CHAPTER THREE
SOURCES OF ENVIRONMENTAL STRESS

I. Introduction

There are a number of different causes of stress on the environment in the Grand Calumet River and Indiana Harbor Ship Canal Area of Concern. These sources of environmental stress have caused the destruction of many stable communities of organisms. Stress can be physical, such as sedimentation, loss of beach nourishment or loss of access to habitat. It can be biological, such as pathogen or parasite infestation, or lack of predators or prey. Stress can be from chemical factors such as too many or too few nutrients. Almost all sources of ecosystem stress are the result of human activity. The six sources of stress include:

-Pollutant and nutrient contamination
-Fragmentation and loss of physical habitat
-Altered hydrology
-Shoreline alterations
-Exotic species introduction
-Fire suppression

This chapter looks at the six major sources of stress to the ecosystem in the Area of Concern. Identification of these sources of stress is one of the first steps in restoring and maintaining the Area of Concern ecosystem. Many of the sources of stress, such as those causing changes in ground water levels and flow, cannot be remediated, but should be accounted for in the design of remedial actions. The following figure (figure viii), Matrix of Beneficial Use Impairments and Stressors Causing Beneficial Use Impairments, identifies these sources of stress in relation to the beneficial uses they impair.

Matrix of Beneficial Use Impairments and Stressors Causing Beneficial Use Impairments						
Beneficial Use Impairments	Stressors Causing Beneficial Use Impairments					
	Contamination	Fragmentation and loss of physical habitat	Altered Hydrology	Shoreline Alterations	Exotic Species	Fire Suppression
Restrictions on Fish and Wildlife Consumption	*					
Tainting of Fish and Wildlife Flavor	*					
Degraded Fish and Wildlife Populations	*	loss of breeding/foraging habitat limits species interaction	loss of breeding/foraging habitat	changes physical structure of habitat	loss of breeding/foraging habitat outcompetes native species	loss of breeding/foraging habitat
Fish Tumors and other Deformities	*	lack of suitable habitat forces increased exposure to contaminants				
Bird or Animal Deformities and/or Reproductive Problems	*	lack of suitable habitat forces increased exposure to contaminants				
Degradation of Benthos	*	lack of suitable habitat	changes physical structure of habitat	changes physical structure of habitat	changes biological structure of habitat outcompetes native species	
Restriction on Dredging Activities	*	protection of high quality habitat complicates sediment removal	changes physical structure of habitat			
Eutrophication or undesirable Algae	*		disrupts surface / groundwater flow			
Restrictions on Drinking Water Consumption or Taste and/or Odor Problems	*					
Beach Closings	*					
Degradation of Aesthetics	*	The beneficial use impairment focuses on negative aesthetic qualities such as discolored water. Restoring natural communities along the river will improve the overall aesthetics of the Area of Concern.				
Added Costs to Agriculture or Industry	*				Zebra Mussels can clog water intakes and discharges	
Degradation of Phytoplankton and Zooplankton Populations	*	lack of suitable habitat	changes in physical habitat structure	changes physical structure of habitat	changes biological structure of habitat outcompetes native species	changers in biological structure of habitat
Loss of Fish and Wildlife Habitat	*	loss of breeding/foraging habitat limits species interaction	changes in physical habitat structure	changes physical structure of habitat eliminates nearshore aquatic and early successional habitat	changes biological structure of habitat outcompetes native species	changes in biological structure of habitat

*The relationship between contaminants and beneficial use impairments are detailed in the front matter.

II. Contamination

Contamination contributes to all fourteen beneficial use impairments. It is the primary stressor causing restrictions on fish and wildlife consumption, tainting of fish and wildlife flavor, fish tumors and other deformities. It also leads to bird or animal deformities or reproductive problems, restriction on dredging activities, restrictions on drinking water consumption or taste or odor problems. It can also lead to beach closings, degradation of aesthetics, and added cost to agriculture or industry. It works in combination with other stressors to cause degraded fish and wildlife populations, degradation of benthos, eutrophication or other undesirable algae, degradation of phytoplankton and zooplankton populations, and loss of fish and wildlife habitat.

A. Contaminated Sediment

There are three major sources that account for the sediment entering the Grand Calumet River and Indiana Harbor Ship Canal. They include: municipal and industrial point discharges, combined sewer overflows (CSOs), and urban runoff. IDEM has issued permits for thirty-nine outfalls on the Grand Calumet River and Indiana Harbor Ship Canal which serve municipal sewage treatment plants, semi-integrated steel manufacturing, chemical producers, and others. In addition to these controlled point sources, the sanitary districts of Gary, Hammond, and East Chicago maintain combined sewer systems that overflow to the Grand Calumet River and Indiana Harbor Ship Canal, even during light storm events.

There are differing views on the amount of sediment entering the system. Two separate studies calculating the annual loadings of sediment to the Grand Calumet River and Indiana Harbor Ship Canal demonstrate a substantial difference in loadings. The first study, conducted by the U.S. Army Corps of Engineers in its Comprehensive Management Plan for dredging the Indiana Harbor Ship Canal, estimates the total annual loading to be 152,000 cubic yards (CY). The second study was conducted by Mark W. Tenney, ScD., P.E. on behalf of the Grand Calumet Task Force. This evaluation estimates the annual total loading from sediment to the Grand Calumet River and Indiana Harbor Ship Canal to be from 15,000 - 26,000 CY. One possible explanation for the difference in values could be differing methodologies. Another reason could be that the original U.S. Army Corps of Engineers study was conducted in the early 1980's, and better management practices could account for the reduction in total loadings estimated in the later Tenney study.

The sediment loading estimate prepared by the U.S. Army Corps of Engineers was part of a larger effort to compute the deposition rate within the federal portion of the Indiana Harbor Ship Canal and to compute the discharge of sediments to Lake Michigan. The loading estimate was used as a confirmation of a deposition rate that was first computed by noting the changes in surveyed volumes over a period of time. In an attempt to discern the total discharge of sediments in this waterway, the U.S. Army Corps of Engineers is collecting data throughout 1996 and 1997

from gauging stations along the Grand Calumet River and Indiana Harbor Ship Canal. Sediment discharges could vary from the sediment loading rates in two important ways. First, the sediment discharge is a function of the sediment loading, but it is also a function of the deposition or erosion of sediments within or along the harbor or canal. Second, the discharge of sediments out of the Indiana Harbor Ship Canal primarily occurs during storm events, and therefore the daily monitoring of suspended sediments may not, in the short term, be consistent with long term averages. Given the sediment discharge data, however, along with future updated surveys, it may be possible to predict the sediment loadings, the deposition rates, and the discharges to Lake Michigan.

Based on monthly discharge reports located at IDEM from August 1993 through July 1995, nineteen National Pollutant Discharge Elimination System permittees in the Grand Calumet River and Indiana Harbor Ship Canal area discharged an average total flow of approximately eight hundred and thrity-three million gallons per day (MGD) or 1,291 cubic feet per second (cfs). In a dry weather period, this amount of effluent flow represents the entire flow in the river system. The estimated soil and sediment loss due to stormwater runoff to the Grand Calumet River and Indiana Harbor Ship Canal is 20,000,000 pounds annually (U.S. Army Corps of Engineers Grand Calumet River Basin BMP Demonstration, 1995).

Most of the Grand Calumet River and Indiana Harbor Ship Canal system has reached a steady-state condition, meaning there is a balance of sediment deposition and scour/transport. (Indiana Harbor and Canal Maintenance Dredging and Disposal Activities, Draft Environmental Impact Statement, U.S. Army Corps of Engineers) The result of this condition is a loading of 100,000 to 200,000 CY of sediment to Lake Michigan from the mouth of the Indiana Harbor annually. The annual sediment load to the lake contains an estimated 67,000 pounds of chromium, 100,000 pounds of lead, and four hundred and twenty pounds of PCB's (U.S. Army Corps of Engineers).

Industrial and municipal outfalls, including combined sewer systems, are a primary source of pollution of the Grand Calumet River and Indiana Harbor Ship Canal sediments. Sediments become contaminated before their deposition in the navigation channel (U.S. Army Corps of Engineers). Characterization of sediments in thirteen miles of the Grand Calumet River and Indiana Harbor Ship Canal conducted by the U.S. Steel Corporation, pursuant to a Consent Decree with the U.S. EPA, identified sediment contamination consistent with wastes from industries that either have discharged directly to the river, or have discharged indirectly to the river through local sewage treatment plants and combined sewer overflows. Many of these sources are located upstream of the Indiana Harbor Ship Canal.

B. Point Source Discharges

The majority of industries in the Northwest Indiana area discharge into the Grand Calumet River and the Indiana Harbor Ship Canal. Municipal and industrial wastewater and industrial cooling and process water are monitored and regulated by National Pollutant Discharge Elimination System (NPDES) permits. However, storm water runoff, combined sewer overflows, spills, and other discharges from nonpoint sources are more difficult to quantify and control.

Stage I of the Remedial Action Plan identified water quality concerns in the river system from several toxic substances that are believed to emanate from numerous sources such as industrial and municipal point sources, nonpoint water sources, air deposition, and the resuspension of sediments. Stage I also identified water quality problems on the river system caused by CSOs from each of the three sanitary districts on the river system. The CSOs cause degradation of the water quality of the river system. IDEM contracted for a limited amount of wet weather, whole effluent toxicity testing of CSO outfalls on the river to determine the toxicity of these discharges during storm events. There was some concern with the results due to the unusually large rain events that occurred prior to the sampling phase of the toxicity tests. On the whole, the results of these tests were considered inconclusive. Further testing will be necessary to clearly establish the effect CSO discharges have on the river system.

C. Nonpoint Source Contributions

Nonpoint source water pollution in the Area of Concern is caused by runoff from urban, industrial and rural sources, and agricultural sources. Other forms of nonpoint source pollution affecting use impairments are sedimentation from the erosion of riparian and other unprotected areas; surface and ground water contamination from excessive use of pesticides and fertilizers; nutrient loadings from improper land application of sludge, wastewater, animal waste, and failing on-site sewage disposal systems. Wet and dry air deposition of atmospheric pollutants also cause nonpoint source pollution. The resuspension of sediments also contribute to diminishing water quality. For a thorough discussion of the effects of sediment resuspension, see the Sediment Cleanup and Restoration Alternatives Project, 1997, published by the U.S. Army Corps of Engineers.

D. Land Development, Erosion and Runoff

The Area of Concern is heavily industrialized. Current industries include three steel mills, two oil refinery/re-refineries, a chemical plant, and a boiler/industrial furnace (BIF). A potential source of pollution in the Area of Concern comes from the mismanagement of hazardous waste being generated, treated, stored and disposed. There are four active hazardous waste Treatment, Storage, and Disposal (TSD) facilities and seven TSD facilities undergoing the closure process. In addition, there are forty-eight operating hazardous waste Large Quantity Generators (LQG)

within the Area of Concern, and a total of four hundred and fifty-nine Small Quantity Generators within Lake County. (This represents the total number of small quantity generators in Lake County, including those sites that may be outside the Area of Concern).

One by-product of this highly industrialized area is waste. A number of sites became contaminated prior to the effective date of the Resource Conservation and Recovery Act (RCRA) program. There are four Superfund sites within the Area of Concern. One site proposed for the NPL, USS Lead, is currently undergoing RCRA corrective action, The Area of Concern also contains four active State Cleanup sites, and ten Corrective Action sites. In addition, the heavy industrialization of the area has resulted in widespread contamination of the soil by hazardous substances and petroleum through accidental spills and releases. IDEM currently maintains a spill database to track these spills.

Leaking underground storage tanks are also a point of concern. As of May 1996, there were one thousand wighty-two facilities in Lake County that have underground storage tanks. As of June 1996, approximately four hundred leaking underground storage tank (LUST) sites have been identified in Lake County. There are two hundred and thirty-six Low Priority LUST sites, one hundred and twenty-eight Medium Priority LUST sites, and thirty-two High Priority LUST sites. Of the four hundred LUST cases, fourteen have completed cleanups and ten are not officially recorded as cleanups but have been discontinued. This leaves three hundred and seventy-six active cases with forty-nine having progressed beyond the investigation phase in which corrective action plans have been submitted for their cleanup. The majority of staff resources are used in the remediation of high priority cases. IDEM has one full-time staff member working out of the Northwest Regional Office who is dedicated to the cleanup of the Lake County LUST sites.

E. Air Emission and Deposition

There are many sources of atmospheric deposition in this region including semi-integrated and fully integrated steel mills, companies supporting steel production, a petroleum refining and marketing operation, utilities, other manufacturing, and the mobile sources associated with dense population and the area's proximity to Chicago. Atmospheric deposition contributes to at least eleven of the fourteen identified impaired uses.

Based on ambient air monitoring data, Lake and Porter Counties have been designated as non-attainment for ozone (O_3) National Ambient Air Quality Standards (NAAQS). The northern portion of Lake county has been designated as nonattainment for particulate matter (PM_{10}) and sulfur dioxide (SO_2) NAAQS. As a result, a significant portion of IDEM activity is focused in these two counties. All efforts and programs that reduce emissions of air pollutants in the area will contribute to restoration of the beneficial uses that are now impaired. This section details specific measures to reduce air emissions in Lake and Porter Counties. Over time, reductions of

air pollutants will help restore the impaired beneficial uses.

The primary indicators of air quality are the NAAQS which U.S. EPA has established for six criteria pollutants: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), lead (Pb), particulate matter ten microns in diameter (PM_{10}) or less, and carbon monoxide (CO). (Table 11). Primary NAAQS have been established to protect public health while secondary standards have been established to protect public welfare and property. Pollutant levels above the primary standards can result in adverse health effects, especially for those segments of the population that are particularly susceptible such as young children, the elderly, or those with respiratory illnesses.

Table 11. National Ambient Air Quality Standards (NAAQS)

Pollutant	Primary (Health Related)		Secondary (Welfare Related)	
	Type of Average	Standard	Type of Average	Standard
CO	8-hour	9 ppm (10 mg/m^3)		Same as Primary
	1-hour	35 ppm (40 mg /m^3)		Same as Primary
Pb	Maximum Quarterly Average	1.5 ug/m^3		Same as Primary
NO_2	Annual Arithmetic Mean	0.053 ppm (100 Ug/m^3)		Same as Primary
O_3	Maximum Daily 1-hour Average	0.12 ppm		Same as Primary
PM_{10}	Annual Arithmetic Mean	50 ug/m^3		Same as Primary
	24-hour	150 ug/m^3		Same as Primary
SO_2	Annual Arithmetic Mean	80 ug/m^3 (0.03 ppm)	3- hour	1300 ug/m^3 (0.50 ppm)
	24-hour	365 ug/m^3 (0.14 ppm)		Same as Primary

Attainment of the NAAQS is determined using ambient air monitoring data. Modeling is used in the development of a State Implementation Plan (SIP) to show that attainment is likely to be achieved with measures included in the SIP. IDEM operates a network of ambient air quality monitors for all criteria pollutants and many toxic compounds. In some cases, industries also operate ambient air quality monitors. The data from this monitoring network provides an indication of air quality trends.

Typically, air quality monitoring in Indiana has focused on monitoring ambient levels of the criteria pollutants to determine compliance with NAAQS. However, IDEM has also monitored ambient air concentrations of certain toxics and heavy metals at the Hammond monitoring site since 1988. Currently, no state or federal rules establish acceptable ambient air

concentrations of toxic pollutants or heavy metals (the one exception is lead, for which a NAAQS has been established). The Hammond toxics monitoring site was originally established as part of an urban air monitoring program, funded by U.S. EPA, and maintained by IDEM since completion of the program in the late 1980s. Data collected at the site are reported to the U.S. EPA's Aerometric Information Retrieval System (AIRs) data repository and provides historical information on ambient air concentrations of toxic pollutants and metals. Since the site was originally established, the number of organic compounds analyzed has increased from eighteen to eighty-two.

U.S. EPA mandated that states establish photochemical assessment monitoring, type-II sites (PAMS-II) in counties designated as severely nonattainment for ozone. The Office of Air Management (OAM) established a PAMS-II monitoring site at Gary IITRI. Throughout the ozone season, PAMS-II monitoring provides hourly determinations of ozone precursors and carbonyl compounds. Fifty-six organic compounds, including alkanes, alkenes, and some aromatic hydrocarbons are monitored.

IDEM also uses special purpose monitoring in areas that have no permanent monitoring sites. Special purpose monitoring provides data that can be used to assess ambient air quality impacts of specific sources, especially in cases where a violation is suspected, or to verify modeling studies.

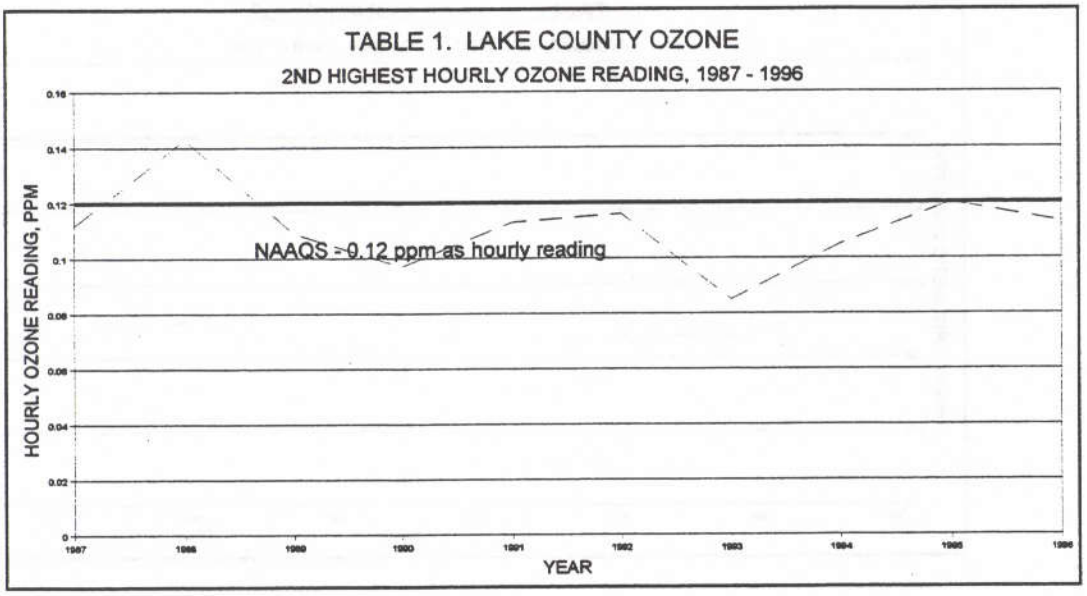
One category of regulated pollutants is criteria pollutants. Criteria pollutants are those pollutants for which NAAQS have been established, along with precursors. The criteria pollutants include ozone, particulate matter, sulfur dioxide, nitrogen dioxide (a subset of nitrogen oxides), carbon monoxide, and lead. These criteria pollutants contribute to the atmospheric deposition in this region.

1. *Ozone*

Ozone is not directly emitted into the atmosphere, but rather is formed when volatile organic compounds (VOCs) react with nitrogen oxides and carbon monoxide in the presence of sunlight. Ground level ozone is often referred to as photochemical smog. VOC, NO_x, and CO along with high temperature, direct sunlight, and low wind speed play a key role in the formation of ozone. Ozone is normally of concern during the hot summer months which are typically referred to as the ozone season.

Lake County and the Chicago Metropolitan area share ozone problems due to heavy motor vehicle traffic, large population, industrial base, and the unique meteorological conditions caused by Lake Michigan. Lake County is included within the Chicago-Northwest Indiana severe nonattainment area for ozone. The Clean Air Act requires states to develop a State Implementation Plan containing comprehensive measures to eliminate the health threat from

ozone in severe nonattainment areas by 2007. Additional information on ozone reduction measures being employed in the Area of Concern is included in Chapter Five. Table 1 on the following page provides a graph of the second highest hourly ozone reading at each ozone monitoring site located in Lake County for each year between 1987 and 1996.

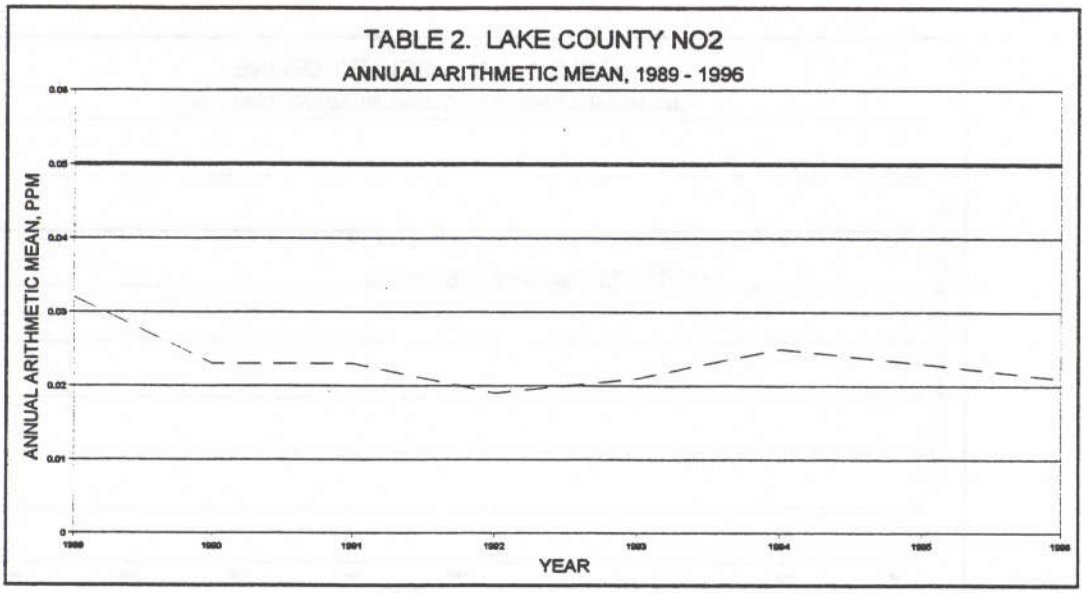


There was one exceedence of the ozone standard (0.12 ppm) within the Area of Concern during the summer of 1996: 0.131 ppm at the Hammond CAAP. On July 18, 1997, the U.S. EPA promulgated revisions to the NAAQS for ozone based on findings that exposures to concentrations lower than that established by the one-hour standard for longer periods of time (six to eight hours) were linked to adverse health effects. U.S. EPA established a standard of 0.08 ppm averaged over an eight hour time period. The Clean Air Act requirements for areas that are nonattainment of the one hour standard (0.12 ppm) remain in place. Development and implementation of measures to attain the one hour standard will further progress in meeting the new standard. U.S. EPA is currently developing implementation guidance for the new standard.

2. Nitrogen Oxides

Nitrogen oxides (NO_x) are formed from high temperature fossil fuel combustion. Primary sources include utility and industrial boilers, and motor vehicles. Nitric oxide is the principal pollutant emitted, but a substantial portion is converted to nitrogen dioxide (NO_2) in a chemical reaction promoted by sunlight. The NAAQS is established for NO_2 because of its direct health

effects, however, NO_x plays a significant role in acid rain and ozone formation. Depending on the specific circumstances, NO_x can either promote or inhibit ozone formation. See Table 2 below.



Acid rain provisions in the CAA require nitrogen oxides reductions from large utility boilers. Title IV of the CAA includes provisions which establish strict emissions standards on source emitting nitrogen oxide in order to reduce acid rain. The control of nitrogen oxides from stationary sources is complicated and difficult. In addition to these requirements, new, utility and industrial boilers are required to meet NO_x emission requirements in the New Source Performance Standards (NSPS) based on the date of construction.

The Clean Air Act Amendments also require states to adopt rules that will reduce NO_x emissions, similar to the VOC measures, in ozone nonattainment areas. However, because of the particular chemistry of ozone formation, NO_x reduction, in some cases, can actually increase ozone levels in the immediate area. The CAAA permits states to request a waiver of the NO_x

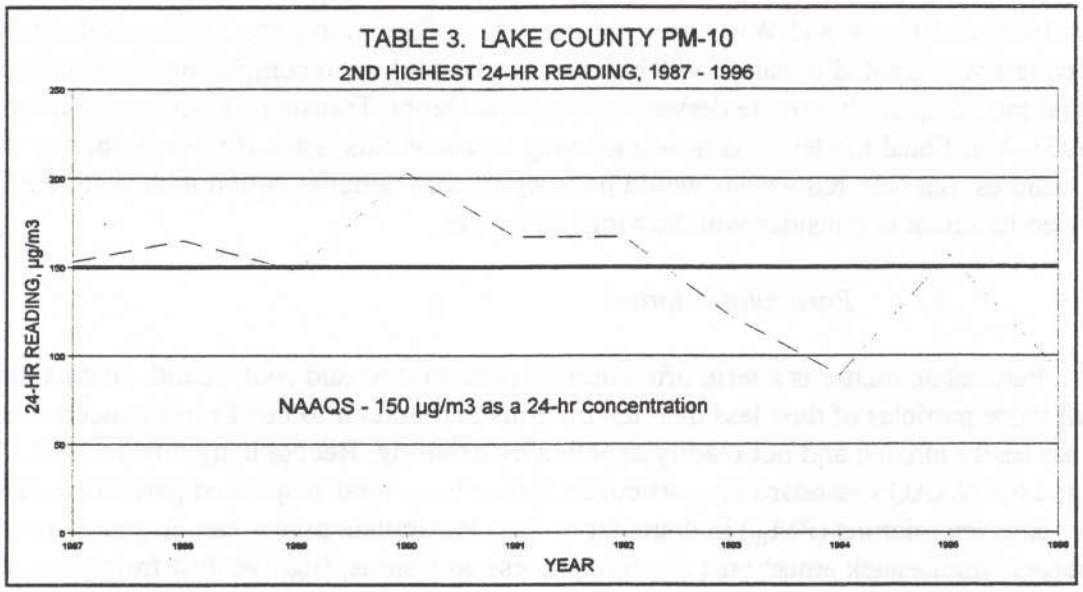
requirements if air quality modeling demonstrates that this would be the result pursuant to Title I. The modeling performed by the Lake Michigan Air Directors' Consortium (LADCO) for the Chicago-NW Indiana nonattainment area showed that NO_x reductions would increase peak ozone levels. Indiana, Illinois, and Wisconsin requested U.S. EPA waive the NO_x control requirements. The request was granted in early 1996 but was conditional upon completion of the larger scale regional modeling study now underway through the Ozone Transport Assessment Group (OTAG). Additional modeling is now underway to assess this issue. If these modeling studies demonstrates that NO_x reductions would have significant benefits region wide, U.S. EPA has indicated its intent to consider withdrawing the waiver.

3. *Particulate Matter*

Particulate matter is a term often used to refer to dust and soot. Health studies have shown those particles of dust less than ten microns in diameter to be of most concern because they are easily inhaled and not readily expelled by exhaling. Recognizing this, in 1987, U.S. EPA changed the NAAQS standard for particulate matter from total suspended particulate (TSP) to particulates ten microns (PM_{10}) in diameter or less. Particulate matter can originate from a variety of sources: smokestack emissions; fugitive process emissions; fugitive dust from plant sites; public roadways; and mobile sources.

Particulate emissions have historically been a significant concern in Lake County. In the 1970s and 1980s, ambient levels of TSP exceeded health standards frequently and by significant margins. In 1993, IDEM completed a rulemaking that established new emission limitations for sources in Lake County to meet the NAAQS for PM_{10}. These rules are part of Indiana's PM_{10} State Implementation Plan (SIP). The PM_{10} SIP also requires the collection and continual update of source emissions data and ambient air monitoring data. IDEM analyzes data on an ongoing basis to identify issues of concern, and then develops rules and policies to maintain the PM_{10} NAAQS.

The PM_{10} SIP also includes a control strategy that focuses on Lake County which has the most serious particulate pollution in the state. This strategy includes process specific emission limitations for major stationary sources which have resulted in significant emission reductions (e.g., shutdown of the Inland Steel coke batteries), fugitive dust control plans, and other measures meant to ensure continuous compliance and improved enforceability. The U.S. EPA's recent approval of the PM_{10} SIP makes it federally enforceable. The PM_{10} levels in Lake County have dropped significantly due to new particulate rules and efforts of Lake County industry. Table 3 provides a graph of the second highest PM_{10} readings at each PM_{10} monitoring site located in Lake County for each year between 1987 and 1996.



On July 18, 1997, U.S. EPA promulgated revisions to the NAAQS for particulate matter based on findings of studies linking exposures to ambient fine particulate matter to adverse health effects. U.S. EPA established a 24-hour and annual standard for particulate matter 2.5 microns in diameter or less. Because limited information is available on sources and ambient concentrations of $PM_{2.5}$, monitoring and planning will be required before control measures to address these standards would be required. IDEM is establishing monitoring sites for $PM_{2.5}$.

4. *Sulfur Dioxide*

As part of this State Implementation Plan, IDEM has developed process specific emission limitations for major stationary sources located in Lake County. These rules include fuel use restrictions, require the use of lower sulfur fuels; and set emission limits for steel mills, refineries, and other facilities in Lake County. Title IV of the CAA includes provisions which establish strict emissions standards on sources emitting sulfur dioxide in order to reduce acid rain. By January 1, 1995, during the first phase of the program, the one hundred and ten largest sulfur-emitting electric utility plants were required to meet more strict standards for annual sulfur dioxide emissions. Continuous emission monitoring (CEMS) is required on all Phase I and Phase II boilers to demonstrate continual compliance. Phase II of the program will require, by January 1, 2000, sulfur dioxide reductions on Phase I boilers and initial reductions on Phase II boilers. In Lake County, two major stationary boilers are subject to Phase II requirements. While still classified as a nonattainment area, IDEM has not monitored an exceedence of the sulfur dioxide

(SO_2) NAAQS in Lake County since 1985.

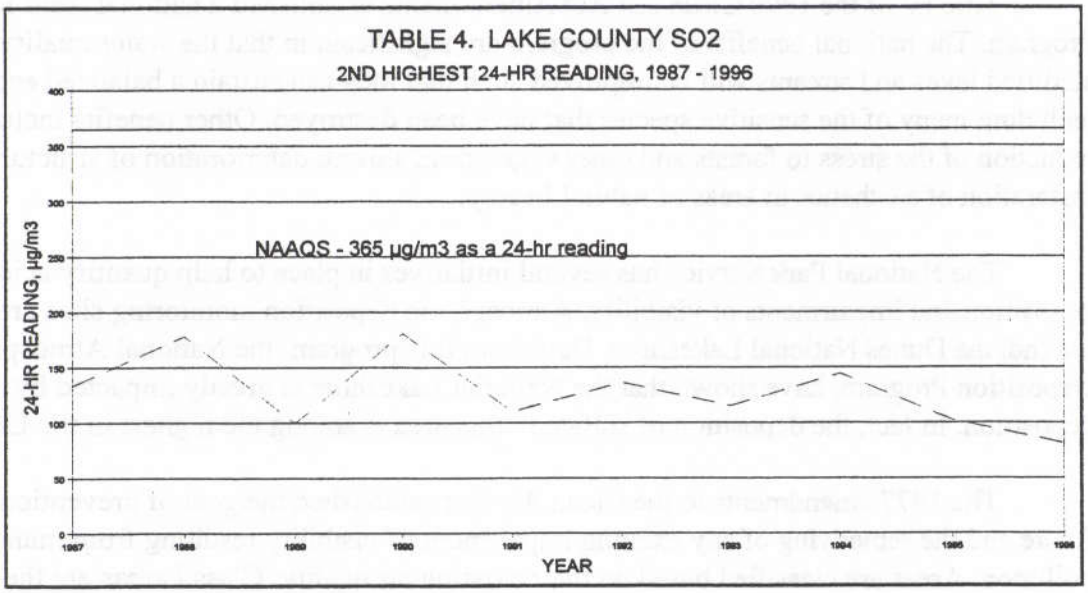


Table 4 (above) provides a graph of the second highest 24-hour SO_2 monitoring site located in Lake County for each year between 1987 and 1996.

Acid deposition, or acid rain as it is commonly known, results when emissions of SO_2 and NO_x react in the atmosphere with water, oxygen, and oxidants to form various acidic compounds. These compounds can be deposited in either dry form (gas and particulate) or wet form (rain, snow, and fog). Winds can transport these compounds long distances before they are deposited. Electric utilities and other fossil fuel combustion sources account for about seventy percent of the annual SO_2 and thirty percent of the NO_x emissions in the United States. Mobile sources are also a significant contributor of NO_x emissions.

Acid rain causes acidification of lakes and streams, and accelerates the decay of structures such as buildings and bridges, and damages paint on automobiles and houses resulting in increased maintenance costs. Additionally, SO_2 and NO_x and their particulate forms, sulfates and nitrates, contribute to visibility degradation and impact public health. Many bodies of water in the upper Midwest, including those within the Area of Concern, have been affected by acidification. Acidification results in a lowering of the pH level in the water which affects many sensitive species. While acidification is often considered a chronic problem, there can be periods of episodic acidification which are brief periods of low pH levels that result from snow melt or heavy rains. Episodic acidification may result in acute impacts on sensitive species which causes

large scale fish kills.

Title IV of the 1990 Clean Air Act Amendments established a national Acid Rain Program. The national benefits of the program are significant in that the water quality in many acidified lakes and streams will be improved such that they can sustain a balanced ecosystem including many of the sensitive species that have been destroyed. Other benefits include a reduction of the stress to forests and other vegetation, slowed deterioration of structures, and the restoration of aesthetics in areas of natural beauty.

The National Park Service has several initiatives in place to help quantify acidic deposition and impairments of visibility. Atmospheric deposition monitoring sites are located in the Indiana Dunes National Lakeshore. Data from this program, the National Atmospheric Deposition Program, have shown that the National Lakeshore is greatly impacted by acidic deposition. In fact, the deposition of sulfate in this area is among the highest in the United States.

The 1977 amendments to the Clean Air Act established the goal of prevention of any future and the remedying of any existing impairment of visibility resulting from manmade air pollution. Areas are classified based on their existing air quality: Class I areas are the most pristine with practically any change in air quality is considered significant; Class II areas have some industry and are expected to experience some deterioration in air quality that is normal with growth; and Class III areas are heavily industrialized with deterioration up to air quality standards not considered significant.

Class I areas typically include areas such as the national parks in the western United States like the Grand Canyon. The National Park Service has instituted several visibility monitoring programs and management activities to protect visibility. Surveys of visitors to national parks indicate a high value is placed on improving visibility and restoring the natural aesthetics of these vistas.

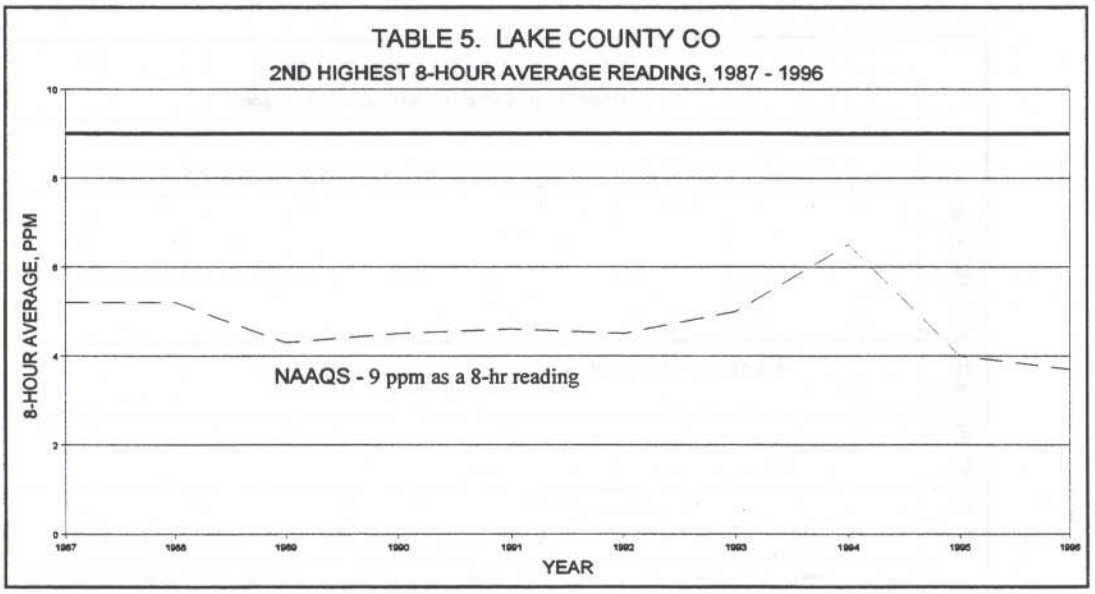
Indiana Dunes National Lakeshore is exempt from the Class I visibility protection requirements because it is located in a Class II area. It is subject to the same air quality requirements as the surrounding area. There are no federal visibility standards for Lake or Porter Counties.

5. *Carbon Monoxide*

Carbon monoxide (CO) is produced by the incomplete combustion of carbon fuels. It is emitted by incomplete combustion of fossil fuel including motor vehicles use and industrial processes. While CO plays a minor role in ozone formation, emissions of CO are more directly

related to ambient concentrations of CO in the atmosphere. Because carbon monoxide represents a loss of fuel, there are economic incentives for stationary sources to reduce emissions. In some industrial processes, such as those used in iron and steel plants and petroleum refineries, carbon monoxide is collected and used in waste-heat recovery systems. IDEM has set process specific emission limits for petroleum refineries, ferrous metal smelters, and municipal waste incinerators. Control of CO from motor vehicles is more complicated because the CO reductions must be balanced with often conflicting considerations such as fuel economy, engine performance and reduction of other pollutants. The Inspection/Maintenance Program requires vehicles to be tested for CO in addition to hydrocarbons. Often a tune-up will help reduce vehicle emissions.

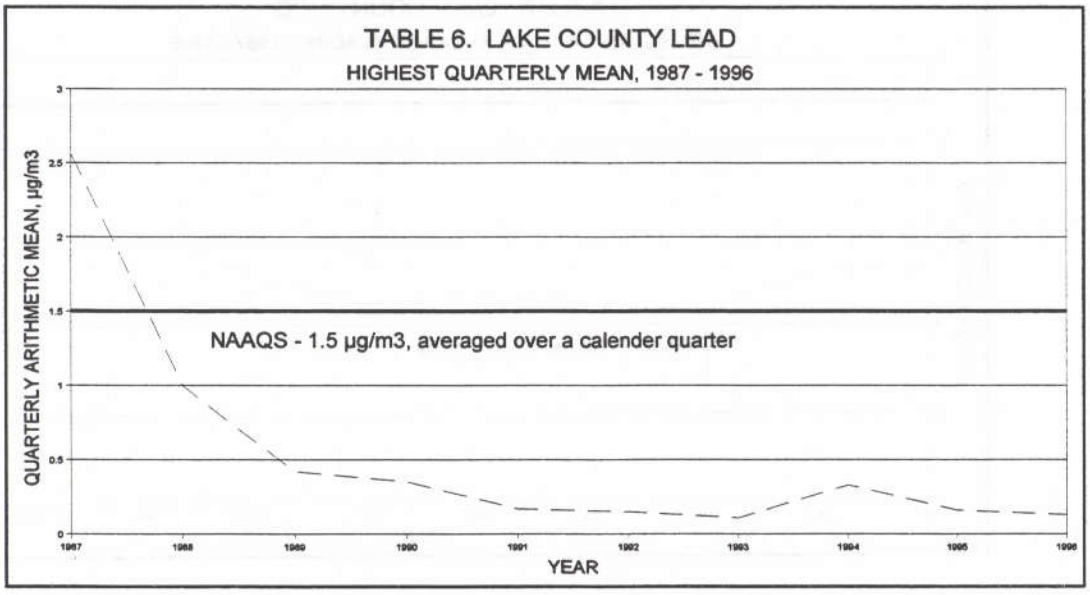
IDEM has not monitored an exceedence of the CO NAAQS in Lake County in over ten years. Table 5 provides a graph of the second highest CO readings at each CO monitoring site located in Lake County for each year between 1987 and 1996.



6. *Lead*

Lead is the only heavy metal for which an NAAQS has been established. The primary health concern of lead is the systemic effects it may have on the central nervous system. Often associated with learning problems in children, environmental exposure can also affect elderly and pregnant adults in Lake County.

The federal phase out of lead in gasoline also helped to significantly reduce emissions of lead. Several process changes at major industrial sources in Lake County have led to a reduction of lead concentrations in the atmosphere measured within the Area of Concern. IDEM has established process specific emission limitations for the three major industrial sources of lead located within the area concern: Hammond Lead Products-HLP Plant, Hammond Lead Products - Halstab Division, and U.S.S. Lead Refinery. In addition to the process specific emission limitations, the sources were also required to upgrade their ventilation and filtration systems and operate their buildings under negative pressure to reduce fugitive emissions. Additional measures are required to control fugitive emissions from storage piles. The Hammond Lead plants have also put into place operational controls and work practices beyond those required in the rules to further reduce lead emissions. Since the rules were adopted, U.S.S. Lead Refinery in East Chicago has shut down resulting in a decrease in ambient air levels of lead. IDEM has not monitored an exceedence of the Pb NAAQS since 1986. Table 6 provides a graph of the second highest Pb readings a teach lead monitoring site located in Lake County for each year between 1987 and 1996.



7. Open Burning

Smoke from open burning is not only an irritant but contains harmful particulate and volatile organic pollutants. Due to high regional ozone levels, residential open burning is not allowed in Lake or Porter County. There are instances, however, when burning may balance

environmental benefits without adverse impacts on air quality. One such instance is the burning of vegetation for wildlife habitat maintenance, forest and natural area management, and fire fighting or prevention. Prescribed fires can benefit Indiana's woodlands and reduce the threat of wildfire.

Federally-managed woodlands, such as the Indiana Dunes National Lakeshore, commonly use prescribed fires to manage wildlife habitats. Special consideration and planning are necessary to ensure the prescribed fires have minimal affect on public health and welfare. Under Indiana's rules, only government agencies are allowed exemptions to use prescribed fires. They are required to prepare formal plans before burning takes place. IDEM may grant a variance for other types of burning provided certain criteria are met.

III. Fragmentation and Loss of Physical Habitat

Fragmentation and loss of physical habitat are directly related to degraded fish and wildlife population, degradation of benthos, degradation of phytoplankton and zooplankton populations and loss of fish and wildlife habitat. They are contributing factors to fish tumors and other deformities, bird or animal deformities and/or reproductive problems. While protecting sensitive habitat areas, such as Roxanna Marsh and DuPont, will not necessarily restrict dredging activities, it will make removing contaminated sediments more complicated.

At one time, the Indiana portion of the strandplain covered over 30,000 acres. Only 2,000 acres of ridge and swale still exist in the state. Aerial photographs taken over the last 60 years document the physical transformation of the region from a natural system to an urban industrial complex. The first complete set of aerial photographs of the Calumet region date back to 1938. Undisturbed sections of ridge and swale topography are easily recognized by their distinctive linear pattern. The photographs show that the strandplain had already been divided into three distinct units and that shoreline alterations that would eventually isolate the strandplain from Lake Michigan had already begun. The city of Gary separated the Miller Woods area in the east from the central ridge and swale section. The central ridge and swale section was divided from the Wolf Lake/George Lake area by the cities of Hammond, East Chicago and Whiting. Although these areas were isolated, there were still fairly large blocks of natural terrain in the Miller Woods and central ridge and swale areas. See Figure 1, Map of Toleston beach ridges and dunes in Northwest Indiana.

Half of the approximately 2000 acres of the remaining natural landscape are found in the Miller Woods area. They are fairly contiguous and include the Miller Woods unit of the Indiana Dunes National Lakeshore, the City of Gary's Marquette Park and private property. Over 430 species of native plants have been documented in the Miller Woods unit of which at least 70 are

considered rare or are limited to a unique niche within the Indiana Dunes National Lakeshore (Wilhelm 1990). The dune complex north of the lagoons supports panne and foredune communities. The ridge and swale complex to the south of the lagoons support some of the highest quality black oak savanna in the Chicago Region (Wilhelm 1990)

The other remaining 1000 acres of natural landscape are scattered throughout the central ridge and swale area. The natural area fragments occur as isolated pockets ranging in size from five to 170 acres. The construction and expansion of the Gary airport isolated the lakeside remnants near Clarke & Pine from those in west Gary, Hammond and East Chicago. Industrial expansion, residential development and landfills contributed to the overall loss of habitat. Despite fragmentation these remnants still support dense assemblages of native plants and animals, including 66 state rare and endangered species.

Clarke and Pine Nature Preserve, Gibson Woods Nature Preserve, Ivanhoe Dune and Swale Nature Preserve and Toleston Ridges Nature Preserve are examples of these islands of biodiversity set in the midst of the urban industrial landscape. These sites support a mosaic of interconnected natural communities that defy mapping. Seven of the community types are globally rare; panne, wet mesic sand prairie, mesic prairie, dry mesic sand prairie, dry mesic sand savanna, dry sand savanna and sedge meadow (TNC). Clarke and Pine Nature Preserve's forty acres support the highest concentration of rare and endangered species in the state of Indiana.

The Wolf Lake/George Lake area has suffered the greatest loss of habitat. Of the five shallow lakes that occupied the northwest section of the strandplain, Berry Lake, George Lake and a portion of Wolf Lake were in Indiana. Berry Lake was filled and converted to industrial property in the early part of this century. The practice of draining and filling the lakes and marshes and converting them to industrial use reduced George Lake to 200 acres, less than half of its original size. A large portion of the southern end of Wolf Lake was also filled. Only a handful of small fragments, less than ten acres apiece, remain of the marshes that surrounded these lakes.

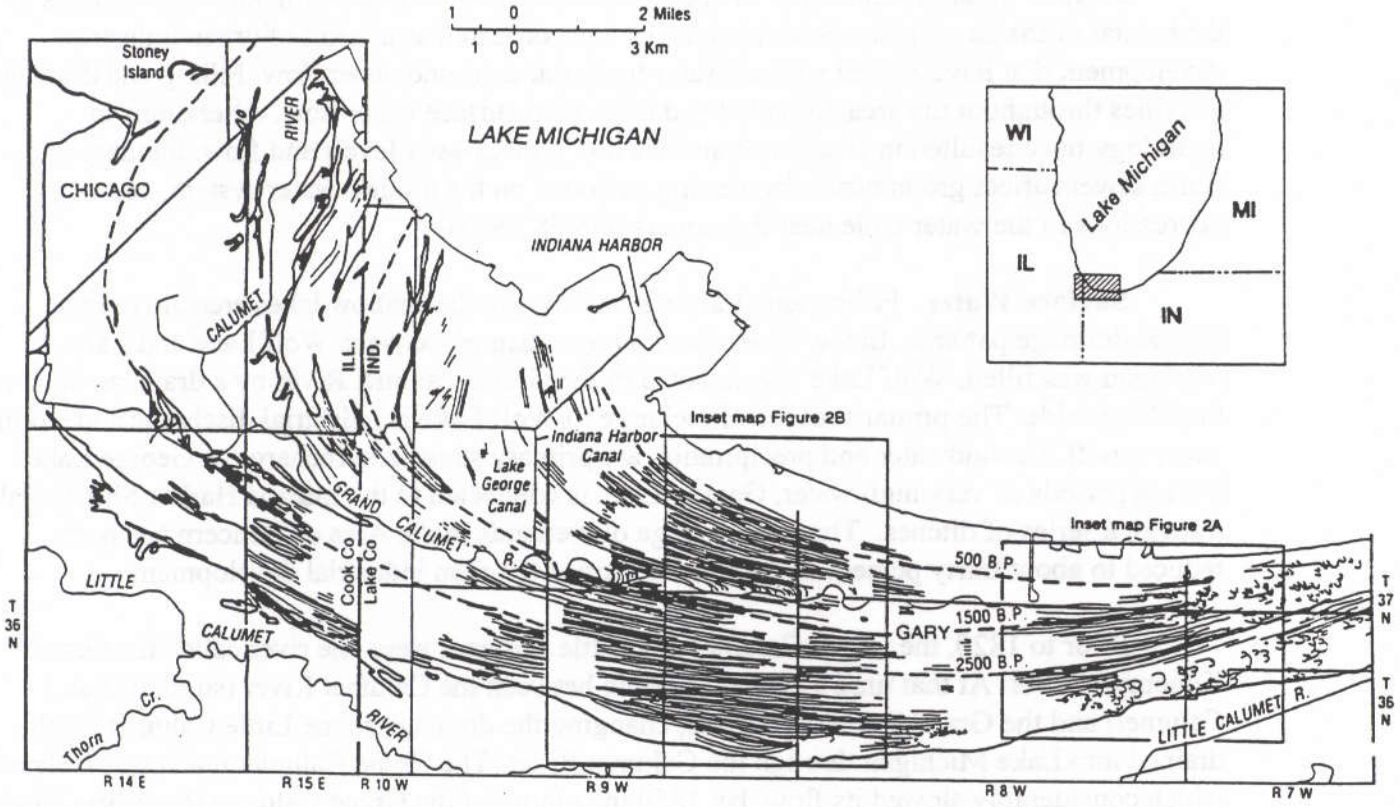


Figure 2. Map of Toleston (Nipissing age) beach ridges and dunes in northwest Indiana. The apex of individual beach and dune ridges were traced from 1938 air photos. By 1938, large tracks of land had been filled, mined or otherwise modified. Thus, many beach ridges and some dunes appear to be segregated or missing (white areas within the Toleston strandplain and dunes) from this map (from Thompson, 1992).

IV. Altered Hydrology

Altered hydrology directly contributes to degraded fish and wildlife populations, degradation of benthos, eutrophication or undesirable algae, degradation of phytoplankton and zooplankton populations, and loss of fish and wildlife habitat.

Surface water/ground water interactions are crucial to maintaining moisture regimes in the habitat of the strandplain. Several changes have occurred as a result of urban industrial development that have altered surface water bodies and ground water flow. Filling and drainage activities throughout the area disrupted and redirected surface water flow. Alterations in hydrology have resulted in changes to surface and groundwater levels and flow. Sanitary and storm sewers affect groundwater by serving as drains on the ground-water system, causing depressions in the water table near the sewers (USGS 1993).

Surface Water. Filling and draining activities in the shallow lakes area altered the natural drainage patterns. In the 1940s the drainage channel between Wolf Lake and Lake Michigan was filled. Wolf Lake is connected to the Grand Calumet River by a drainage ditch on the Illinois side. The primary source of recharge to Wolf Lake is industrial discharge and storm water runoff. Groundwater and precipitation are primary sources of recharge to George Lake. During periods of very high water, George Lake is connected to the Indiana Harbor Ship Canal through a series of ditches. The total acreage of wetlands in the Area of Concern has been reduced to about thirty percent of what existed prior to urban industrial development.

Prior to 1820, the Grand Calumet and Little Calumet were one river called the Grand Konomick River. At that time a channel opened between the Calumet River (south of Lake Calumet) and the Grand Konomick River, changing the drainage so the Little Calumet reach drained into Lake Michigan through the Calumet River. The Grand Calumet reach was isolated which considerably slowed its flow. By 1850 the mouth of the Grand Calumet River was blocked by beach and dune deposits and the river channel was choked with aquatic vegetation.

In the late 1800's the Corps of Engineers removed 37,743 cubic yards of material from the Grand Calumet River near Hammond to facilitate navigation for the Hammond packing plant. Dredging of this portion of the river was abandoned in 1895 because the channel filled with industrial waste and sewage faster than it could be removed by dredging. Construction of the Indiana Harbor Ship Canal began in 1903. The reach south of Columbus Drive was excavated by private interests between 1908 and 1912 to a depth of 15 feet.

Portions of the Grand Calumet Channel have been relocated during construction and expansion of the U.S. Steel plant and the I-90 toll road. A two-mile reach of the river was moved

1000 feet southward between 1906 and 1917. The lagoons were formerly connected to the river via open channel; however, the channel was filled and replaced with a culvert sometime after 1951. Between 1953 and 1959, two reaches of the river between Clark and Grant Streets in Gary were relocated for construction of the I-90 toll road.

In addition to relocation of the river channel, several sections of the river have been dredged either to facilitate commercial navigation or to enhance the discharge capacity of the river. U.S. Steel periodically dredged the river along its property through 1967. The dredged sediment, mostly untreated industrial and municipal waste, was side cast along the channel or placed in an area between Bridge Street and Taft Street north of the river. The western portion of the East Branch, between Bridge Street and the Indiana Harbor Ship Canal, may never have been dredged.

These developments changed the direction of the river flow. The former mouth of the river, the Grand Calumet Lagoons, is now the headwaters. The East Branch of the Grand Calumet River flows west from the lagoons to the junction with the Indiana Harbor Ship Canal, then north to Lake Michigan. Flow in the West Branch is more complex; it flows in two directions. Roxana March lies near the flow divide. East of Roxana Marsh, the rivers flows east to the confluence with the Indiana Harbor Ship Canal, then north to Lake Michigan. West of Roxana Marsh, the river flows west into Illinois, forming a confluence with the Calumet River. Lake Michigan surface level is a significant factor in the flow direction and velocity of the Grand Calumet River, not only in the Indiana Harbor Ship Canal, but in the east and west branches as well.

Ground Water. The complex surface water/groundwater interactions are complicated by sheet piling that has been driven throughout the region. Sheet piling in the Gary Harbor and along reaches of the Grand Calumet River, Lake Calumet (in Illinois), the Indiana Harbor Ship Canal and Lake Michigan form a barrier to the flow of surface water and groundwater. Large gradients between surface and groundwater can be built up as a result (USGS 1996).

The study of shallow ground water in the Area of Concern has focused mainly on the transport of contaminants. The impacts of changes in groundwater flow on the natural systems is unknown. The pattern of ground water flow has been altered locally by surface structures and changes in run-off patterns. While the impacts of changes in groundwater flow on the remaining biotic communities has not been quantified, it is evident in the composition of biotic communities. Again, urban industrial development has had an impact on groundwater flow, recharge and discharge.

V. Shoreline Alterations

Shoreline alterations directly contribute to degraded fish and wildlife populations, degradation of benthos, degradation of phytoplankton and zooplankton populations, and loss of fish and wildlife habitat.

The state gave the first permits to fill into Lake Michigan in 1907. Since that time, most of the lakeshore has been altered by fill, armoring, breakwaters, and the creation of harbors, marinas and recreational parks. Shoreline alterations throughout the entire southern Lake Michigan area have severely disrupted the transport of sand along the shore and inhibited new beach and dune formation. Virtually all of the natural nearshore aquatic and terrestrial habitat has been severely degraded or eliminated from the Area of Concern. The Miller Woods Unit of the Indiana Dunes National Lakeshore is the only remnant natural area to border the lakeshore. Sites such as the "migrant bird trap" or the municipal and county parks offer specific limited habitat value.

VI. Exotic Species Introduction

Exotic species directly contribute to degraded fish and wildlife populations, eutrophication and undesirable algae, degradation of phytoplankton and zooplankton populations, and loss of fish and wildlife habitat. It is a contributing factor to degradation of benthos.

In the Chicago region there are approximately 2500 species of plants, of which, 900 have been introduced since European settlement. Of the 900 introduced species, 150 dominate 95 percent of the landscape. (Swink and Wilhelm 1994). In the Area of Concern there are a handful of exotic plants that are having a major impact on the biological structure of habitat. Plant species commonly associated with urban residential development dominate most of the vegetated landscape. Natural habitat has been replaced with manicured landscaping. A handful of exotic species, typha (cattails), purple loosestrife, phragmites, buckthorn and sweet clover, are having a major impact on the remaining natural habitat.

Typha migrated into the Great Lakes Region after European settlement and reached southern Lake Michigan around 1880. Typha is far more widespread locally than it was at the turn of the century, and is now common in marshes throughout the Calumet region (*Ibid*). Purple loosestrife, a Eurasian species, was introduced into the area as a cultivar and escaped to overtake many wetland areas. Each purple loosestrife plant produces as many as 250,000 seeds, that are dispersed through flowing water. Phragmites is opportunistic in disturbed areas and establishes large monocultures that quickly take over more diverse wetland communities. It primarily

reproduces by sending off long stolons, but can spread by seed. Common buckthorn is a Eurasian shrub that spreads by bird-dispersed seeds and invades native communities. It replaces native shrubs and is especially prevalent in areas that are fire-suppressed. While the other exotics discussed above are primarily wetland species, sweet clover, a biennial herbaceous plant, invades the upland sand prairies and savannas.

VII. Fire Suppression

The fires that were an integral part of the southern Lake Michigan lakeplain ecosystem became a threat to private property as permanent settlements developed in the region. As residential and industrial development expanded, the frequency and range of fires decreased. In some areas, this has caused the elimination of much of the herbaceous layer that served as fuel for the fires. In other cases, it caused fuel build-ups that made occasional wildfires more intense. Fragmentation has made it difficult for fire sensitive species to recolonize after fires have occurred.

The National Park Service, IDNR, Lake County Parks and Recreation, and The Nature Conservancy all use prescribed burns as a management tool for natural areas in the Area of Concern. Controlled burns are carried out under prescriptions that detail ecological objectives, appropriate weather conditions to control the fire and smoke, and emergency procedures. Records are kept of all fires including post-burn evaluations. Because of air quality concerns, open burning is not allowed in Lake County. Therefore, controlled burning for ecological purposes requires permits from the appropriate state and local agencies.

VIII. Conclusion

Significant stress in the Area of Concern has caused much of the degradation of the ecosystem, resulting in the loss of habitat, increased sedimentation and lack or excessive nutrient loadings. The stress can occur from either biological, physical, or chemical factors. The six leading contributors to the high level of stress are derived from human activity. Contamination seriously alters fish and wildlife populations, drinking water standards, aesthetics, deformities, agricultural and industrial work. Contamination contains a variety of factors which affect the environment. Contaminated sediment from municipal and industrial point discharge, combined sewer overflow, and urban runoff all contribute to the decreasing efficiency of the ecosystem. Also, non-point source pollution, land development, erosion, runoff, and air emissions limit the beneficial uses in the Area of Concern. Other major stressors include fragmentation and loss of physical habitat, altered hydrology, shoreline alterations and introduction of exotic species. All of these sources of stress impair fourteen beneficial uses degrade the environment.