hence assimilative capacity exists. The presence of assimilative capacity for these constituents allows the use of a mixing zone in establishing discharge limits. In addition, the proposed mixing zone covers a limited area and will not impair the integrity of the receiving waterbody, as further documented in Sections 2 and 3.

Furthermore, the federal recommendation of mixing zone use to define the point of application for criteria has to be recognized by the state. Indiana concurs with federal guidance that water quality criteria apply in the receiving water and not at end-of-pipe as discussed in the Sections 1.4 and 1.5. Indiana defines a mixing zone as follows:

> ***327 IAC 2-1.5-2 (55) Definitions***. *"Mixing zone" means an area contiguous to a discharge where the discharged wastewater mixes with the receiving waters. Where the quality of the effluent is lower than that of the receiving waters, it may not be possible to attain within the mixing zone all beneficial uses which are attained outside the zone. The mixing zone should not be considered a place where effluents are treated.*

[5] USEPA, 1991, Technical Support Document for Water Quality-based Toxics Control (TSD), and 1993 Water Quality Standards Handbook, Second Edition (WQSH)

Guidelines in the Indiana Water Quality Standards for demonstrating the appropriateness of a mixing zone in State waters are presented in the following paragraph.

> ***327 IAC 2-1.5-7 Mixing Zone Guidelines.*** *"(a) All surface water quality criteria in this rule, except those provided in section 8(b)(1) of this rule, are to be applied at a point outside of the mixing zone as determined under 327 IAC 5-2-11.4 to allow for a reasonable mixture of waste effluents with the receiving waters.*

Indiana does have a prohibition for the use of mixing zones in permitting, hence, Amoco is not requesting (nor does it need) a mixing zone for Indiana-defined bioaccumulative constituents of concern (BCCs).

As a mixing zone is appropriate for Outfall 001, Amoco proceeded to fulfill the Indiana requirements to demonstrate that a mixing zone can be defined and is applicable to assure attainment of water quality criteria. The implementation of a mixing zone will continue to maintain water quality standards for Lake Michigan without requiring unnecessary wastewater treatment and increased multi-media impacts.

1.4 BASIS FOR ALLOWANCE OF A MIXING ZONE

In discussing mixing zones, terminology frequently varies with the intent and context of the discussion. For instance, the use of certain terms may depend on whether the discussion relates to engineering (hydrodynamics and modeling), field assessment (scientific measurements), or laws and guidance (regulatory). Federal and individual state laws and guidances often have specific defined mixing zone terms, therefore, selected terms and their corresponding definition used in this report are presented in Table 1-3.

When a liquid effluent is discharged to a lake, a natural area of mixing is created. This area of mixing is where the effluent commingles, spreads out, and disperses in the receiving water. Initially, mixing is driven by the hydraulic force of the discharged water. This zone is defined as the jet entrainment zone. After the hydraulic energy of the effluent is dissipated, differences in density and relative movement of the spreading effluent and the receiving water body combine for further mixing, described as the transition zone. The jet entrainment zone and transition zone combine to form the near-field mixing zone. Eventually, the natural currents of the receiving waterbody become the dominant force.

This area is defined as the far-field mixing zone. Natural driving physical processes such as flow, density differences, temperature gradients, or variable chemical concentrations, continue to drive mixing between effluent and receiving water in this zone.

Water quality criteria based on Indiana Water Quality Standards are listed in Table 1-4 for metals and conventional constituents. Water quality criteria are defined by three factors:

- magnitude,
- duration, and
- frequency.

These factors are necessary to define criteria to protect the designated use of the waterbody. The criteria consider both the acute (short-term) effects and the chronic (long-term) effects. Short-term and long-term effects are measured through laboratory toxicity bioassay testing of a chemical. Acute criteria are based on protecting the most sensitive species from acute effects and are expressed as Acute Aquatic Criteria (AAC). For example, Indiana's AAC for chlorides is expressed as: 860 mg/L (magnitude) of chlorides as a one-hour (duration) average concentration not to be exceeded more than once every three years (frequency) on average. The Chronic Aquatic Criteria (CAC) are derived to protect the most sensitive species from chronic toxic effects and are expressed as a four-day average concentration. For instance, Indiana's CAC for chlorides is expressed as: 230 mg/L (magnitude) of chlorides as a four-day (duration) average not to be exceeded more than once every three years (frequency) on average.

As stated in 327 IAC Articles 2 and 5, the AAC and CAC, due to their duration (exposure) and frequency (time) elements, are to be met in the receiving water. To ensure protection of the receiving water, the point of application of criteria are:

- AAC at edge of the Discharge-Induced Mixing Zone (DIMZ) (327 IAC 2-1.5-8(b)(1)(E)(i)
- CAC at the edge of the applicable mixing zone (327 IAC 2-1.5-8(b)(2))

Indiana Articles 2 and 5 also state that the Continuous Chronic Criteria (CCC), which includes the CAC as well as any other Tier II chronic criteria, apply at the edge of the

"applicable mixing zone"[6]. Similarly, Tier II acute criteria apply at the edge of the "discharge-induced mixing zone" (DIMZ).

The USEPA[7] has determined that travel time through an acute mixing zone (DIMZ) must be roughly less than fifteen minutes if a one-hour average exposure is not to exceed the acute criterion. In addition, USEPA has recommended receiving water flow or velocity design conditions to establish the mixing zone to mimic the three-year return interval. This type of assessment for receiving water quality addresses the magnitude (acute criteria concentration to be attained at edge of DIMZ), duration (rapid mixing of less than 15 minutes to minimize exposure), and frequency (critical/conservative receiving water velocity or flow) of exposure.

To reconcile hydraulic and Indiana regulatory terms, this mixing zone demonstration equates the "discharge-induced mixing zone" to the "jet entrainment zone". The "applicable mixing zone" equates to the "far-field zone" and is also referred to as an "alternate mixing zone"[8] when a site-specific mixing zone demonstration is requested. For a Lake Michigan discharge, the extent of the alternate mixing zone is limited to the discharge-induced mixing zone (327 IAC 5-2-11.4(b)(2)(A)(v)), hence, only one delineated area and one dispersion ratio will apply to the DIMZ. At this point, both the AAC and CAC criteria are to be attained. Therefore, this demonstration delineates the discharge-induced mixing zone for the Amoco Outfall 001.

1.5 INDIANA MIXING ZONE REQUIREMENTS

In February of 1997, Indiana adopted new water quality standards (WQS). The 1997 WQS are based on the USEPA Water Quality Guidance for the Great Lakes System (commonly referred to as the "GLI") 40 CFR Part 132. The GLI WQS establish numeric standards for some specific chemicals and a procedure for developing numeric WQS for other specific chemicals. In addition, the GLI WQS adopt mixing zone criteria for use in converting the numeric criteria into water quality-based effluent limits (WQBELs).

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[6] 327 IAC 2-1.5-8(b)(2) refers to applicable mixing zones and 327 IAC 5-2-11.4(b)(2)(A)(ii) refers to alternative mixing zones in defining where chronic criteria are to be attained.
[7] USEPA, 1991 TSD, and 1993 WQSH
[8] Pursuant to 327 IAC 5-2-11.4(b)(2)(A)(i), (ii), and (iii) and (b)(3)(B)(i) and (ii) and (C)

An applicant must address the following items in an application for a mixing zone:

- Document the characteristics and location of the outfall structure, including whether technologically enhanced mixing will be utilized.
- Document the amount of dilution occurring at the boundaries of the proposed mixing zone and the size, shape, and location of the area of mixing, including the manner in which diffusion and dispersion occur.
- For sources discharging to the open waters of Lake Michigan, define the location at which discharge-induced mixing ceases.
- Document the physical, including substrate character and geomorphology, chemical and biological characteristics of the receiving waterbody, including whether the receiving waterbody supports indigenous, endemic or naturally occurring species.
- Document the physical, chemical, and biological characteristics of the effluent.
- Document the synergistic effects of overlapping mixing zones or the aggregate effects of adjacent mixing zones.
- Show whether organisms would be attracted to the area of mixing as a result of the effluent character.

327 IAC 5-2-11.4(b)(4)(A)(i)-(vii).

IDEM must grant the mixing zone if an applicant demonstrates the following:

- The mixing zone would not interfere with or block passage of fish or aquatic life.
- The level of pollutant permitted in the waterbody would not likely jeopardize the continued existence of any endangered or threatened species listed under Section 4 of the ESA or result in the destruction or adverse modification of such species habitat.
- The mixing would not extend to drinking water intakes.
- The mixing zone would not impair of otherwise interfere with the designated uses of the receiving water or downstream waters.
- The mixing zone would not promote undesirable aquatic life or result in a dominance of nuisance species.
- By allowing the additional mixing: (AA) substances will not settle to form objectionable deposits; (BB) floating debris, oil, scum, and other

matter in concentrations that form nuisances will not be produced; and (CC) objectionable color, odor, taste, or turbidity will not be produced.

- In no case shall a mixing zone for a discharge into the open waters of Lake Michigan be granted that exceeds the area where discharge induced mixing occurs.

327 IAC 5-2-11.4(b)(4)(B)(i)-(vi).

If an applicant documents the required information and demonstrates the listed items, IDEM must grant the request for a mixing zone:

> *...unless the commissioner determines that the mixing zone should be denied based upon a consideration of harm to human health, aquatic life, or wildlife. The commissioner shall evaluate all available information, including information submitted by the public, relevant to the consideration of harm to human health, aquatic life, or wildlife. The commissioner shall identify the harm to human health, aquatic life, or wildlife, and document the rationale for this decision.*

326 IAC 5-2-11.4(b)(4)(B)(6).

If an applicant satisfies its specified obligations under the rule, the burden shifts to IDEM to prove some specific harm that warrants the denial of the mixing zone.

As documented in Sections 2 and 3, Amoco has satisfied its obligation under the rule in demonstrating that a mixing zone is appropriate for Outfall 001.

TABLE 1-1. NPDES OUTFALL 001 DISCHARGE LIMITATIONS AND EFFLUENT QUALITY

PARAMETER	UNITS	1990 PERMIT LIMITS (a)		HISTORICAL PERFORMANCE (b)	
		MONTHLY AVERAGE	DAILY MAXIMUM	MONTHLY AVERAGE	DAILY MAXIMUM
TBOD5	lbs/day	4,161	8,164	721	3,580
TSS	lbs/day	3,646	5,694	2,059	4,904 (c)
COD	lbs/day	30,323	58,427	7,973	18,515
Oil & Grease	lbs/day	1,368	2,600	463	1,594
Phenolics (4AAP)	lbs/day	20.33	73.01	3.1	17.9
Ammonia as N	lbs/day	1,030	2,060	551	1,446
Sulfide	lbs/day	23.1	51.4	6.7	14.3
Total Chromium	lbs/day	23.90	68.53	2.4	5.3
Hexavalent Chromium	lbs/day	2.01	4.48	0.6	1.2

Notes:

(a) 1990 Permit Limits are based upon previous permit effluent limitations since they were more stringent than BPT/BAT limits.

(b) Historical performance based on monthly DMR data for April 1991 to April 1994 (consistent with Form 2C).

(c) Daily maximum does not include a 24-hour time period when the WWTP experienced a known upset condition on August 31, 1993.

BPT - Best Practicable Control Technology Currently Available

BAT - Best Available Technology Economically Achievable

TABLE 1-2. WATER QUALITY MANAGEMENT PROGRAM ELEMENTS

ELEMENT	DATE INITIATED	DATE COMPLETED
EFFLUENT CHARACTERIZATION		
- Chemical Specific	1990	Ongoing
- Flow/Hydraulics	1991	Ongoing
- Whole Effluent Toxicity Studies	1991	1993
TREATABILITY STUDIES	1991	1994
SOURCE CONTROL	1991	Ongoing
WWTP UPGRADES	1991	Ongoing
BENZENE NESHAP CONTROL PROJECTS	1990	1994
SARA (TRI) EMISSION REDUCTION PROJECTS	1990	Ongoing
ZEBRA MUSSEL CONTROL	1992	Ongoing
STORMWATER QUALITY CONTROL PROJECTS	1992	Ongoing
RECEIVING WATER CHARACTERIZATION		
- Hydraulics	1990	Ongoing
- Chemical Bioavailability	1991	Ongoing
- Aquatic Biological Community & Habitat Characterization	1992	Ongoing
- Background Water Quality	1991	Ongoing
POINT OF APPLICATION ESTABLISHMENT FOR IN-STREAM WATER QUALITY CRITERIA (Mixing Zone Delineation)	1990	1997
WASTELOAD ALLOCATION DETERMINATION	1992	1997
SITE-SPECIFIC WATER QUALITY CRITERIA ASSESSMENT	1991	1993
PRELIMINARY DIFFUSER DESIGN	1994	1994

TABLE 1-3. MIXING ZONE TERMINOLOGY FOR LAKE MICHIGAN

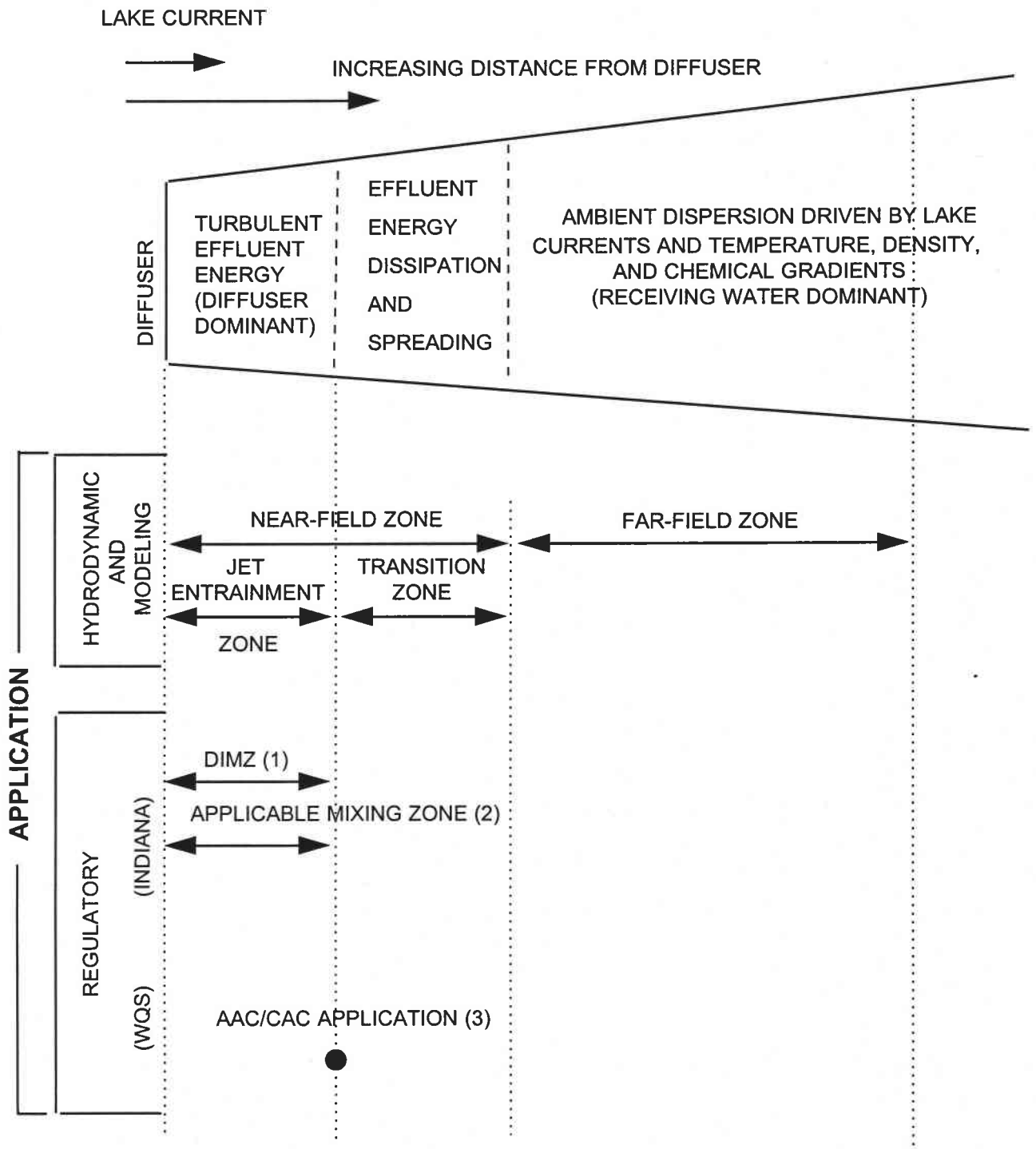

TABLE 1-3. MIXING ZONE TERMINOLOGY (continued)

FOOTNOTES	ABBREVIATION	DEFINITION
(1)	DIMZ	Discharge-Induced Mixing Zone: Concentrations of toxic substances shall not exceed the CMC outside the zone of initial dilution ... unless an alternate mixing zone demonstration is conducted and approved in accordance with 327 IAC 5-2-11.4(b)(4), in which case, the CMC shall be met outside the discharge-induced mixing zone ... (327 IAC 2-1.5-8(b)(1)(E)(i)). In no case shall a mixing zone for a discharge into the open waters of Lake Michigan be granted that exceeds the area where discharge-induced mixing occurs. (327 IAC5-2-11.4(b)(4)(C)).
(2)	MZ	Mixing Zone: An area contiguous to a discharge where the discharged wastewater mixes with the receiving waters. Where the quality of the effluent is lower than that of the receiving waters, it may not be possible to attain within the mixing zone all beneficial uses which are attained outside the zone. The mixing zone should not be considered a place where effluents are treated. (327 IAC 2-1.5-2(55)). In addition, this is equivalent to the designated mixing zone and the approved mixing volume. (327 IAC 5-2-11.3(b)(1)(C)(iii)(HH) and 5-2-11.7(c)(4)). At all times, all waters outside of the applicable mixing zones determined in accordance with 327 IAC 5-2-11.4(c) through (f) shall be free of substances in concentrations ... chronically toxic to, or be carcinogenic, mutagenic, or teratogenic to humans, animals, aquatic life, or plants. (327 IAC 2-1.5-8(b)(2)). For discharges into the open waters of Lake Michigan, ... for allocations based on acute aquatic life criteria of values, the CMC shall not be exceeded ... , unless a mixing zone demonstration is conducted and approved under subdivision (4), in which case the CMC shall be met outside the alternative mixing zone. (327 IAC 5-2-11.4(b)(2)(A)(i)). ... chronic criteria or value shall not be exceeded ... unless an alternative mixing zone is demonstrated ... (327 IAC5-2-11.4(b)(2)(A)(ii)). Historical Footnote: In the March 23, 1995 federal GLI, USEPA used the term "alternate mixing zone" to differentiate a demonstrated mixing zone using site information from a 10:1 default dilution. Indiana adopted this terminology but eliminated the default dilution in its regulations when implementing the GLI.
(3)	AAC	Acute Aquatic Criteria: Receiving water application point. (327 IAC 5-2-11.4(b)(2)(i)(AA)).
	CAC	Criterion Aquatic Concentration: Receiving water application point. (327 IAC 5-2-11.4(b)(2)(ii)(AA)).
	AAC/CAC	For a discharge with an approved alternate mixing zone, acute and chronic wasteload allocations are calculated using the same mixing ratio. (327 IAC 5-2-11.4(c)(4)(B) and (5)).