

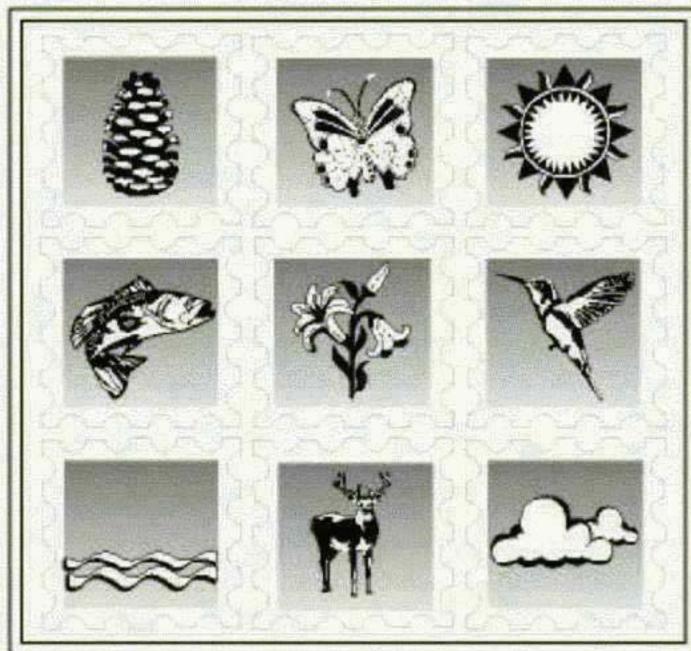
2005



2005



2005



State of
MICHIGAN'S ENVIRONMENT 2005

Third Biennial Report



*State
of
Michigan's Environment 2005
(Third Biennial Report)*

**Michigan Department of
Environmental Quality
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**Michigan Department of
Natural Resources
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Jennifer M. Granholm, Governor

Message from the Governor

With over 37 million acres of land contained within its two majestic peninsulas and bordered by the largest freshwater resource in the world, Michigan is unlike any other state in the country. Michigan's natural environment is composed of glacially-formed landforms ranging from extensive flatlands to rolling hills to mountains, transitioning broadleaf to mixed to conifer forests, extensive Great Lakes' shorelines, over 11,000 inland lakes and 36,000 miles of rivers and streams, and a diversity and abundance of fish and wildlife.

Also included within Michigan's environment are the more than 10 million people that live and work within its borders. Many industries, businesses, and farms, and numerous cities and villages co-exist amongst the state's natural communities that provide livelihoods for its citizens and recreational opportunities for its citizens and visitors alike.



In 1999, the Michigan Departments of Environmental Quality (MDEQ) and Natural Resources (MDNR) were legislatively mandated with the task of developing a scientifically sound environmental indicators program for Michigan for tracking changing environmental trends in the state and to report on this program on a biennial basis. In 2000, the Michigan Environmental Science Board reviewed the scientific validity of the MDEQ and MDNR proposed program. The first comprehensive environmental indicators report for Michigan was published in 2001. I am pleased to present you with the third environmental indicators report entitled, *State of Michigan's Environment 2005: Third Biennial Report* (2005 Biennial Report).

The 2005 Biennial Report continues to follow important trends in previously reported environmental indicators such as land use and cover, mammal, bird, and fish populations, ambient air pollutant levels, and surface and ground water quality, and looks at some new indicators and measures such as annual Great Lakes ice cover, greenhouse gases, and the prevalence of arsenic, lead, and volatile organic chemicals in drinking water. The 2005 Biennial Report also addresses several other issues of importance including the impact of the many exotic species that have invaded Michigan's waters and land and the progress the state has made to help control the invasions. Finally, the 2005 Biennial Report discusses the status of Michigan's endangered and threatened plants and animals, urban sprawl, numerous environmental programmatic measures, and several emerging contaminants of concern and their increasing prevalence and potential impact on Michigan's environment.

In the words of an ancient Native American proverb, *Treat the earth well: it was not given to you by your parents, it was loaned to you by your children. We do not inherit the Earth from our Ancestors; we borrow it from our children.* As we meet the current and future environmental challenges facing Michigan to ensure clean air, fishable and swimmable waters, and an abundance of clean drinking water, these Biennial Reports will help us to measure our progress and define future environmental policy in our continuing efforts to conserve resources and preserve Michigan's environment for our future generations.

A handwritten signature in black ink, appearing to read 'J. Granholm', written over a white rectangular background.

Jennifer M. Granholm
Governor

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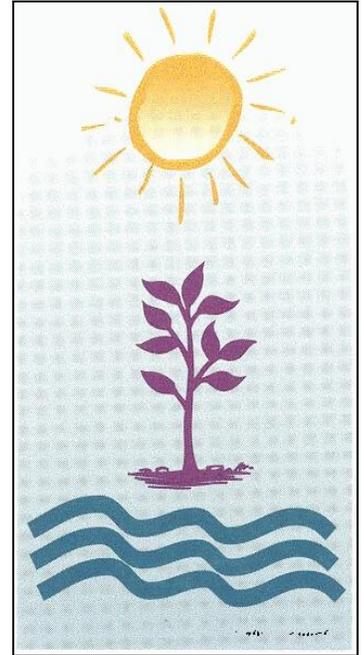
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Introduction

Beginning in the late 1960s and early 1970s, concerns regarding the health of the nation's environment and how well it was being protected by state and federal agencies heightened amid numerous reports of contaminated drinking water, rivers, and streams resulting from open dumps and polluting industries, and of reports of sick and dying song, predatory, and shore birds resulting from the misuse and overuse of pesticides. These and other environmental consciousness-raising concerns ultimately led to the passage of a series of state and federal environmental regulations during the 1970s that were designed to identify and reverse the often long-standing contamination practices that lead to the environmental degradation.

During the 1980s and 1990s, state and local governments began to move away from the strict regulatory approach to pollution control and began to explore many new and/or innovative, non-regulatory programs, such as pollution prevention and minimization, recycling, and, later, brownfield redevelopment programs. This same period also saw the beginnings of an enhanced awareness among many Michigan citizens, businesses, and communities regarding the need for greater environmental stewardship and the need to conserve. As a direct result of these and other factors, many of the air, water, and land environmental problems that were of greatest concern 30 years ago either have been corrected or are in the final stages of being corrected.



The state is now faced with new and more complex environmental issues. Unfortunately, many of the environmental concerns of today are not as obvious as were those of the past and are frequently now of a more diffuse nature (e.g., non-point source pollution, air deposition of contaminants, invasive non-native species, urban sprawl, and exposure to waste pharmaceuticals). Consequently, the extent of the problem is often more difficult to define and the corrective actions and other types of solutions more complex and/or elusive. Compounding this further has been a greatly enhanced technical capability to measure pollutants at ever decreasing levels coupled with an increased difficulty to understand the degree of actual risk that such pollutants pose to the environment and/or human health at such low levels.

The challenges facing Michigan in the 21st Century will be to accurately identify and track changes in the environment resulting from human-related activities and to develop meaningful ways to measure the change and the degree of success or failure of the regulatory and non-regulatory programs designed to protect the environment. To date, there have been several attempts to do this. However, many of the attempts employed either have not been designed to be integrated into a comprehensive understanding of the impact of human-related degradation or mitigation activities on the natural environment, or have been incapable of differentiating natural from human-caused environmental change. Consequently, most of the attempts to identify and track human-influenced environmental change have resulted in a patchwork of disjointed programs and scientifically invalid measurements.

Public Act 195 of 1999 (Environmental Indicators Act) was signed into law in December 1999. The law requires the Michigan Department of Environmental Quality (MDEQ) to work with the Michigan Department of Natural Resources (MDNR) to prepare biennial reports on the quality of the state's environment based on scientifically supportable environmental indicators and using sound scientific methodologies.

On January 28, 2000, the Governor of Michigan requested the Michigan Environmental Science Board (MESB) to evaluate a series of environmental indicators proposed by the MDEQ and MDNR for use in the

legislatively mandated report. The MESB report entitled, *Recommended Environmental Indicators Program for the State of Michigan*, was submitted to the Governor in July 2001. Of the environmental indicators proposed for consideration by the MDEQ and MDNR, the MESB recommended that 20 be included into a statewide environmental indicators program. The MESB also recommended that one additional indicator (Climate and Weather Change) be taken into consideration in the state’s evaluation (Exhibit 1).

The first biennial *State of Michigan’s Environment Report* (Biennial Report) was completed and transmitted to the Michigan Legislature in November 2001. The second Biennial Report was completed in December 2003. The purpose of this document is to present the third Biennial Report.

The 2005 Biennial Report is divided into three sections: environmental measures, programmatic measures, and emergent contaminants of concern in Michigan. The first section presents the ecological, physical, and chemical measures used to track the overall quality of the state’s environment and fulfills the legislative mandate. The second section discusses additional state agency measures that are tracked to fulfill various state or federal environmental

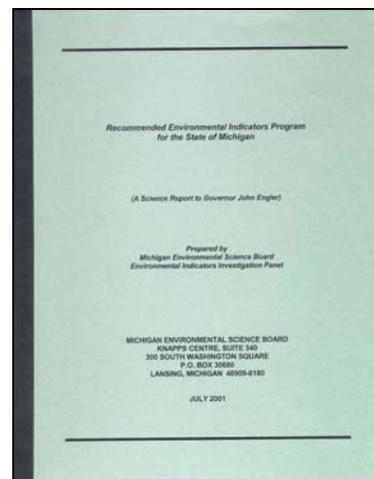


Exhibit 1. Michigan Environmental Science Board Recommended Environmental Indicators	
Ecological Indicators:	<ul style="list-style-type: none"> Land Use/Cover Breeding Bird Abundance Trends in Habitat of Interior and Edge Bird Species Trends in Game Fish Populations Trends in Benthic Macroinvertebrate and Fish Populations Trends in Frog and Toad Populations Invasive (Exotic) Species Forest Acreage, Mortality, Growth, and Removal Vegetation Structure and Diversity Lichen Communities
Physical/Chemical Indicators:	<ul style="list-style-type: none"> Ambient Levels of Criteria Air Pollutants Stream Flow Inland Lake Water Quality Contaminant Levels in Fish Inland Lakes Sediment Trends Contaminant Levels in the Connecting Channels, Saginaw Bay, Grand Traverse Bay, and Major Tributaries Climate and Weather Change
Future Indicators:	<ul style="list-style-type: none"> Ambient Levels of Air Toxic Contaminants Rates of Deposition of Persistent and Bioaccumulative Air Toxics and Acidic Components Trends in Mammal Populations
Optional Indicator:	<ul style="list-style-type: none"> Contaminant Levels in Bald Eagles
<p>Source: Michigan Environmental Science Board, <i>Recommended Environmental Indicators Program for the State of Michigan</i>, July 2001.</p>	

programmatic requirements. These latter measurements, while in and of themselves may ultimately detect a change in the overall quality of the environment, are designed more to assess how well a given regulatory

program is functioning to correct or control more short-term, localized environmental problems. The third section discusses several newly recognized contaminants that environmental and public health experts have an incomplete understanding regarding their potential for adverse environmental and human health effects.

As with the previous Biennial Reports, caution should be exercised with the information presented in this Biennial Report. First, care should be taken not to understate or overstate the importance of a change that may be observed in any given environmental indicator from one two-year reporting period to the next. Two years is an extremely short time frame for a natural or human-influenced disturbance or corrective action to be realized within most ecosystems. Also, with most environmental measures, it can take many years of monitoring data to properly identify and assess the emergence of either a positive or negative variation in the environment. The importance of this and subsequent Biennial Reports will be best reflected in terms of their ability to detect long-term changes that may be taking place in the environment, rather than short-term anomalies that may be observed from one reporting period to another.

Second, care also should be taken not to oversimplify the results of the Biennial Report. It is not reasonable to summarize the results of the collective environmental indicators down to a one- or two-word conclusion about the overall health of such a highly complex system as the state's environment. While certainly simple to understand, such relative comparison labels as *good, moderate, bad, healthy, unhealthy, etc.*, are indefinable scientifically and often can be misleading. In almost all cases, additional qualifying information is needed to describe accurately what the various environmental measures appear to be indicating.

Finally, it is recognized that incomplete information exists for many of the environmental measures presented in this Biennial Report. These data gaps will be filled by each successive Biennial Report. With time, the Biennial Reports should provide Michigan with an invaluable tool to track and evaluate its dynamic environment. More importantly, the Biennial Reports should help to spur the development of new and innovative environmental stewardship policies and programs to further improve the state's overall environmental quality.



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January 2006



Environmental Measures

Environmental Measures

Ecological Indicators

Trends in Land Use/Cover

Monitoring change in land use/cover types provides a useful indirect measure of trends in ecosystem health. High rates of land conversion place stress on natural ecosystems. Human population growth and/or dispersal usually cause a conversion of land use/cover types from natural vegetation or agricultural types to urban uses. While quite often economically beneficial in the short-term, these changes often have long-term negative impacts on ecosystem health through the loss of wildlife habitat and incremental increased water and air pollution.

Change is the only constant with Michigan's environment. Change occurs through natural processes such as ecological succession and fire, and through human activities such as agricultural, residential, urban, and industrial development. Since European settlement, Michigan's land cover has changed dramatically. At times, this change has occurred quite rapidly over relatively short periods of time. The original land surveyors of Michigan recorded a landscape dominated by forest in the north and a mix of forest and savanna in the south. Early settlers cleared land for agriculture while logging companies provided



wood to a growing nation. The logging era of the late 19th and early 20th Centuries changed Michigan's landscape dramatically. The 20th Century was marked by a return of forest to the northern Michigan landscape and intensive agriculture and urban development in southern Michigan. Exhibits 2 and 3 provide a graphic representation of the loss of wetlands in Michigan between 1800 and 1980 and the percent change in natural vegetation, respectively, that has taken place due to competing uses of land resources in Michigan between the 1880s and the 1990s.

Michigan's land cover was mapped in 1978 by the MDNR. At that time, Michigan was composed of 37 percent forest, 29 percent agricultural, 18 percent wetland, 8 percent open field, 6 percent urban, and 2 percent inland water. The United States Department of Agriculture (USDA) also tracks changes in Michigan's land cover through its National Resources Inventory program. According to the USDA, between 1982 and 1997 there was a 30 percent increase in developed land with almost half that increase occurring between 1992 and 1997 (Exhibit 4). Most of this development occurred on former agricultural land. During this same time period, there was a loss of



approximately 1.4 million acres of crop and pasture land.

Other noticeable recent trends include an increase in forests and a decrease in wetlands. Between 1982 and 1997, there was an increase of 538 thousand acres of forest on non-federal rural land in Michigan. The increase in forest was the result of natural succession of open fields and abandoned agricultural land. In 1978, Michigan had approximately 6.2 million acres of wetlands. The United States Fish and Wildlife Service (USFWS) reports that the rate of wetlands loss has declined dramatically across the nation compared to previous decades; however, loss of wetlands is still occurring with conversions to urban and agricultural uses. The most disturbing trend in land cover has been the rapid conversion of natural landscapes and agricultural areas to

suburban and urban development. These conversions of agricultural land have traditionally resulted in increases in water and air pollution.

Urbanization. As previously indicated, the percentage of Michigan land in urban use in 1978 was six percent. Numerous studies have documented the changes in Michigan's land cover since 1978, most notably the spreading of urbanization along with a population out-migration from parts of many cities. According to one such study, if current land use patterns continue, between 1.5 and 2 million more acres of land area will be urbanized by 2020.

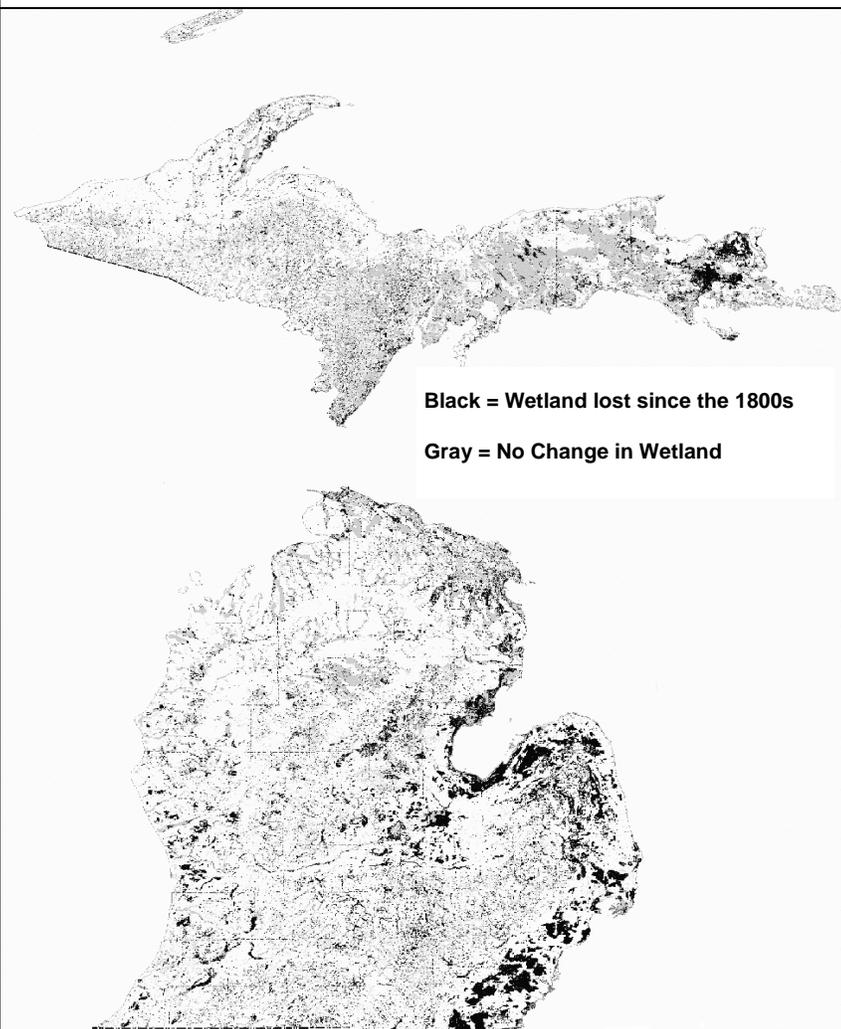
In 2001, the Michigan Land Resource Project looked at the future of Michigan's land-based industries if current development trends continue.

The Michigan Land Resource Project projected that by 2040 the amount of developed land in Michigan will have increased by 178 percent, nearly three times that which currently is developed. At the same time, it was predicted that the amount of acres in agriculture, private forests, wetlands, and other vegetated lands, would decrease by 17 percent, 8 percent, 10 percent, and 24 percent, respectively (Exhibit 5).

In February 2003, the Governor of Michigan created the Michigan Land Use Leadership Council (Council). The Council was charged with studying and identifying trends, causes, and consequences of urban sprawl and providing recommendations to the Governor and the state legislature designed to minimize the negative effects of current and projected land use patterns on Michigan's environment and economy. The Council's report entitled, *Michigan's Land, Michigan's Future: Final Report of the Michigan Land Use Leadership Council* (Land Use Report), was released in August 2003.

The Council's Land Use Report recommendations were organized along four categories (urban revitalization, land resource-based industries, planning and development regulation, and infrastructure and community services), and addressed nine key issues to combat urban sprawl (Exhibit 6).

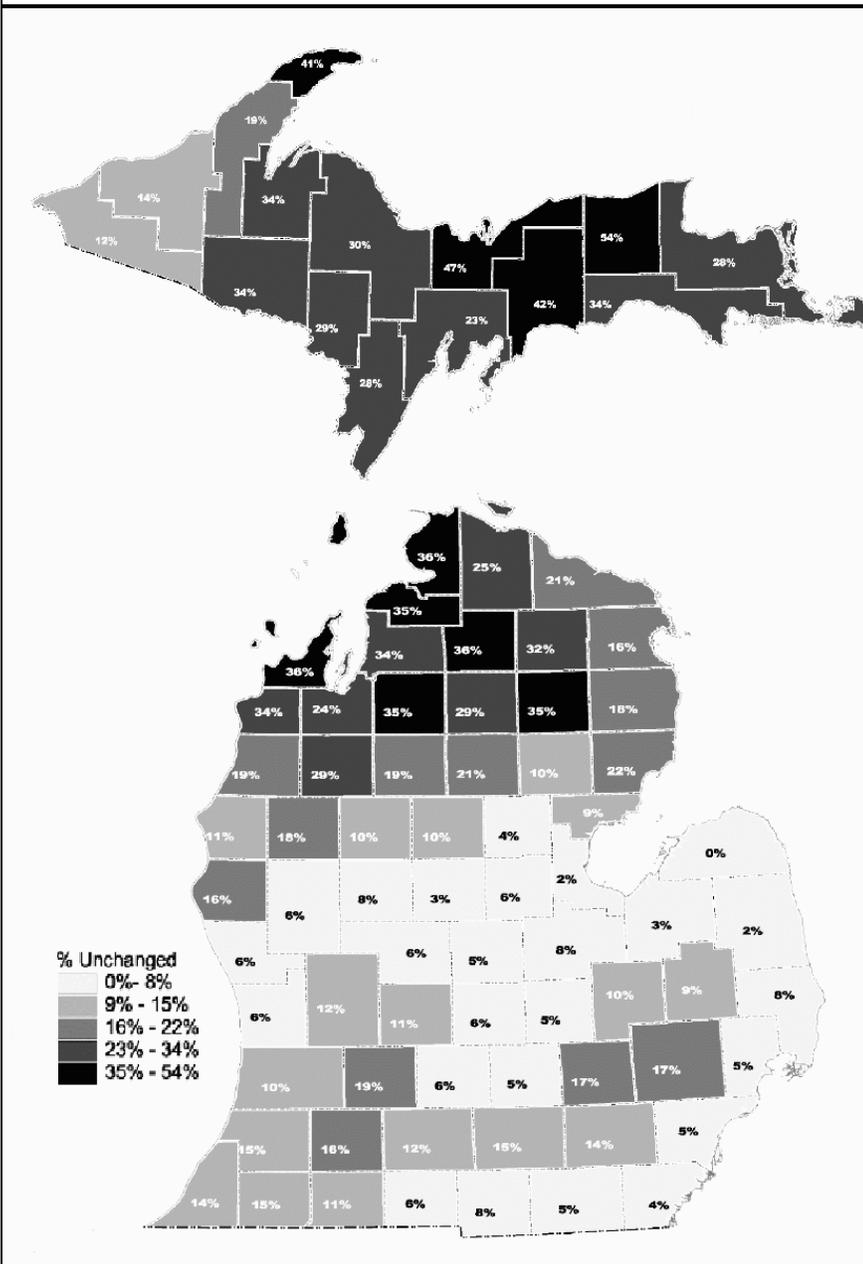
Exhibit 2. Changes in Michigan's Wetlands 1800 - 1980



Among the recommendations in the Land Use Report, the Council called for the state to complete its natural features inventory and to update its 1978 Michigan Resource Information System Current Inventory by completing a new round of aerial photography and land use/cover classifications. The Land Use Report also called for the development of a report every five years that would evaluate the amount of farmland and forested lands that were in active production, the change in land cover by county, and the number of Michigan citizens housed each year in



Exhibit 3. Percent Change in Native Vegetation by County between the 1880s and 1900s



new construction.

Since the release of the Council's Land Use Report in 2003, several pieces of legislation have been enacted, many state initiatives have been developed, and many new state policies implemented to begin the process of addressing the over 160 recommendations contained in the Land Use Report. Exhibit 7 highlights some of the key activities taken thus far by five state departments to address urban sprawl and the various problems that have resulted from it.

Changing long-held attitudes and past practices regarding how land should be and, ultimately, is used within the state will require a long-term commitment and a cooperative effort on the part of federal, state, and local governments, and the citizens of Michigan. A copy of the Council's Land Use Report may be obtained from the Governor's Internet site (www.michigan.gov/gov).

Trends in Forest Acreage, Mortality, Growth, and Removals

The Forest Acreage, Mortality, Growth, and Removals indicator addresses several dimensions relating to the health of Michigan's forests. As previously indicated, Michigan's forests have been recovering following over-exploitation and fire devastation that took place towards the end of the 19th Century and the beginning of the 20th Century. The state

will never again see the vast forest acreages or the old growth forests that once were present; however, recent inventory data indicate the state's forests have been steadily recovering from the earlier devastation.

Five statewide forest inventories were conducted during the last century and information from a new inventory is now available. These inventories indicate that forest acreage has remained relatively stable since the 1950s. The only exception to this was a slight decrease between 1966 and 1980, followed by an expansion between 1980 and 1993 (Exhibit 8). Losses (or conversions out) of forested land between 1980 and 1993

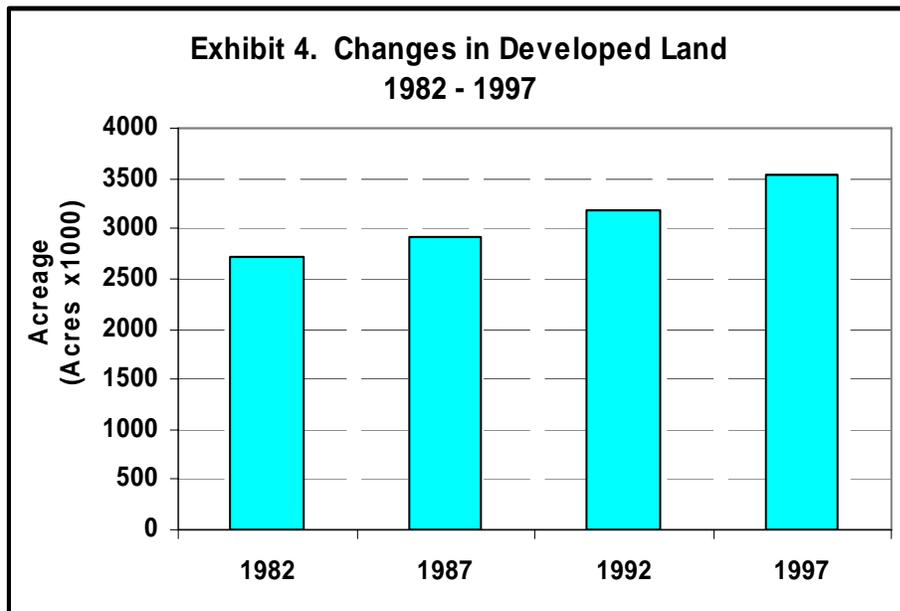


Exhibit 5. Classes of Land Use in 1980 and Projections to 2040

Land Use Classes	1980 (Millions of Acres)	2040 (Millions of acres)	Change	Percent
Agriculture	11.0	9.1	-1.9	-17%
Developed Land	2.3	6.4	+4.1	+178%
Private Forestland	18.2	16.9	-1.3	-8%
Other Vegetated Lands	2.9	2.2	-0.7	-24%
Wetlands	1.8	1.7	-0.2	-10%

Source: Public Sector Consultants, *Michigan Land Resource Project*, November 2001.

were made up for by other lands being converted into forest. The predominant land type converting into forest was agricultural. In contrast to the stable forest acreage, total standing timber volumes have almost tripled since the middle of the last century, reflecting a maturing forest. This expanding volume also indicates that more growth has been continuously added to the forest than what has been removed or died through natural causes. Annual growth has steadily increased over the past 50 years (Exhibit 9).

Trends in Vegetation Diversity and Structure

Michigan's forests are some of the most diverse in the United States. Statewide forest inventories identify over 75 different tree species with substantial mixtures of species within each of the



Exhibit 6. Identified Land Use Issues Needed to Address Urban Sprawl

- Preserving agricultural land, forests, wildlife habitat, and scenic resources that form the basis of Michigan's land resource-based industries by enhancing existing programs and creating new incentives for private land owners to maintain these valuable undeveloped open spaces.
- Supporting efforts to make Michigan cities more livable by expediting the reuse of abandoned properties, controlling blight, encouraging private investment, encouraging mixed-use development, improving transportation options, supporting a full range of housing options, and attracting and retaining residents who can contribute to the viability of our urban core areas.
- Making better use of existing public infrastructure by encouraging public and private investment in already developed areas.
- Providing new tools to local government to encourage better land use decisions that allow more compact, mixed-use development.
- Creating incentives to encourage interagency and intergovernmental cooperation in addressing land use issues and public investments of more than local concern.
- Encouraging private investment in already developed areas by removing governmental barriers and creating incentives.
- Streamlining state and local government financial assistance and regulatory programs that support land use practices.
- Seeking government partnerships with for-profit and non-profit sectors to create a range of affordable housing options.
- Identifying commerce centers where infrastructure is already serving relatively dense populations to guide the future investment of state resources to support private investment and development.

Source: Michigan Land Use Leadership Council, *Michigan's Land, Michigan's Future: Final Report of the Michigan Land Use Leadership Council*, August 2003.

major forest cover types. This diverse forest provides habitat for a wide variety of plant and animal species.

In addition to maturing, Michigan's forests have been gradually transitioning towards more shade-tolerant, late successional tree species. For example, aspen, paper birch, and jack pine, species particularly adapted to full sunlight, have been declining in acreage while the more shade tolerant species such as maples, northern white cedar, spruces, and oak-hickory types have been increasing. Similarly, animals that depend on pioneer tree species for habitat also have been declining. For instance, ruffed grouse, American woodcock, golden-winged warbler, and other songbirds dependent upon early successional tree species have suffered from this change in habitat while other bird species dependent on the shade-tolerant tree species have benefited. Between



Exhibit 7. Examples of Recent State Department Activities to Address Urban Sprawl

→ Michigan Department of Agriculture

Anticipated completion by fall 2005 of a new aerial photography survey of the state. Development of legislation to establish *Agricultural Production Districts* (if passed, local units of government could grant certificates to owners of agricultural land that would allow them to pay in lieu of certain personal and property taxes, an alternative agricultural production tax, which would encourage retention and use of agricultural land). Initiation of a *Purchase of Development Rights Grant Program* to provide grants to local units of government to fund purchase of development rights on farmland in areas of the state that have comprehensive land use plans in place.

→ Michigan Department of Environmental Quality

Identification and evaluation of department administered state environmental regulations, rules, and policies (e.g. drinking water funding, permitting and all grant and loan programs) that impact or are impacted by the land use reform recommendations contained in the Land Use Report. Of the 160 recommendations, 88 were found to have either direct or indirect relevance to existing department programs. The department currently is addressing 38 of the recommendations and another 18 are scheduled to be implemented with adjustments made to existing agency program policies in order to facilitate the implementation and achieve regulatory consistency with as many of the Land Use Report recommendations as possible. An additional 28 Land Use Report recommendations will require additional resources and/or statutory authority before they can be addressed.

→ Michigan Department of Labor and Economic Growth

Launching of the Governor's *Cool Cities Initiative* in 2003 and the *Centers for Regional Excellence Program* in 2005. Both initiatives will assist in urban revitalization efforts and promote the multi-jurisdictional cooperation as prescribed within the Land Use Report

→ Michigan Department of Natural Resources

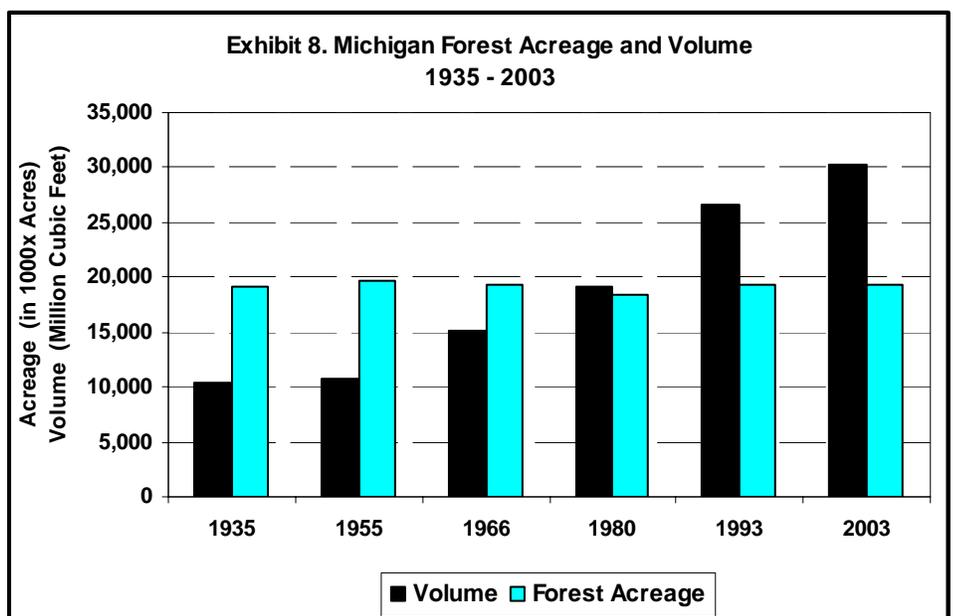
Development of land consolidation strategies for 10 state counties and classification of land under state ownership or management into one of three action categories: retention under state ownership and management, retention and transfer to another unit of government or an alternative conservation organization, or disposal because the parcel has limited natural resource, recreational, or cultural value.

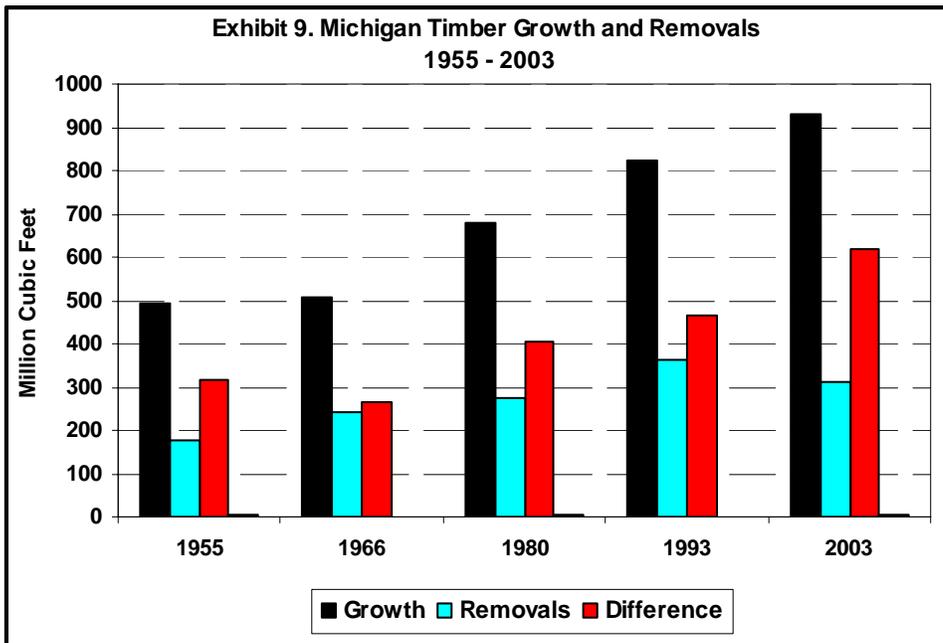
→ Michigan Department of Transportation

Adoption of a *Context Sensitive Design Concept* that calls for greater public input, review, and special attention for all new transportation projects, closer attention to the assessment of impacts that roadway projects may have on the social, economic, environmental aspects of the impacted community, and the planning and enactment of mitigation measures before any project proceeds.

1980 and 1993, maple-beech-birch cover type, by far the largest in Michigan, increased by almost one million acres. Given existing conditions, the trend towards more shade tolerant, older trees can be expected to continue.

The MDNR, in conjunction with the University of Michigan, participates in a national program that conducts annual evaluation of the condition, changes, and trends in the health of forest ecosystems in Michigan. The USDA Forest Service manages this national program, referred to as the *Forest Health Monitoring Program* (FHM





the atmosphere as a source of nutrition. A large body of scientific literature has documented the close relationship between lichen communities and air pollution, especially acidifying nitrogen, fertilizing nitrogen, sulfur dioxide, and other sulfur-based pollutants.

The composition of a lichen community is one of the best indicators of air pollution in forests. Long-term observations of the abundance of a particular group or species of lichen can provide early indication of changes in air quality or changes in forest composition. A decline or increase in the abundance of a particular species of lichen can be

a bellwether of declining or improving environmental conditions.

The USDA Forest Service's FHM Program developed the lichen community indicator. On forested plots samples of each lichen species are collected for laboratory identification and the relative abundance is estimated. To date, the program has identified 29 epiphytic lichen species representing 17 genera on Michigan plots (Exhibit 10).

This indicator is still in its early stages of development in Michigan,. As such, it is difficult to interpret what the collected lichens data may be suggesting about the quality environment at this time. The collected data will be used to establish

Program). The vegetation diversity and structure indicator is composed of a suite of measurements of forest understory diversity, vegetation structure, down woody debris, and forest fire fuel loading. Variables collected for this indicator can provide information to help evaluate wildlife habitat, plant diversity, vitality, soil conservation, and carbon cycling. As part of the FHM Program, botanists field identify nearly all the plant species on site, including locally rare species and exotic species from overseas. An immediate return from this evaluation will be to detect areas of exotic plant invasion and spread. Multi-scale data on plant diversity will be used to evaluate species richness patterns over time. This information will help to evaluate the effect of exotic plants relative to their native counterparts. The MDNR has piloted vegetation diversity and structure measurements since 1998. The first year for the collection of standardized plot data was 2001. Two evaluation projects are currently under way. It is anticipated that more information on this environmental indicator will be available for presentation in the 2007 Biennial Report.

Trends in Lichen Communities

Lichens are unique organisms, made up of cooperating algae and fungi. Individual species in this very diverse group are useful as environmental indicators. Epiphytic lichens, or lichens that live on other plants, are very sensitive to changes in air quality since they rely totally on



baseline information necessary to measure future changes in Michigan's environment. Over the next several years, the MDNR will be carefully monitoring changes in the abundance of lichen species, especially in the rarest species (Exhibit 11). It is anticipated that comparative information on species abundance may be available for the 2007 Biennial Report.

Trends in Mammal Populations

The majority of mammal population trend data are determined by using indices such as the *Winter Track Survey* and *Harvest Surveys*. Indices use data that are significantly correlated to population size. Obtaining population counts for mammal species can be difficult since many mammals

either have large home ranges or daily movement patterns, or hide extremely well making detection difficult. Consequently, total population counts are attempted on only a few large mammal species that are easily seen or leave significant markings.

The MDNR conducts an annual Winter Track Survey for gray wolves. The Winter Track Survey is a minimum count and is completed after new snow events to identify individuals and packs. The data collected on gray wolf populations since 1989 indicate a steadily increasing population of wolves in the state's Upper Peninsula (Exhibit 12). In addition, three wolves were verified in the northern Lower Peninsula in 2004.

The success of Michigan's recovery program for wolves suggests that the state has the potential for increasing its biodiversity through restoration of extirpated species. Although the gray wolf holds a position at the top of the food chain and

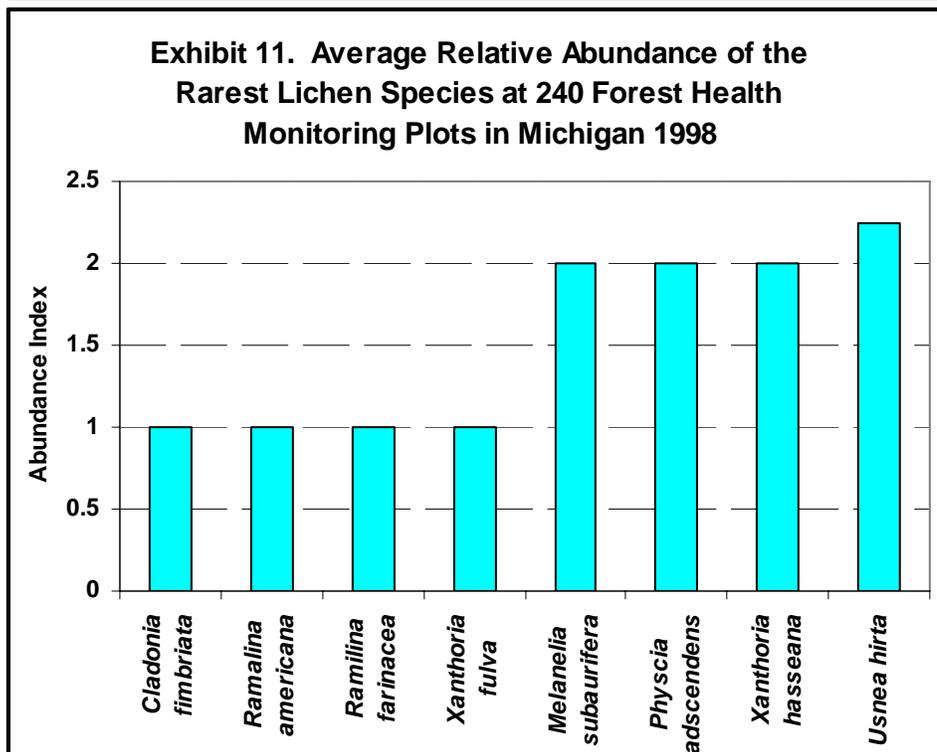
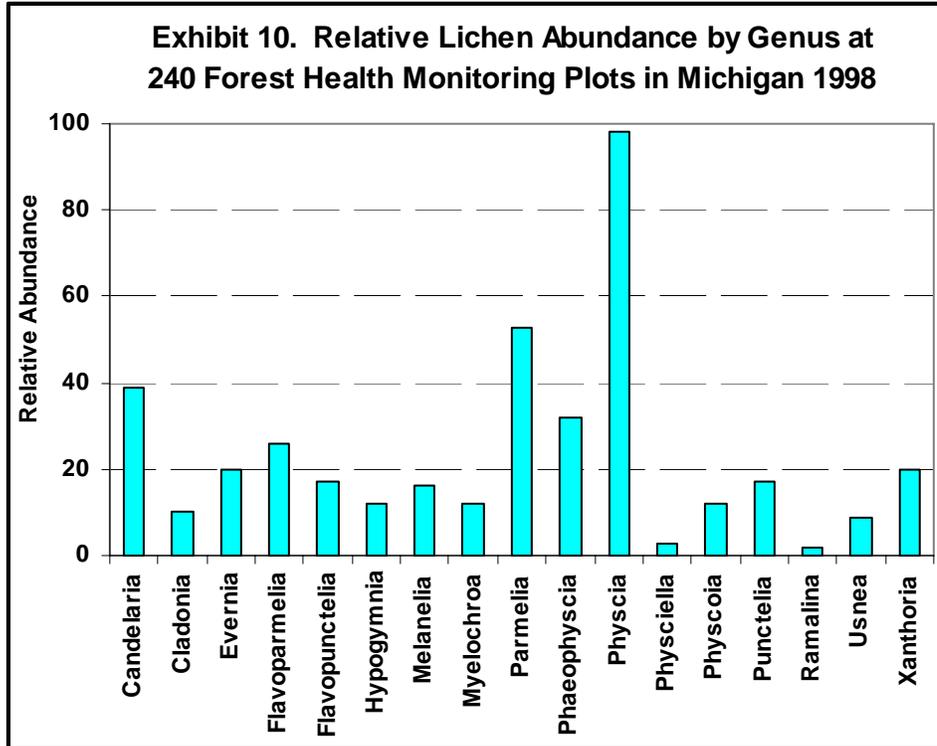
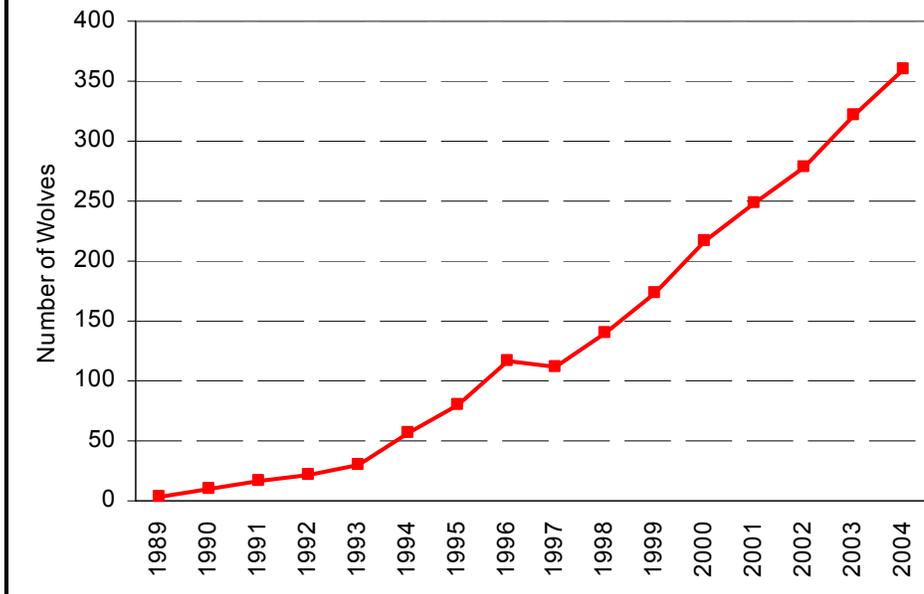


Exhibit 12. Number of Wolves in the Upper Peninsula 1989 - 2004



seasons have closed, surveys are randomly sent to hunters and trappers inquiring of their total harvest for selected species. The assumption is that success is related to population size. While this assumption is reasonably accurate, factors such as weather, timing of opening days, season lengths, and even economic conditions can affect the number of hunters and trappers and the amount of time spent pursuing game.

The harvest surveys provide a reasonably accurate assessment of the number of animals and can be a useful tool in tracking long-term population trends once other influencing factors are taken into consideration. Trapper harvest surveys have been conducted

information on its population status can be useful to enhance baseline biodiversity information, its use as indicator of the overall quality of the environment poses some problems. Wolves and other large mammals, such as black bears, are subject to both habitat and social carrying capacity factors.

annually since 1996 when they were reformulated into a standardized survey. Prior to 1996, they were not conducted on an annual basis. The harvest of several furbearer species are required to be registered and sealed. The registration information serves as another index on population size. Exhibits 13 – 15 present hunter harvest

Habitat carrying capacity refers to the number of animals capable of being supported by the environment, while social carrying capacity refers to the number of animals that humans will tolerate. The social carrying capacity is much lower than is the habitat carrying capacity for wolves. Most experts agree the wolf population is currently at or very near its social carrying capacity and, consequently, its population may need to be maintained by human intervention to remain at an acceptable level.

The most readily available index for small mammal populations are annual harvest surveys. Michigan undertakes both hunter and trapper harvest surveys. Once hunting

Exhibit 13. Hunter Harvest of Cottontail Rabbits in Michigan 1952 - 2004

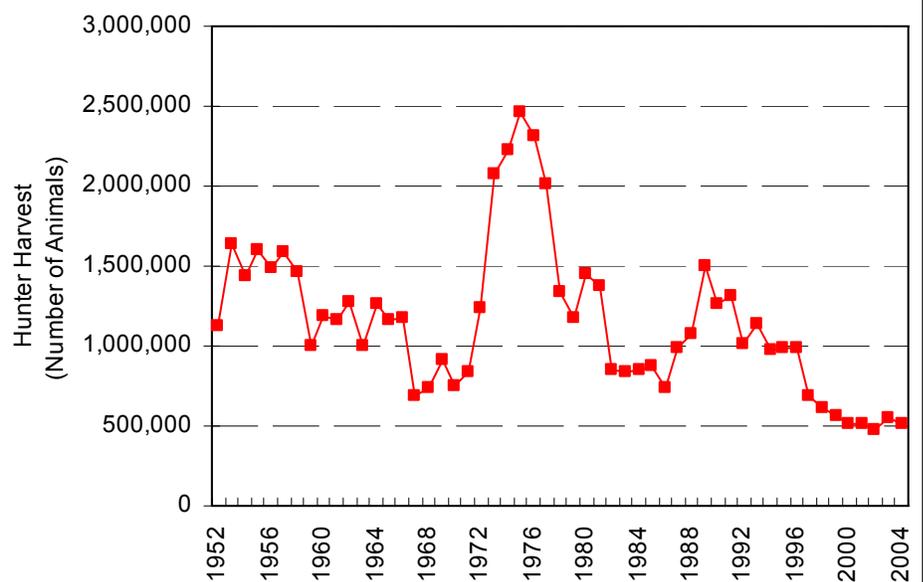


Exhibit 14. Hunter Harvest of Snowshoe Hares in Michigan 1952 - 2004

Trends in Breeding Bird Populations

Migratory songbird abundance can provide an excellent source of information on changes occurring at a landscape level. Since the mid-1960s, the USFWS has maintained an annual breeding bird survey to monitor bird abundance across the United States. While information at only the state level does not always provide reliable trends, combining data across physiographic regions does provide some level of reliability.

Michigan falls within two physiographic regions (*Great Lakes Transition* and *Great Lakes Plain*). Data collected over the last 25 years for the two physiographic regions indicate some common patterns among bird species. The largest decline has been observed in grassland species, such as the eastern meadowlark, bobolink, vesper sparrow, and Henslow's sparrow. Similarly, transitional species, such as the golden-winged warbler, willow flycatcher, yellow-billed cuckoo, and American woodcock have shown sizable declines. During this same period, several generalist species, such as the house finch, northern cardinal, house wren, and eastern bluebird, which benefit from human activity, have demonstrated increases in population (Exhibit 16).

Observed declines in bird species can be attributed to several factors including habitat fragmentation and loss of early age shrub and forest systems. Decline of grasslands species has resulted from development and natural succession. Breeding bird data are summarized every five years by the MDNR.

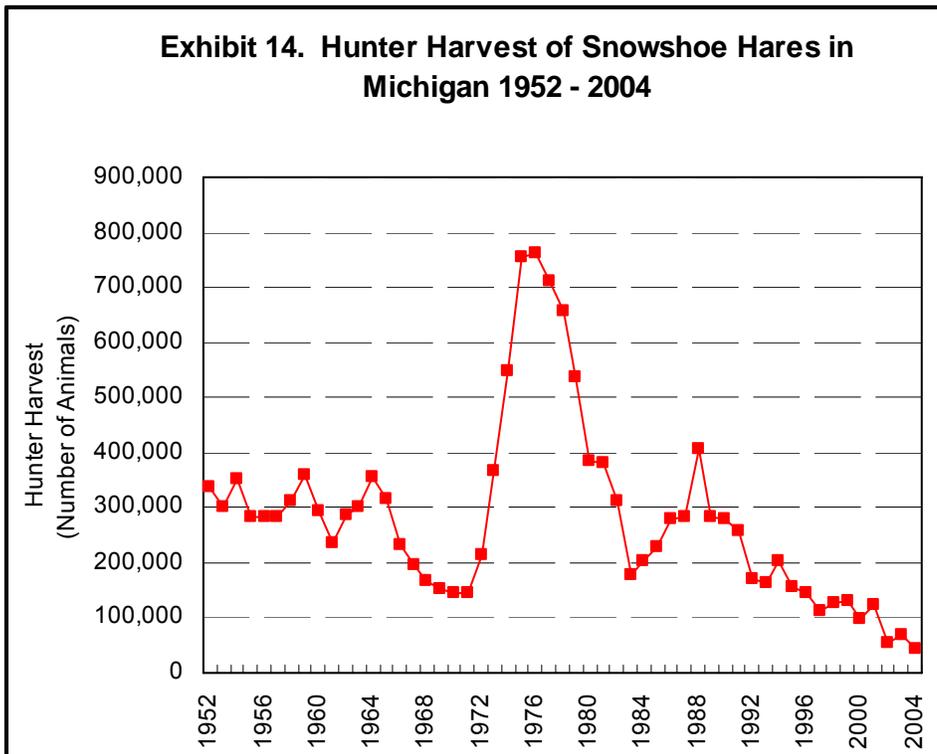
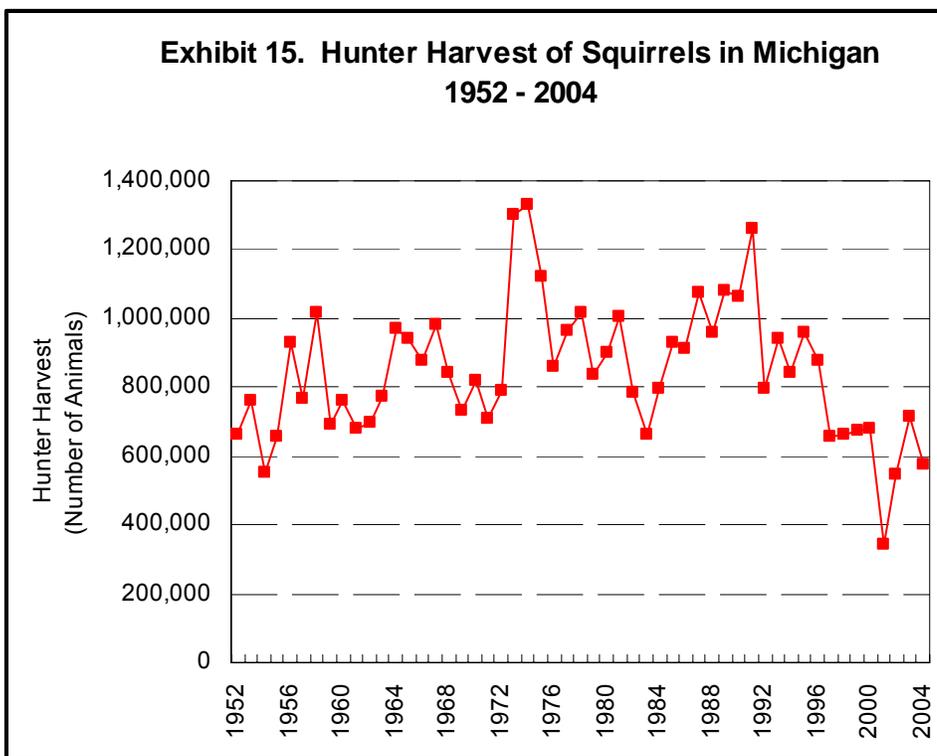
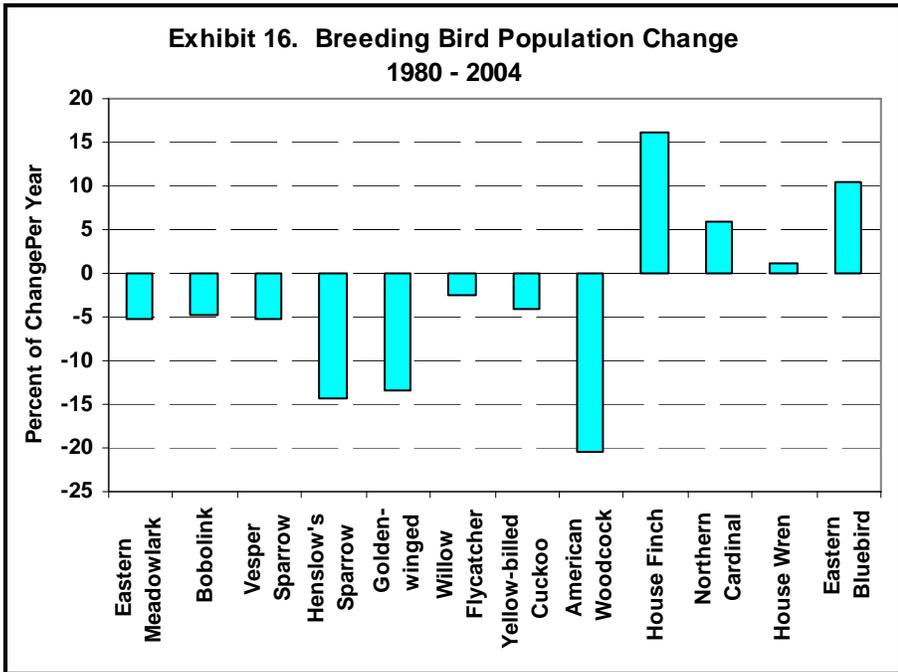


Exhibit 15. Hunter Harvest of Squirrels in Michigan 1952 - 2004



survey data for Michigan cottontail rabbits, snowshoe hares, and squirrels for the period 1952 to 2004, respectively. Part of the decline observed in the small mammal populations is related to declines in hunter participation in the annual hunter harvest surveys and in sales of small game licenses.



eagle and many other predator and colonial species of birds declined significantly due to years of widespread pesticide and other contaminant use. With the advent of strict environmental laws on the production and use of pesticides, the bald eagle and other bird populations began to recover.

Trends in Bald Eagle Populations and Contaminant Levels

Population. The bald eagle is a top-level predator of aquatic ecosystems. The bald eagle's position at the top of the food chain makes it highly vulnerable to impacts that result from contaminants that accumulate in the food chain. During the late 1950s and early 1960s, the bald

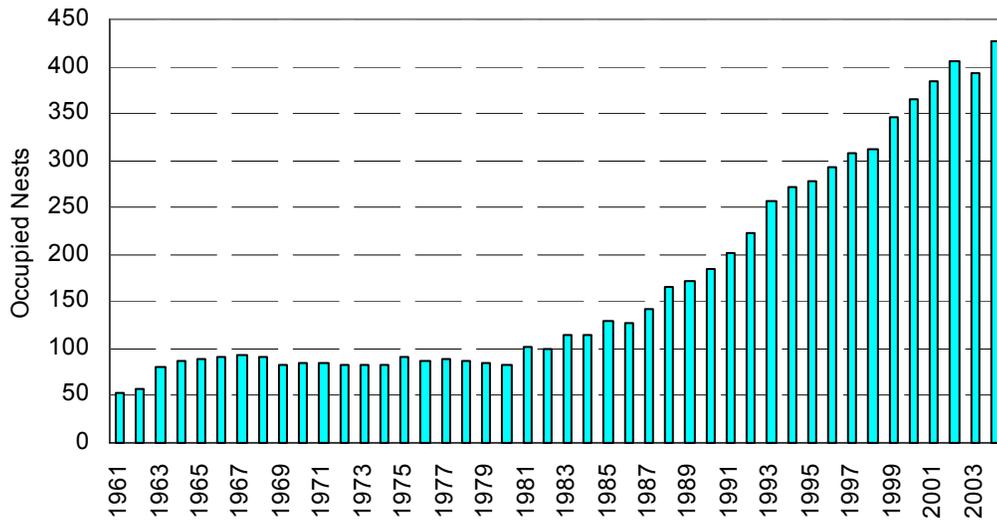
As one measure of population change, the MDNR began conducting annual censuses of bald eagle nests in Michigan in 1961. From a low of 50 nests recorded in 1961, the bald eagle population has continued to increase to a high of 427 occupied nests in 2004 (Exhibit 17). In addition to an increasing population, bald eagle productivity, measured as number of young fledged per nest, also has increased 50 percent (0.42 to 0.63) since 1961 (Exhibit 18). Combined, these two measures suggest that not only are bald eagles increasing in number, but that they also are successfully raising more young per breeding pair than in the past.

Contaminant Levels. The bald eagle's position at the top of the food chain also makes it a good indicator species for monitoring changing trends in levels of certain contaminants in the environment (e.g., polychlorinated biphenyls and mercury). The use of the bald eagle in this manner has been recognized by both the International Joint Commission, a United States-Canadian entity charged with overseeing Great Lakes water quality protection, and the United States Environmental Protection Agency (USEPA) as a useful Great Lakes Indicator of environmental health.

Building on an earlier research program, a consortium composed of the MDEQ, USFWS, and researchers from MSU and Clemson University initiated the Bald Eagle Contaminant Monitoring Project in 1999. Under the project, eagle blood



**Exhibit 17. Occupied Bald Eagle Nests in Michigan
1961 - 2004**



eagles were dramatically lower in the 1999 - 2001 period compared to a decade ago for interior Upper Peninsula and Lower Peninsula nests and nests near Lakes Superior, Michigan, and Huron. The Lake Erie PCB data should be judged with caution because only five eagles were sampled between 1999 and 2001.

Exhibit 20 compares the geometric mean mercury levels in bald eagle feathers between 1985 - 1989 and 1999 - 2000. Mercury concentrations showed little or no change between the two sampling periods. The analytical results for bald

eagle samples collected through 2004 will be available from the MDEQ by the end of 2005.

Trends in Frog and Toad Populations

Michigan is home to 13 native species of frogs and toads. In recent years, scientists have been concerned about observed declines or population



and feather samples are collected (using non-lethal procedures) from permanent inland nests, from nests in additional inland watersheds being

assessed as part of the MDEQ's five-year rotating watershed schedule, and from Great Lakes and connecting channel nests.

Exhibit 19 shows changes in polychlorinated biphenyl (PCB) concentrations in bald eagles between the late 1980s - early 1990s and 1999 - 2002. PCB levels in the blood of bald

Exhibit 18. Success Rate for Bald Eagle Young Fledged per Occupied Nest 1961 - 2004

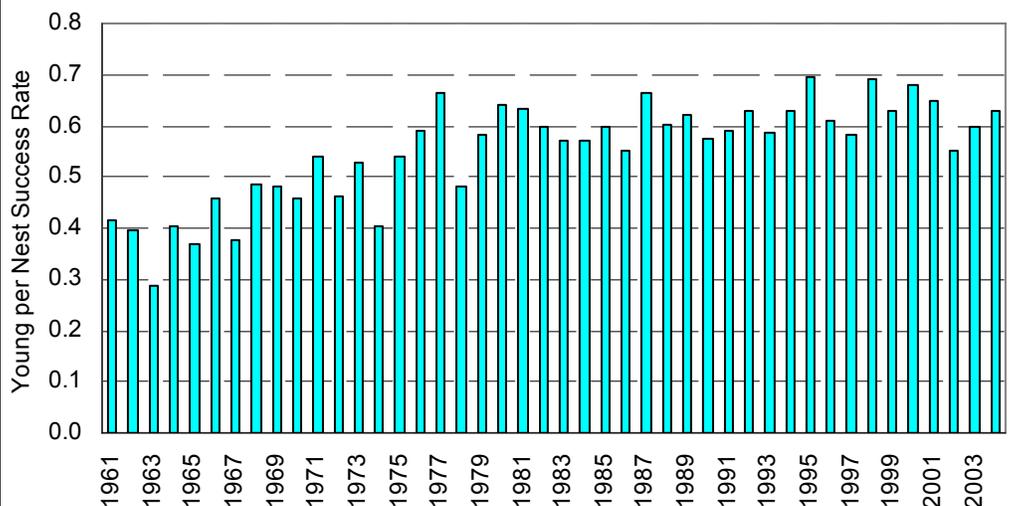
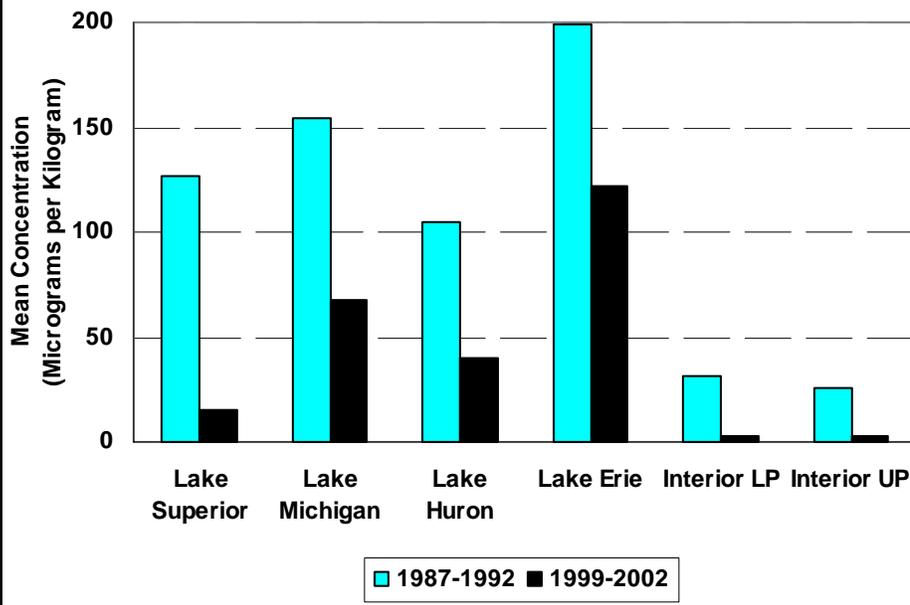


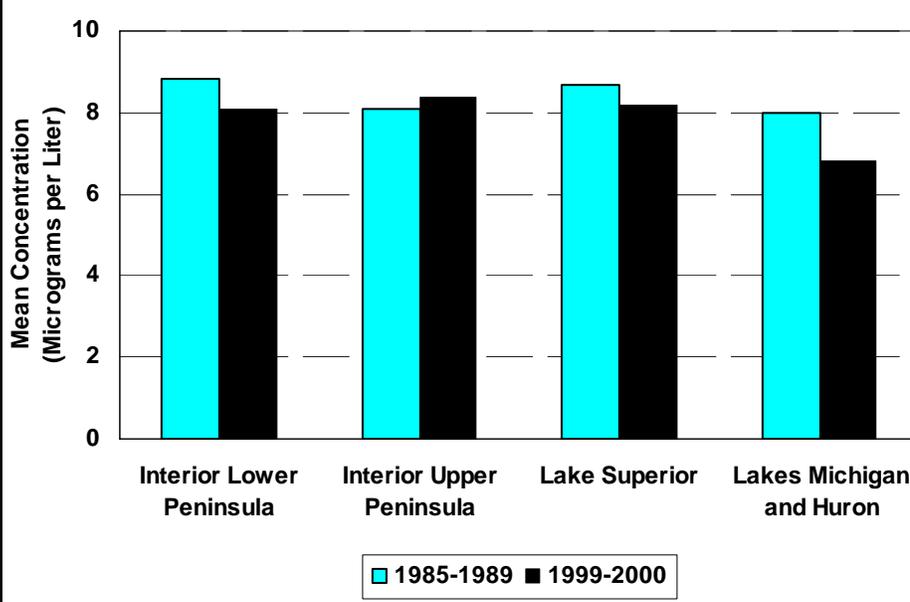
Exhibit 19. Geometric Mean Polychlorinated Biphenyl Concentrations in Nestling Bald Eagle Blood 1987 - 1992 and 1999 - 2002



to changes in environmental quality. In 1996, the MDNR instituted a statewide volunteer calling survey to monitor frog and toad populations and to evaluate the amphibian decline issue in Michigan. It is anticipated that site-specific research projects may be initiated in areas where amphibian declines are identified to determine the causes of those declines and to gain insight into habitat degradation.

The initial amphibian survey protocol used by the state mirrored that of a long-running and successful survey in Wisconsin. Later, the United States Geological Survey (USGS) developed nationwide protocols as part of the *North American Amphibian Monitoring Program*, which Michigan is a participant. Survey routes currently consist of 10 sites at which volunteers stop and listen for the amphibians and record the species and an abundance index for each species on a data sheet. Each survey route is visited three times during the breeding season. Statewide surveys have not been conducted in the past, so any comparison to historical data is only possible for local areas.

Exhibit 20. Geometric Mean Mercury Concentrations in Nestling Bald Eagle Feathers 1985 - 1989 and 1999 - 2000

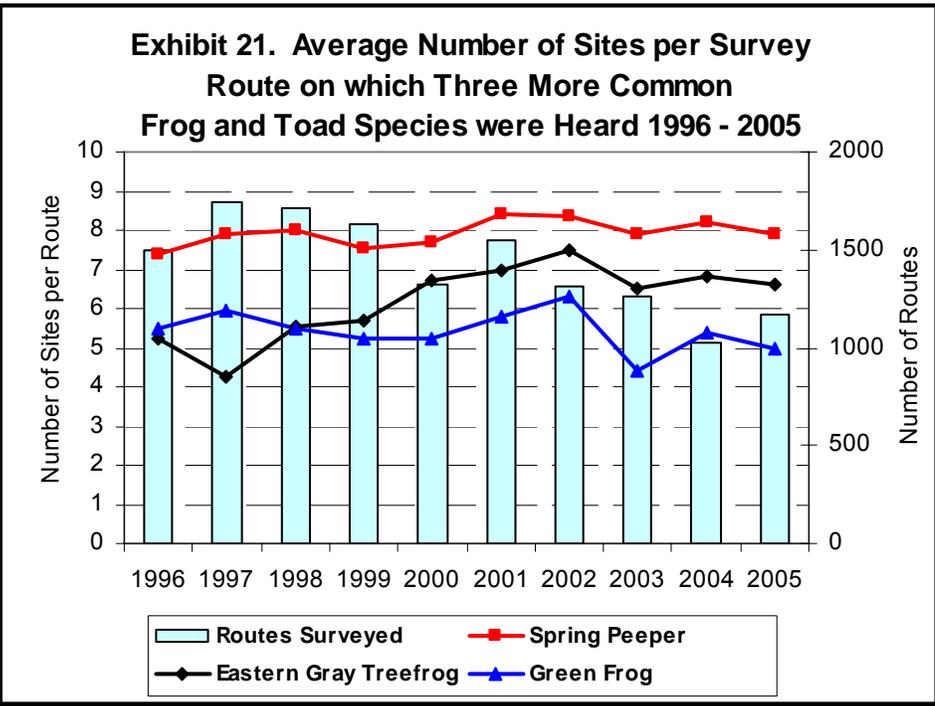


Exhibits 21 and 22 illustrate abundances of six frog and toad species that have statewide distribution. The number of routes surveyed each year (solid bars) also tracks the level of volunteer effort. Exhibit 21 shows the average number of sites per route at which three of the most common species of frogs in Michigan

die-offs of several of these species worldwide. This concern was not only for the loss of the species themselves, but also for the loss of the habitats on which they depend. Frogs and toads are sensitive to changes in water quality and adjacent land use practices. Consequently, changes in their populations can serve as an index

(spring peeper, eastern gray tree frog, and green frog) were heard over the ten-year period. Trend analysis of these data currently shows no significant increase or decrease for any of these species.

Exhibit 22 shows the average number of sites per

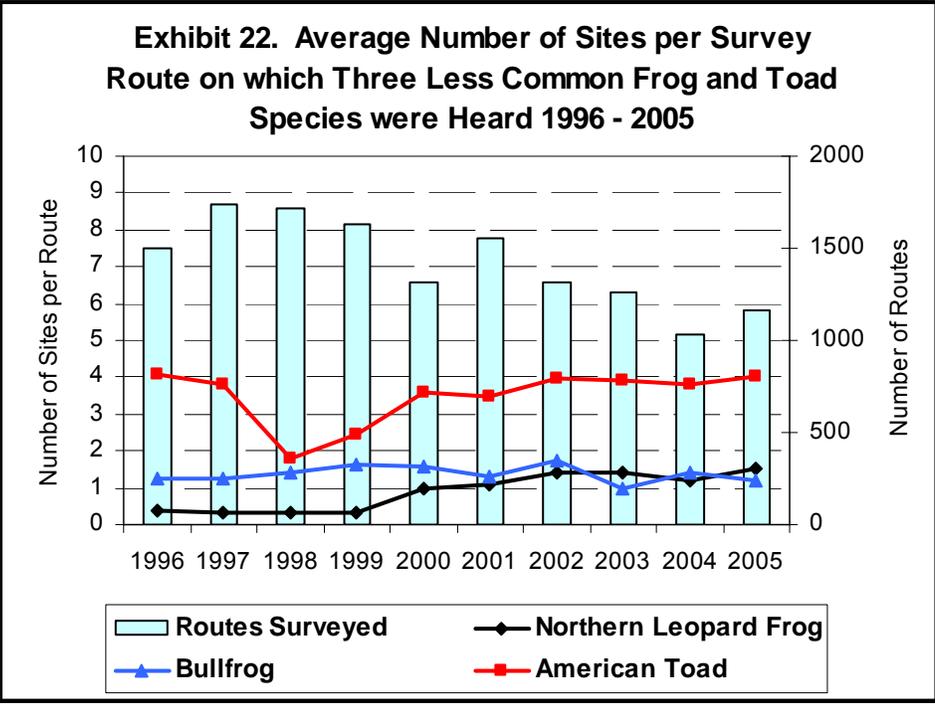


fluctuation or a human-influenced environmental factor. Trend analysis shows no significant increase or decrease in the northern leopard frog or bullfrog.

Long-term trends will require many years of data before meaningful information can be discerned. It is known that natural fluctuations occur in amphibian populations.

route at which three of the less common species of frogs and toads in Michigan (northern leopard frog, bullfrog, and American toad) were heard over the ten-year period. The fluctuation of abundance of the American toad is a good example of how factors in one year may impact survey results. The reason for the decline in 1998 of American toads is currently unknown. Hopefully, longer term monitoring should show if the low number of American toads in 1998 was the result of a natural

Many years of data will be necessary in order to be able to distinguish these fluctuations from those caused by human-related factors such as pesticide use or habitat losses. Weather factors also play an important role in calling surveys and can affect the amount and the quality of the data in any one year. The MDNR plans to continue the statewide surveys indefinitely and hopes to maintain a consistent and knowledgeable volunteer workforce.



Trends in Fish Populations, Benthic Macroinvertebrates, and Contaminant Levels

Walleye in Lake Erie. The MDNR has employed an experimental gill

net fish sampling protocol at two stations in western Lake Erie since the fall of 1978 as part of a cooperative interagency Walleye Assessment Program. This protocol, referred to as the *Index Gill Net Survey*, typically includes two 1,300-foot sets of variable-mesh multi-filament gill nets at each sampling station. The gill nets are suspended from the surface of the water. The Index Gill Net Survey is conducted during early October each year.

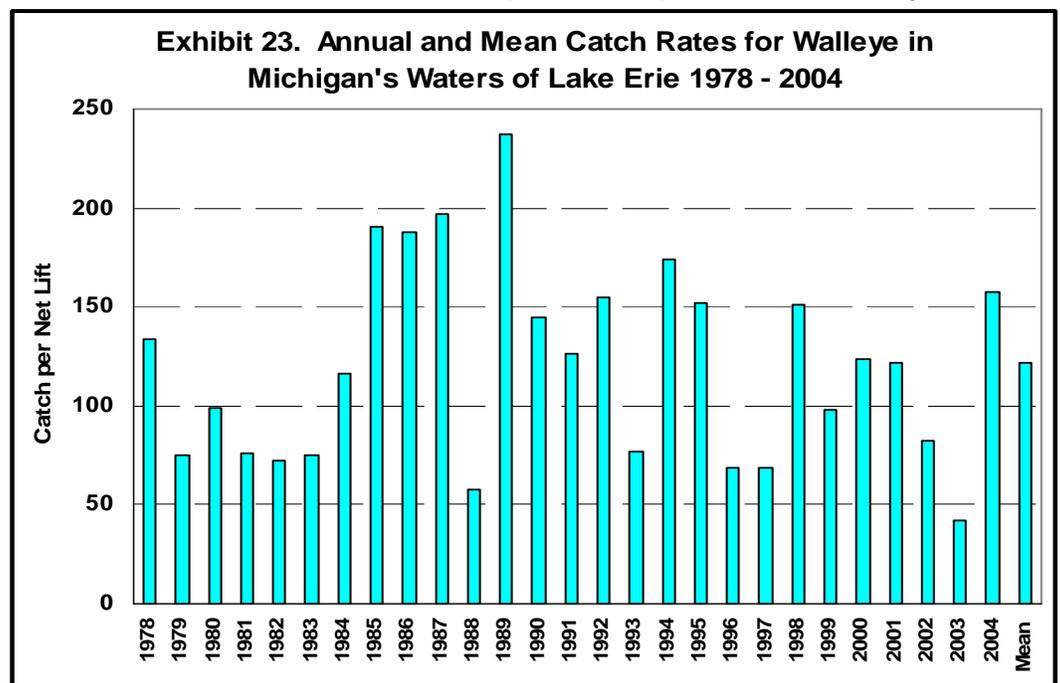
Gill net catch rates reflect trends in walleye abundance. Exhibit 23 shows the trend in the total walleye catch rate for each year of the MDNR Lake Erie Index Gill Net Survey. In general, walleye abundance was relatively low in the late 1970s and early 1980s, increased in the 1980s, and peaked in 1989. From 2000 to 2003, walleye abundance declined to the lowest level observed since 1978. However, the 2004 survey documented a substantial rebound in abundance to the highest level since 1994. Annual walleye abundance is strongly related to annual variation in reproductive success. This is reflected in yearling catch rates each year (Exhibit 24). Poor recruitment for Lake Erie walleye is well illustrated in the low catch rates observed for yearlings from the 1992, 1995, 1998, 2000, and 2002 year classes. In contrast, the yearling catch for the 2003 year class indicates reproductive success was the highest achieved since the mid-1980's.

Lake Trout in Lake Superior. The lake trout is the dominant native predator fish in the cold-water fish communities of the upper Great Lakes. Lake trout numbers are a good indicator of aquatic ecosystem health. Lake trout are long-lived and accumulate toxins in their bodies. The concentrations of these toxins are monitored by the MDEQ to evaluate potential health risks to the public. Imbalance in fish community dynamics also is reflected in shifts in lake trout population dynamics. During the 1940s and 1950s, lake trout

populations significantly declined due to high levels of commercial exploitation and parasitism by the non-native sea lamprey. Subsequently, an extensive lake trout rehabilitation program was implemented to re-establish self-sustaining populations. Lake trout populations increased during the 1970s and early 1980s due to sea lamprey control, restrictions on commercial



fisheries, and stocking of hatchery-raised lake trout. During the mid-1980s, wild lake trout populations (sustained by natural reproduction) were increasing in most areas of Michigan's waters of Lake Superior. By the mid-1990s, wild lake trout abundance increased to a point where stocking of hatchery-produced fish was discontinued in all areas of Michigan's waters of Lake Superior, except in Keweenaw Bay and





lake trout (rainbow smelt and lake herring) are at low abundance levels.

Brown and Brook Trout in the Au Sable River System. Trends in stream fish populations can be useful environmental indicators because the quality of their habitat is shaped by conditions in the watershed upstream. Stream trout may be a particularly good indicator because healthy, self-reproducing trout populations require specialized environmental conditions. Trout need relatively cold and well-oxygenated water. They also require clean gravel for spawning, shelter from predators, high velocity water, a diverse and abundant food supply, and free access to different habitats at different stages of their lives.

Human activities in a watershed have the potential to either enhance or degrade trout habitat quality. Activities that reduce ground water yield to streams can result in a warming of the water body, which reduces the area available for trout to survive. Cutting or clearing trees from land adjacent to streams reduces shading, reduces the potential for trees to fall into the stream to provide shelter and nutrients, and may increase erosion of sediment into the channel. Any construction in a watershed that increases soil erosion to streams degrades trout habitat. Activities in a watershed that change the magnitude or timing of flood flows also diminish habitat quality. Examples of such activities include construction of drains and storm sewers, increases in water-impermeable surfaces

Whitefish Bay. During the period of increasing wild lake trout abundance, hatchery lake trout abundance and survival declined.

Currently, lake trout populations are nearly rehabilitated in all areas of Michigan's waters of Lake Superior, except in Whitefish Bay (Exhibit 25). Hatchery lake trout comprise less than 20 percent of lake trout abundance in Michigan's waters of Lake Superior, except in Whitefish Bay where most fish are of hatchery origin. High levels of commercial exploitation and lack of significant natural reproduction have been inhibiting lake trout abundance in Whitefish Bay. In addition, moderate levels of fishery exploitation in Keweenaw Bay and the Munising region may be affecting recovery of lake trout and is monitored closely. Another concern in the fish community that may be affecting lake trout dynamics is the high predator to prey ratio. Recent survey data indicate that the major prey fish of

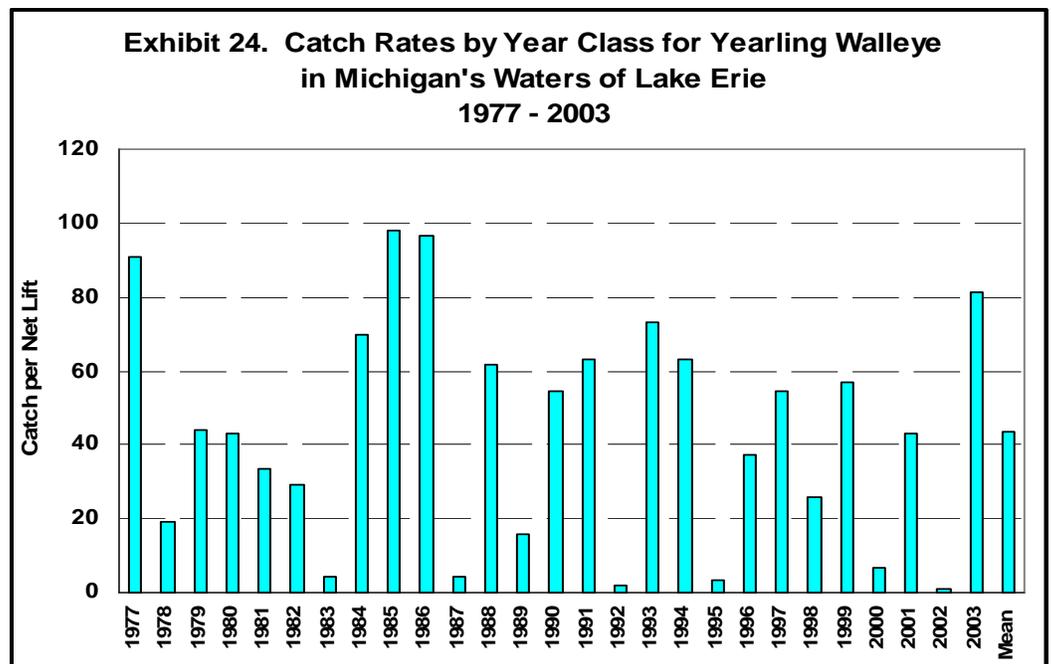
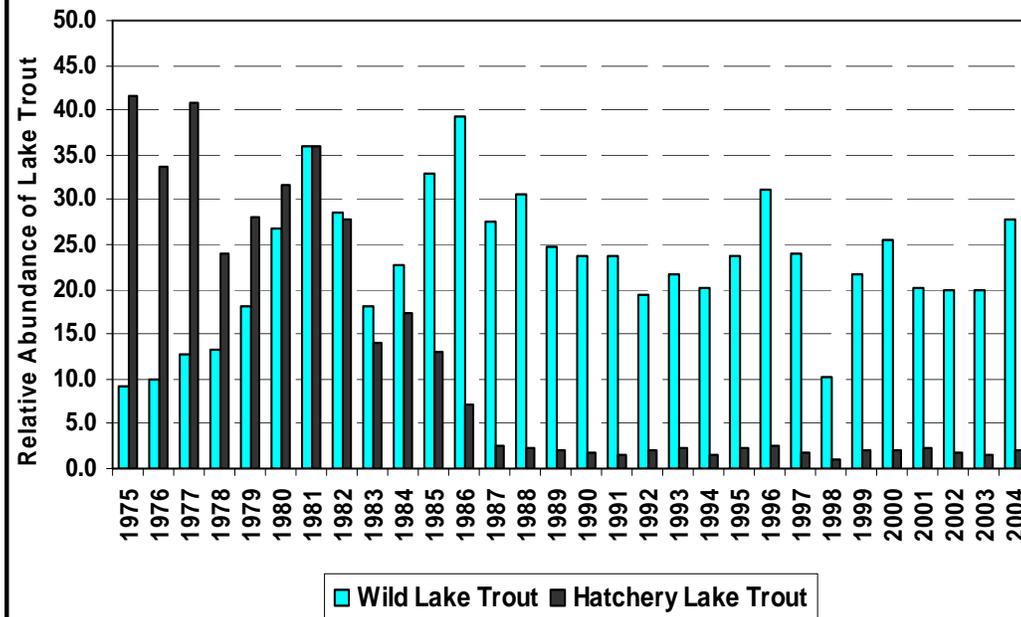


Exhibit 25. Trends in Abundance of Wild and Hatchery Lake Trout in Michigan's Waters of Lake Superior 1975 - 2004



many years at fixed sites in portions of the upper Au Sable River system in Crawford County. Fall standing stocks (expressed in pounds per acre) of brook and brown trout in the mainstem and north branch of the Au Sable River were generally higher during the 1960s and 1970s than in subsequent decades (Exhibit 26). By contrast, fall standing stocks in the south branch of the Au Sable River have remained relatively stable, generally ranging from 35 to 45 pounds per acre. Standing stocks of trout in the mainstem and north branch of the Au Sable

such as parking lots, and operation of lake level control structures. Forest harvesting practices may either enhance or detract from trout habitat quality. A wide variety of chemical pollutants and changes in fishing regulations or angler harvest over time also can affect trout populations.

The MDNR has sampled trout populations for



River declined substantially during the 1980s and remained at lower than average levels during the first half of the 1990s. The declines in total trout standing stocks were caused primarily by declines in growth, survival, and reproductive rates for brown trout. This resulted in fewer large fish and lower standing stocks. Long-term trends in total numbers of brook and brown trout combined are not as obvious and the range of trout densities observed was quite large (Exhibit 27). Contemporary trout abundance in the upper Au Sable River is indicative of good overall habitat quality.

The MDNR has used a variety of fishing regulations intended to improve survival or growth rates of trout during this period. In addition, privately- and publicly-funded habitat restoration efforts have been directed toward reducing erosion of sediment into the river system, removing excess sand bedload by way of sediment basins, protecting trees that fall into the stream, and adding large woody material to provide trout shelter. Recent increases in trout abundance suggest that these efforts are having a positive effect.

Weather conditions favorable for reproduction, growth, and survival during recent years also have contributed to the recent rebound in trout

abundance. Moreover, fishing regulations were made more restrictive in 2000. Yet, abundance of trout in the upper Au Sable River system may not reflect regional trends in habitat quality. In 2002, the MDNR implemented stream sampling protocols that will provide more comprehensive information on the status and trends in fish populations over a broader geographic area. These protocols include increased sampling of habitat features in order that trends in habitat quality can be determined and related to changes in fish abundance.

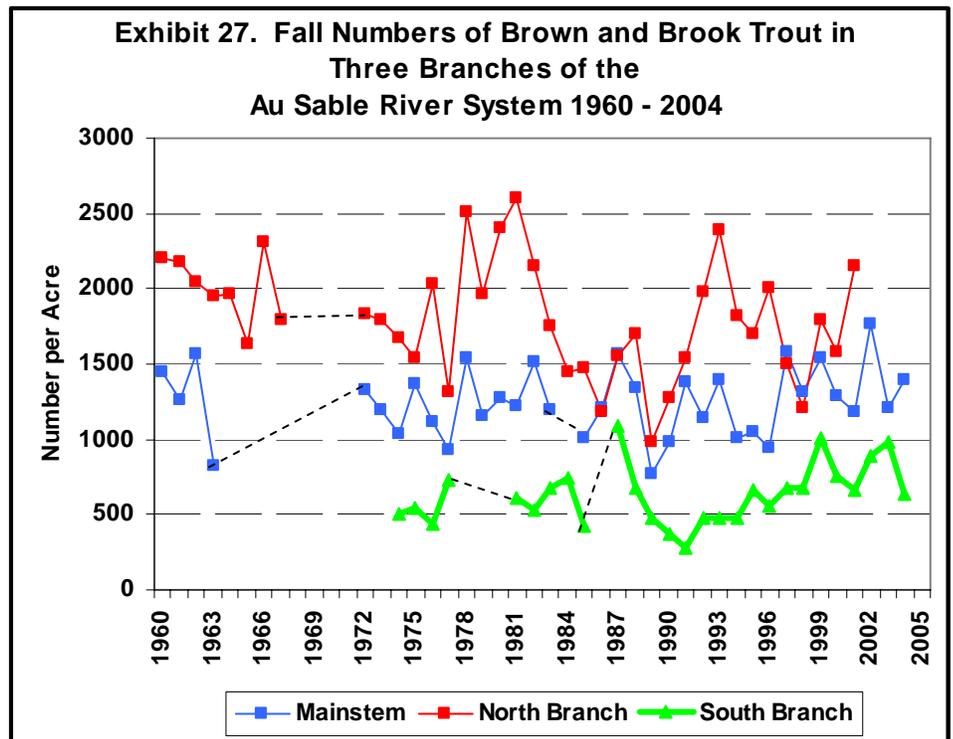
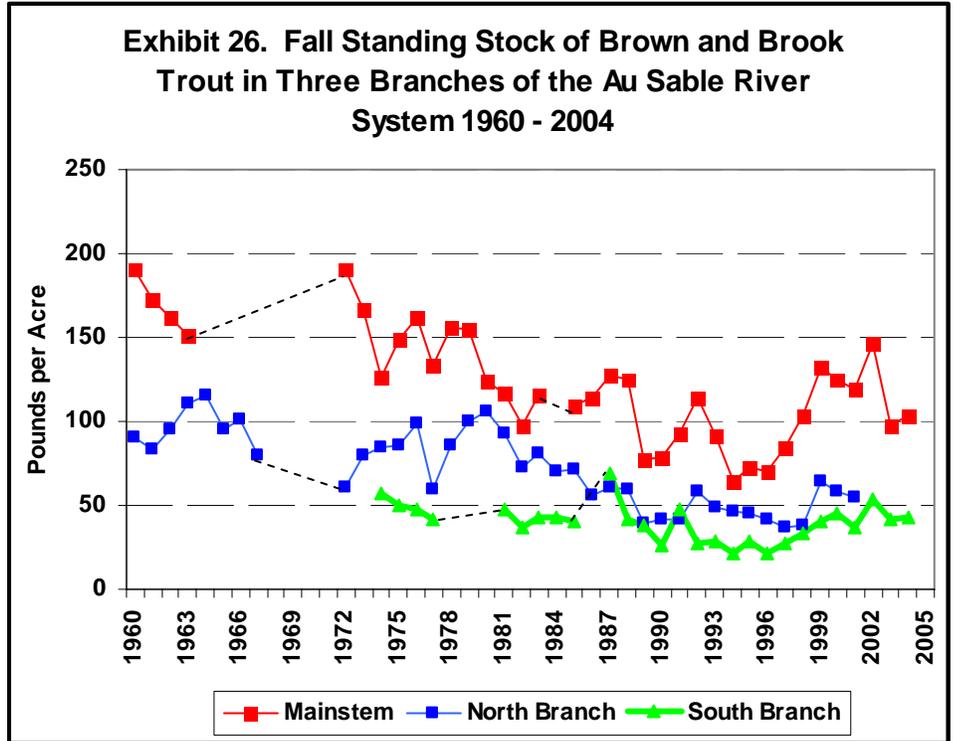
Benthic Macroinvertebrates.

The MDEQ collects data on the relative abundance of benthic macroinvertebrates and fish in wadable streams and rivers throughout Michigan. These surveys, which are a major component of the state's watershed assessments, are conducted on a five-year rotating basin schedule to support the National Pollutant Discharge Elimination System and nonpoint source protection programs. The sampling method, known as *Procedure 51*, is a rapid assessment protocol designed to quickly assess stream and aquatic life conditions. Biologists sample streams to identify the benthic macroinvertebrate and fish species present and estimate their relative abundance. Fish are not always collected due to the extra time, equipment, and staff required. As a result, benthic macroinvertebrates are collected from many more sites than fish.

Because Procedure 51 is a rapid assessment technique, it is considered more of a qualitative rather than quantitative measure. Quantitative, statistical measures for each species, such as population densities, currently are not widely used. This limits the use of these data as a long-term, consistent water quality indicator.

Another limitation is the absence of fixed sites that are monitored for biota on a regular basis, since watersheds are assessed over a five-year rotating basin schedule.

The MDEQ is developing a statistically-based network design and sampling procedure to measure long-term trends in benthic



macroinvertebrates at a mix of fixed and randomly selected stations. This procedure will be implemented in part in 2005, and more fully in subsequent years. The results will be summarized in future Biennial Reports.

New Sampling Protocols. Assessing the status of over 10,000 inland lakes and 36,000 miles of stream habitat in Michigan is a daunting task. Over the past several decades, the MDNR has conducted numerous surveys of fish populations in lakes and streams across the state. Although a few assessments have been conducted with consistent methods over a long period of time, most surveys have been short-term, with the intention of addressing immediate site-specific issues. While this strategy has proven useful for providing information to support fisheries



management on individual water bodies, it does not provide an adequate statistical framework for inferences regarding status and trends in fish populations and communities across broader spatial or temporal scales. Consequently, this historical data strategy does not allow fishery managers to put the results of individual lake surveys in the context of larger scale trends that may need to be addressed.

Recognizing the limitations of this approach to provide regional or statewide trends in fish populations, the MDNR formed the Resource Inventory Planning Committee in 1995 to develop

a more scientifically sound sampling protocol. As a part of this committee's work, the MDNR instituted the newly designed *Status and Trends Sampling Program* in 2002. This program annually evaluates habitat conditions and fish communities at approximately 30 of 65 fixed stream locations, 40 randomly selected stream locations, and 70 randomly selected lakes throughout the state to obtain statistically sound estimates of status and trends of game fishes, non-game fishes, and aquatic habitat while still providing information essential for effective fisheries management. During 2002 - 2004, 127 randomly selected lakes and 35 fixed and 72 random stream locations were sampled (Exhibit 28). Data analysis for both these sampling programs is ongoing; and results were not available at the time of this Biennial Report.

Contaminants in Fish. The MDEQ monitors persistent, toxic pollutants in fish from waters of the state. Extremely low concentrations of some of these pollutants in water can bioaccumulate to relatively high concentrations in fish tissue. In some cases, contaminant concentrations in fish tissue may reach levels that pose a wildlife or human health risk. Currently, Michigan collects and analyzes over 700 fish tissue samples from approximately 50 locations annually. Since 1980, Michigan has collected and analyzed over 17,000 fish tissue samples from more than 800 locations. These samples have been used to develop sport fish consumption advisories and to track environmental trends.

Since the 1970s, pollution control efforts have resulted in significant reductions of many contaminants. For example, PCBs in whole lake trout from the Great Lakes have declined dramatically (Exhibit 29). These data also indicate that PCB levels in lake trout from the Great Lakes, after declining from the 1970s through the mid-1990s, have remained fairly constant in recent years. In addition, PCB levels have declined in the edible portion of Chinook salmon from Lakes Michigan and Huron, although these declines also have leveled off in recent years (Exhibit 30). Based on these data, the general population consumption advisory for Chinook salmon was removed in 1996. Additional lake trout and Chinook salmon were collected between 2001 and 2004, but have not been analyzed yet by the USEPA. The new data will be included in the 2007 Biennial Report.

Exhibit 28. Locations of Fixed and Random Sites on Rivers and Lakes Selected for Monitoring Long-Term Trends in Fish Populations 2002 – 2004.



The MDEQ coordinates the collection and analysis of whole fish from eight inland lakes as part of an effort to measure spatial and temporal trends in contaminant concentrations. Samples are collected from each site every two to five years. Select species of adult fish from each lake are targeted. Statistically significant changes in mercury concentrations were detected in data sets from five of the eight inland lakes. Mercury concentrations declined in fish from four of the five inland lakes where a trend could be detected (Exhibit 31). Although mercury concentrations apparently increased in lake trout from Grand Sable Lake (Alger County), that conclusion is based on only three sample years, and fish have not been collected there since 1995.

Trends in Endangered, Threatened, and Special Concern Species

The MDNR, through an agreement with the MSU Extension - Michigan Natural Features Inventory (MNFI), conducts field surveys to locate and identify endangered and threatened plant and animal species and natural communities throughout the state, and maintains databases on the various species and community locations. An *Endangered species* is one that is in danger of extinction throughout all or a significant part of its range in Michigan. A *Threatened species* is one

that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in Michigan. The MNFI databases include plant and animal species that are protected under Part 365, Michigan Endangered Species, of the Natural Resources and Environmental Protection Act, 1994 Public Act 451, as amended (Michigan Endangered Species Act).

Also included in the databases are plant and animal species of *Special Concern*. While not afforded legal protection under the Michigan Endangered Species Act, many of these species are included because of declining or relic populations in the state. Should these species continue to decline,

Exhibit 29. Polychlorinated Biphenyl Concentration in Lake Trout from Four Great Lakes 1970 - 2000

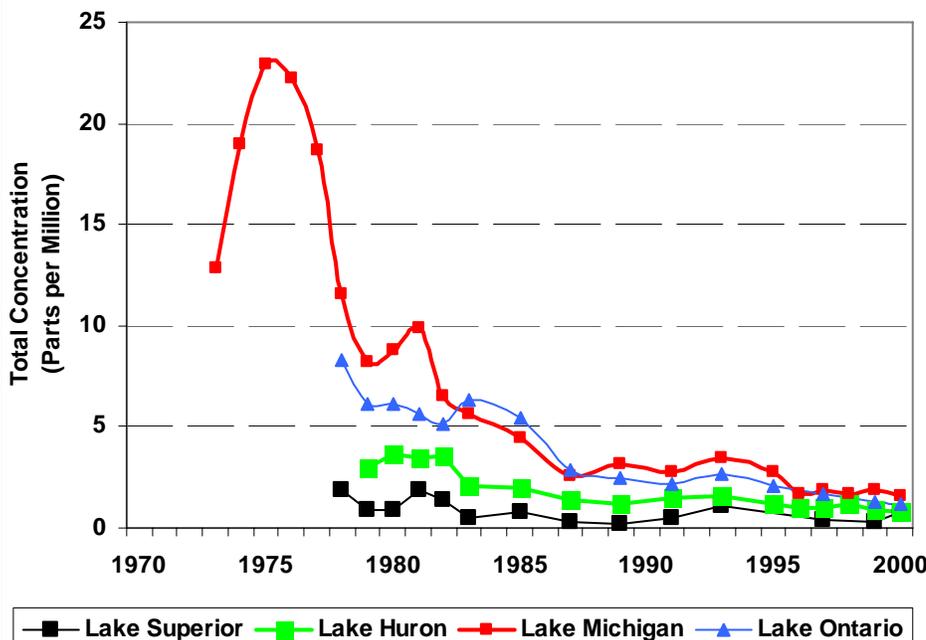
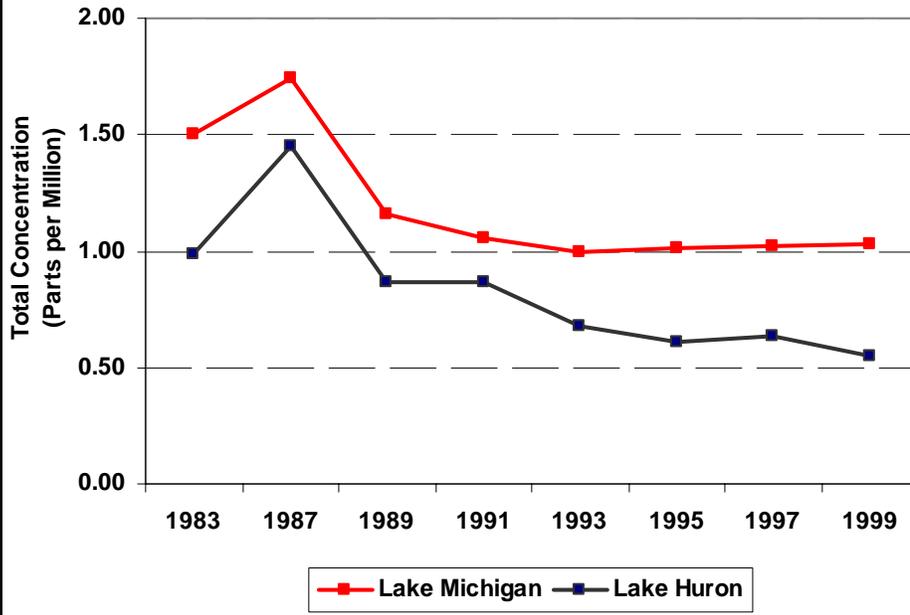


Exhibit 30. Polychlorinated Biphenyl Concentration in Chinook Salmon Fillets from Lakes Michigan and Huron 1983 - 1999



species also are listed as Special Concern pending more precise information on their population status. When such information becomes available, these species could be moved to threatened or endangered status or deleted from the databases. Exhibit 32 presents the number of animals and plants that are currently considered Endangered, Threatened, or of Special Concern in Michigan.

Exhibit 31. Temporal Changes in Mercury Concentrations at Selected Inland Lake Whole-Fish Trend Monitoring Sites 1990 - 2003

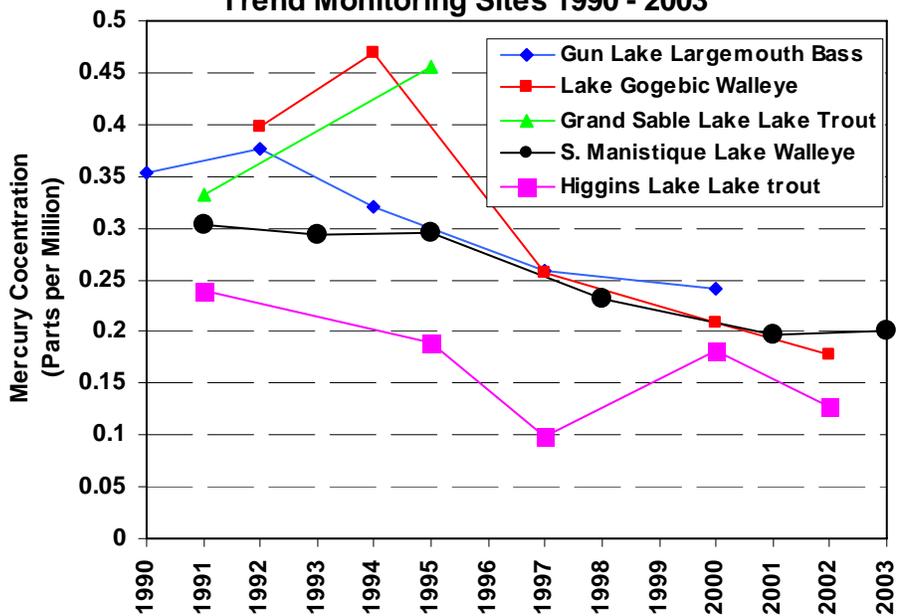


Exhibit 33 presents the frequency counts of occurrence of Endangered, Threatened, and Special Concern species in Michigan. The purpose of Exhibit 33 is to provide a graphic representation of where historical and modern observations of such plants and animals have occurred and where surveys for specific species or natural communities have been conducted. The frequency count consists of the number of occurrences of a species or natural community within each public land survey system section (one square mile) and is based on the known geographic extent of each occurrence. In some cases, the extent of an occurrence is only known in general terms. In other

cases, the extent of an occurrence may be very specifically known. they would be recommended for threatened or endangered status. Monitoring and protection of these species now, before they reach dangerously low population levels, may help to prevent the need to list them in the future by maintaining adequate numbers of self-sustaining populations within Michigan. Some other potentially rare

cases, the extent of an occurrence may be very specifically known.

The use of the state's lists of Endangered, Threatened, and Special Concern Species as a statewide environmental indicator was not recommended originally by the MESB for inclusion

in the Biennial Reports. The reason for this was that many endangered and threatened species tend to be very localized and, therefore, changes in their status would not necessarily be representative of a change in the state environment as a whole. Also, such species lists tend not to distinguish between naturally rare species from those that have been or are being depleted in numbers due to changing environmental conditions and/or direct or indirect human intervention. However, extensive lists, such as Michigan's, of geographically and ecologically diverse species coupled with known habitat requirements and population trend information for these species (i.e., whether a species is increasing, decreasing, or stable) can serve over time as an indirect measure of the



Exhibit 32. Numbers of Plants and Animals Considered Endangered, Threatened, or of Special Concern in Michigan 2005

Category	Endangered Species	Threatened Species	Special Concern Species
Plants	51	210	110
Animals			
Snails	2	2	29
Mussels	8	2	8
Insects	8	11	75
Fish	8	7	11
Amphibians	1	1	2
Reptiles	2	2	6
Birds	8	13	21
Mammals	4	2	4
Total Animals	41	40	156
Total Plant and Animals	92	250	266

Source: Michigan Natural Features Inventory, 2005.



state's biological diversity and species richness and provide an indirect measurement of a changing environment. Consequently, this measure was included in the 2003 Biennial Report and will be continued to be addressed in subsequent Biennial Reports.

Trends in Exotic Species

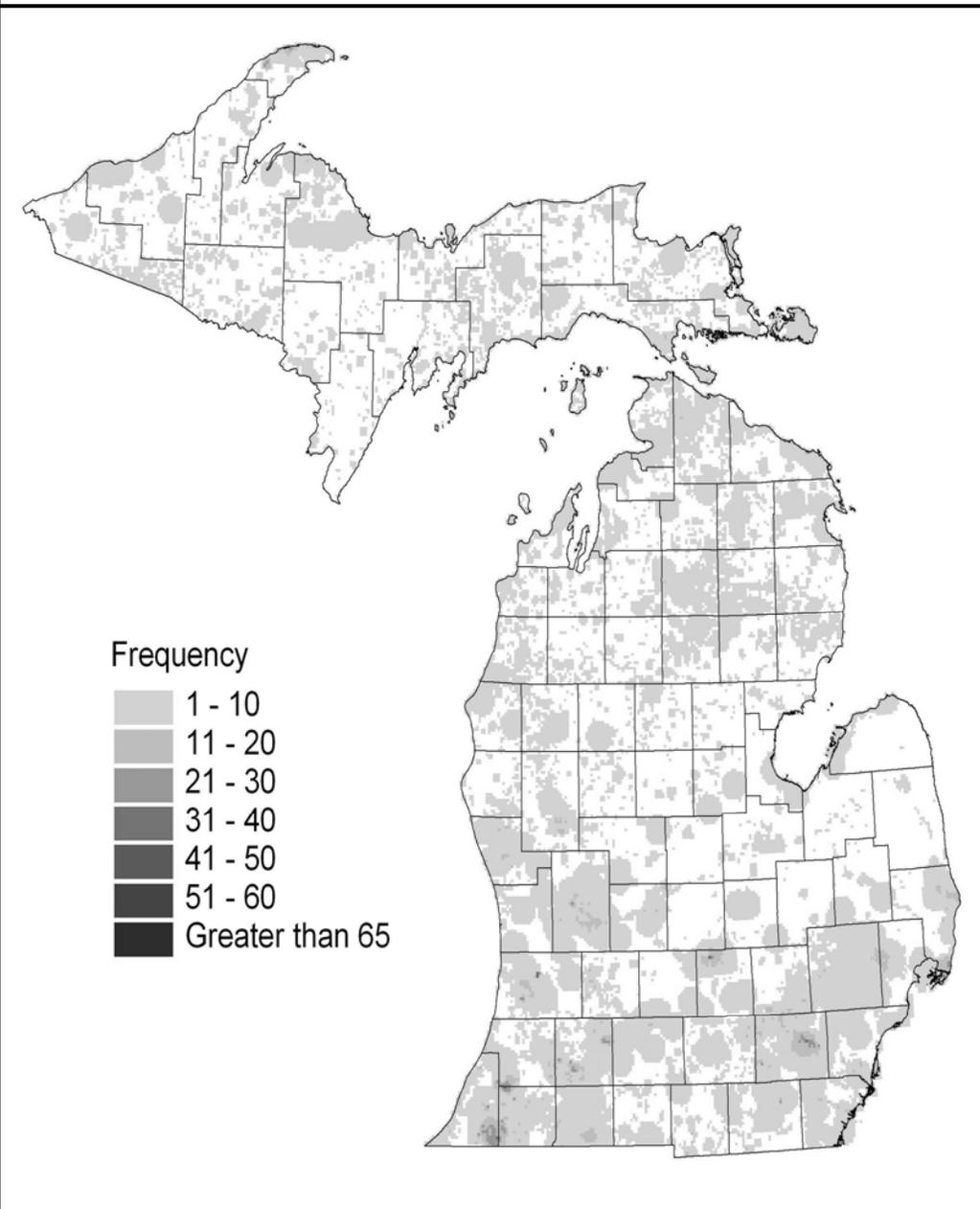
Exotic species are plants and animals that have been introduced by human activity into an ecosystem in which they are not native. Once introduced, many of these species spread

naturally, producing a significant change in the composition, structure, or processes of the invaded ecosystems.

Introductions of exotic species whether intentionally or unintentionally, play a major role in modifying terrestrial and aquatic ecosystems of the Great Lakes Basin. Freed from competitors, predators, parasites, and pathogens that naturally regulate populations in their native environments, some exotic species can become a nuisance by

growing at or near their potential exponential growth rate and out-competing native species for food and other habitat resources. Invasions of terrestrial and aquatic ecosystems by exotic nuisance species now rank second only to habitat loss as the major threat to biodiversity in the Great Lakes Basin. Exhibit 34 presents the number of exotic terrestrial and aquatic plants and animals that are *known* to have been introduced into the Great Lakes Basin since the 1800s. The exact number is not known, but is thought to be much larger.

Exhibit 33. Frequency of Occurrence of Endangered, Threatened, and Special Concern Species in Michigan 2005



Exotic Terrestrial Species. Currently, 47 exotic terrestrial plant and animal species are *known* to have successfully invaded the Great Lakes Basin (Exhibit 34). One of the more recent species that has had a major environmental and economic impact on Michigan is the emerald ash borer.

The emerald ash borer is native to eastern Russia, northern China, Japan, and Korea and affects ash trees. The insect was first detected in the summer of 2002 in six southeast Michigan counties and in Windsor, Ontario, Canada. As survey techniques for this pest improved and a statewide detection system was implemented, the emerald ash borer was found in 14 additional southeast Michigan counties, two Indiana counties, and eight Ohio counties.

To date, the emerald ash borer has destroyed or damaged millions of ash trees in the affected areas of Michigan, Indiana, Ohio, and Canada. Immediate efforts within Michigan to contain the emerald ash borer have entailed quarantining



counties where the insect has been found and effectively limiting the movement of hardwood firewood, ash trees, branches, lumber and other ash tree materials that may be harboring the insect. A permanent inspection station at the Mackinac Bridge also has limited the movement of hardwood firewood and ash logs into Michigan's Upper Peninsula.

A number of isolated outlying infestations also have been detected in Michigan, Indiana, Ohio, and Canada. In an attempt to curb further infestations, a USDA science advisory panel,

1. Peninsula approximately 50 miles south of the Mackinac Bridge;
2. Gateway B in St. Clair County along the
3. St. Clair River; and
4. Gateway C, along the southern border of Michigan shared with Indiana and Ohio (Exhibit 35).

Outlying infestations of emerald ash borer found in these areas are considered a priority in the state's program. Management activities to contain the spread of the insect include removing the ash host material, thereby eliminating the insect from around known positive infestations detected in the Gateways.

Efforts also are underway by the *Emerald Ash Borer Task Force* to learn more about the emerald ash borer's biology and to develop additional control and detection options through research projects spearheaded by MSU. Members of the Emerald Ash Borer Task Force include representatives from the Governor Office, Michigan Department of Agriculture (MDA), MDNR, MSU, and the USDA's Animal and Plant Health Inspection Service and Forest Service, in

Exhibit 34. Numbers of *Known* Exotic Terrestrial and Aquatic Plant and Animal Species Introduced into the Great Lakes Basin as of 2003

Ecosystem Type	Plant Species		Animals Species				Total
	Phytoplankton	Vascular	Invertebrates	Insects	Fish	Birds	
Terrestrial	--	37	--	7	--	3	47
Aquatic	<u>25</u>	<u>57</u>	<u>52</u>	<u>2</u>	<u>26</u>	--	<u>162</u>
Total Species	25	94	52	9	26	3	209

Sources: National Oceanic and Atmospheric Administration's National Center for Research on Aquatic Invasive Species, Great Lakes Environmental Research Laboratory: *Great Lakes Aquatic Nonindigenous Species List*, May 2003. Center for Exotic Species, Michigan Technological University, April 2003. National Invasive Species Council, July 2003.

compose of scientists from the USDA, MSU, and Ohio State University, developed a *Gateway* concept to prioritize management and control activities in the affected regions of each state and nation. Three gateway areas were established for Michigan:

1. Gateway A in Michigan's upper Lower

cooperation with local units of government and various industry groups, associations, and universities. One research activity that currently is being evaluated suggests that a component (a naturally occurring fungus) of a USEPA-approved commercially available bioinsecticide, *BotaniGard ES*, can cause a fatal infection to the larval stage of the emerald ash borer without harming animals

or humans. This bioinsecticide is being field-studied to confirm its effectiveness against the insect.

Additional information on this and other exotic terrestrial species may be found at the Internet sites for the MDA (www.michigan.gov/eab), Michigan Technological University's Center for Exotic Species (www.forest.mtu.edu/research/ces/), and the National Invasive Species Council's Internet sites (www.invasivespecies.gov/).

Exotic Aquatic Species. Currently, 162 exotic aquatic plant and animal species are known to have been successfully introduced into the Great Lakes Basin since the 1800s (Exhibit 36). The list of exotic aquatic species, which is continually updated, is maintained by the National Oceanic and Atmospheric Administration's (NOAA) National Center for Research on Aquatic Invasive Species and can be accessed on the NOAA Internet site (www.glerl.noaa.gov/res/Programs/invasive/). The largest number of exotic aquatic species

introduced into the Great Lakes Basin coincides with the expansion of the St. Lawrence Seaway in 1959, which allowed greater transoceanic shipping traffic. More than one-third of the known exotic aquatic species were introduced into the Great Lakes during the last half of the 20th Century (Exhibit 37).

The four primary routes of entry for aquatic exotic species into the Great Lakes include ballast water from ocean-going ships, unintentional releases, multiple sources, and unknown sources (Exhibit 37). Some of the more problematic introductions in recent decades have been the sea lamprey, Eurasian watermilfoil, and zebra mussel. The latter two species have propagated not only throughout the Great Lakes, but also throughout many of the state's inland lakes at an alarming rate. Limited progress has been made in terms of control of the Eurasian watermilfoil and research has yet to discover an effective control for the zebra mussel.

While some progress has been made to decrease the number of new exotic aquatic

Exhibit 35. Locations of Emerald Ash Borer Michigan Gateways under the Cooperative Emerald Ash Borer Project

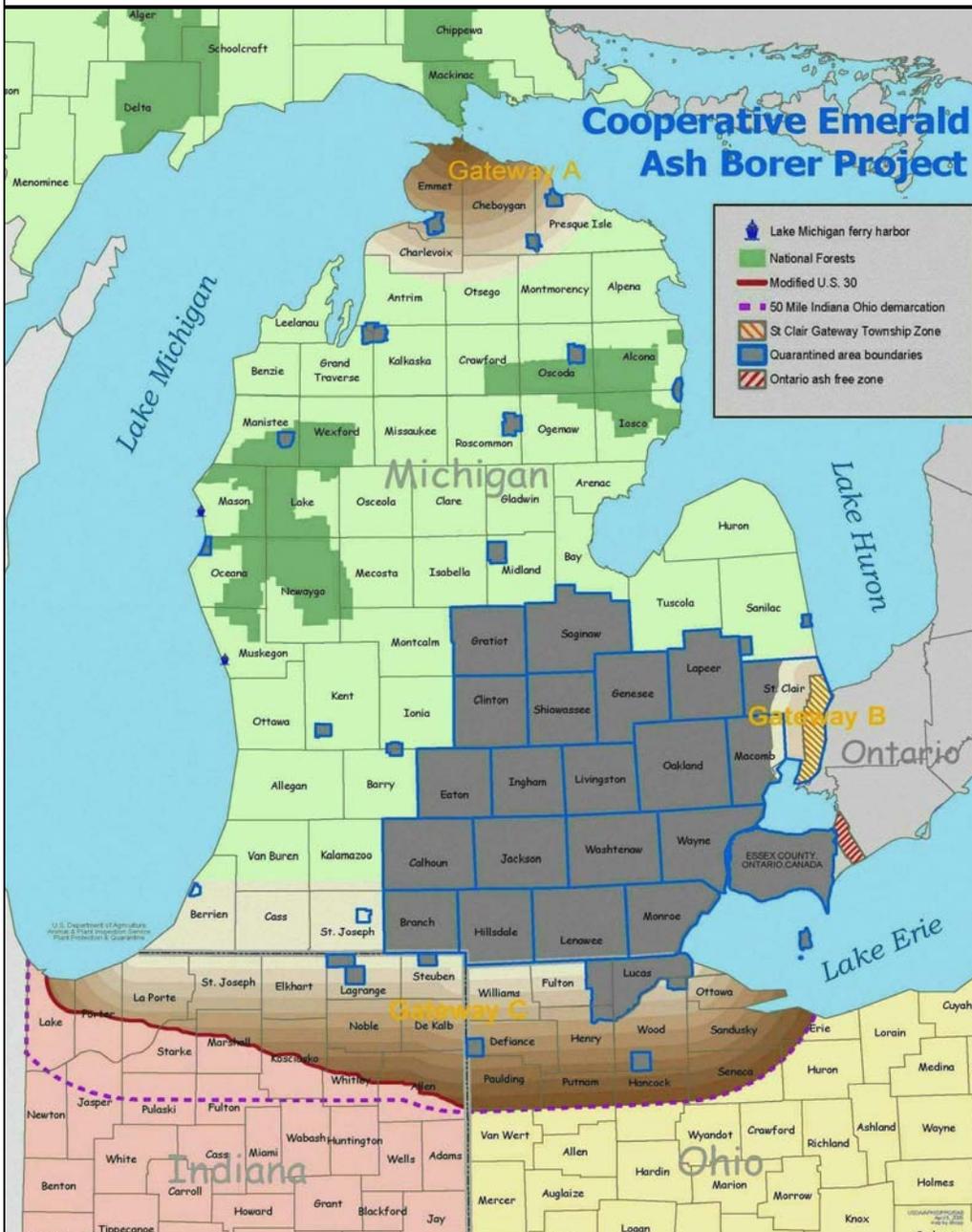
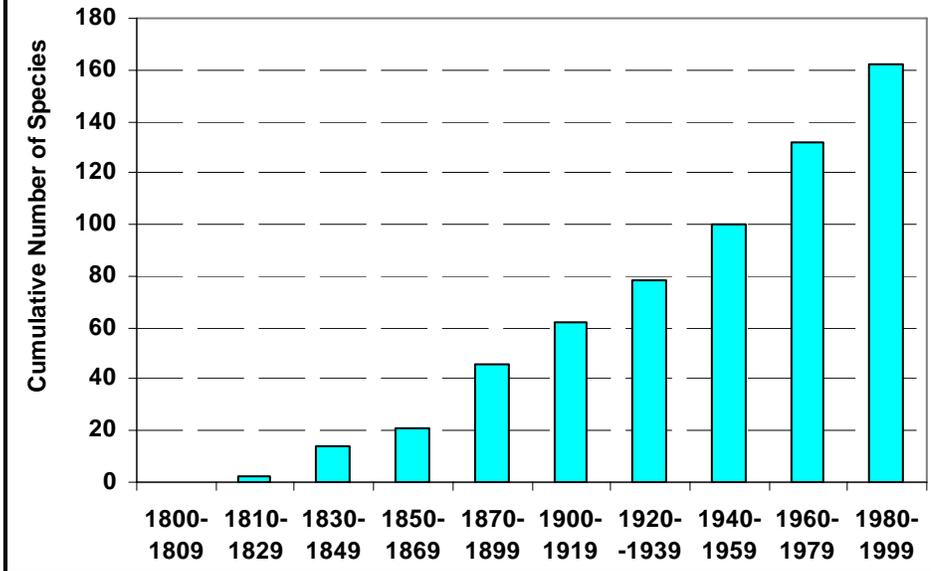


Exhibit 36. Introduction of Exotic Aquatic Species into the Great Lakes 1800 - 1999



NOBOB vessels to protect the Great Lakes from introduction and spread of exotic aquatic species. During the last year and a half, the state has called for the active regulation of NOBOBs, first by joining in July 2004 with states of New York, Wisconsin, Minnesota, Ohio, Illinois, Pennsylvania, and Great Lakes United in a petition to the United States Coast Guard (USCG) requesting NOBOB regulation and a March 2005 follow-up correspondence regarding the lack of action on the earlier petition.

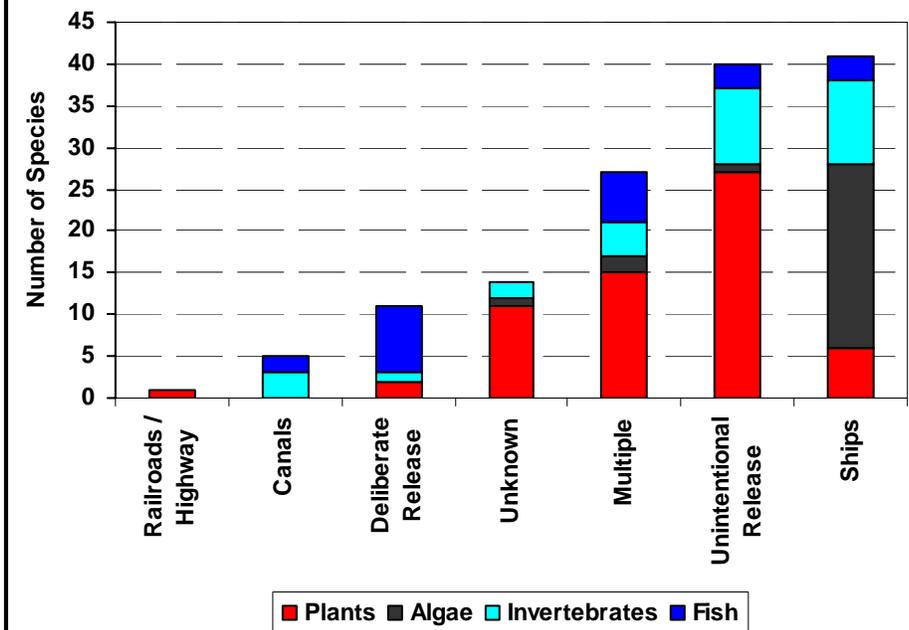
Ballast Water Research. In 2001, the MDEQ sponsored research to evaluate the effectiveness of using hypochlorite and copper ion as

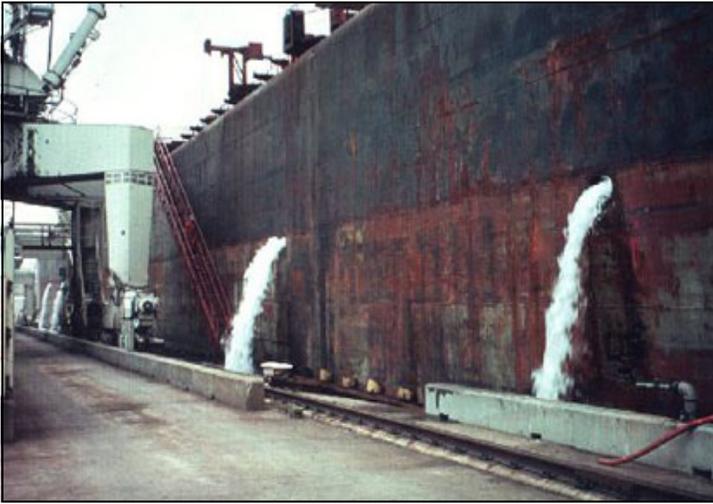
species being introduced into the Great Lakes, much remains to be accomplished. Pursuant to federal law, ships entering the Great Lakes are now required to exchange their ballast water at sea, flushing out organisms, and raising the salinity of the ballast water to kill freshwater organisms that might remain alive in the ballast tank. Although open water exchange helps to reduce the risk of finding exotic aquatic species in ballast tanks and sediments, it does not ensure protection of the Great Lakes since even with ballast pumping, many aquatic species remain in the unpumpable residual ballast water and sediments and can gain entrance into the Great Lakes. A ship under this condition is referred to as *No Ballast on Board* (NOBOB). Over 90 percent of vessels entering the Great Lakes are NOBOB and contain viable forms of life, including potential aquatic invasive species. Many NOBOB vessels contain fresh or low-salinity water from other countries that can pose an especially serious risk of new exotic aquatic species introductions.

ballast water biocides. The research project was completed in July 2002 and was subsequently reviewed by the MESB. The MESB concluded that the research was not definitive and recommended that it be supplemented with an additional investigation to further evaluate the effectiveness and corrosiveness of the hypochlorite biocide in ballast tanks. The follow up research was completed in 2004. The research reports are

Michigan supports the adoption of strict, mandatory regulations for

Exhibit 37. Sources of Entry of Exotic Species into the Great Lakes





vessels operating on the Great Lakes and the St. Lawrence Seaway. Oceangoing vessels are required to report compliance with the *Code of Best Management Practices for Ballast Water Management* developed by the Shipping Federation of Canada. Non-oceangoing vessels are required to report compliance with a set of voluntary best management practices developed by the Lake Carriers' Association and the Canadian Shipowners' Association to reduce the number of introductions of exotic aquatic species into the Great Lakes. A list of the ships reporting compliance with the voluntary best management practices is maintained on the MDEQ's Internet site (www.michigan.gov/deqballastwaterprogram). In 2005, over 200 vessels complied with the MDEQ reporting requirements.

available on the MDEQ's Internet site (www.michigan.gov/deqmigiprotectionfund).

In 2003, a worldwide survey was conducted by the MDEQ to determine the status of ballast water treatment research. The MDEQ survey requested information on the progress of the research and the effectiveness and availability of the treatment protocols under consideration. In general,

1. Nine treatment protocols were reported as available for at least some ships in at least some circumstances and condition of ballast;
2. Nine treatment protocols were reported to be safe for ship operation;
3. Six treatment protocols were reported as having been tested on board an oceangoing vessel; and
4. Three treatment protocols were reported as currently being tested.



Also contained within the provisions of the Ballast Water Reporting Program is a provision requiring the MDEQ to make a determination whether there exists ballast water treatment protocols that could be used by oceangoing vessels to prevent introductions of new aquatic species into the Great Lakes. In April 2005, the MDEQ made such a determination and beginning with the 2008 shipping season, all oceangoing vessels that ply the Great Lakes will have to report to the MDEQ on its ballast water treatment protocol and use.

In June 2005, legislation was signed (Public Act 33 of 2005) that established a requirement for a ballast water discharge permit from ocean-going ships in Michigan ports. The permit requires ocean-going vessels to either not discharge ballast water or to treat ballast water before discharge to



State, Federal, and International Ballast Water Action. In 2001, Michigan legislation was passed (Section 3103, *Ballast Water Reporting Program*, Public Act 451) requiring the MDEQ to determine annually whether ballast water management practices are being complied with by all



prevent introductions to the Great Lakes by exotic aquatic species. The effective date for the Michigan law is January 1, 2007.

Nationally, the USCG continued implementation of the National Invasive Species Act in 2004 - 2005, including commencement of the Shipboard Technology Evaluation Program in 2004 and a programmatic environmental impact statement on the setting of national ballast water standards.

In March 2005, a decision by the Northern District Court in California ordered the USEPA to rescind a rule to exempt the discharge of ships' ballast water from regulation under the 1972 Clean Water Act. The USEPA and the plaintiffs are continuing the case in 2005.

Internationally, a Convention for the Control and Management of Ships' Ballast Water and Sediments (Convention) was adopted by the International Maritime Organization (IMO) in 2004. The Convention sets a ballast water discharge standard and timetable for compliance, pending ratification by at least 33 member states of the IMO. Full compliance by all ships, pending ratification, is scheduled to occur in 2016.



Aquatic Nuisance Species Management Plan. In 2002, Michigan released an update to its 1996 *Nonindigenous Aquatic Nuisance Species State Management Plan*, which was approved as Michigan's plan under the auspices of the federal National Nuisance Species Act. The 2002 document entitled, *Michigan's Aquatic Nuisance Species State Management Plan Update: Prevention and Control in Michigan Waters* (2002 Plan), provides a framework for action and outlines critical steps necessary to help prevent and control aquatic nuisance species (exotic aquatic species) in the state. Several key recommendations of the 2002 Plan already have been implemented. For example, Executive Order 2002-21 created an Aquatic Nuisance Species Council (ANS Council) in November 2002. The ANS Council is charged with the responsibility of advising the Office of the



Great Lakes, MDEQ, MDNR, MDA, and the Michigan Department of Transportation on:

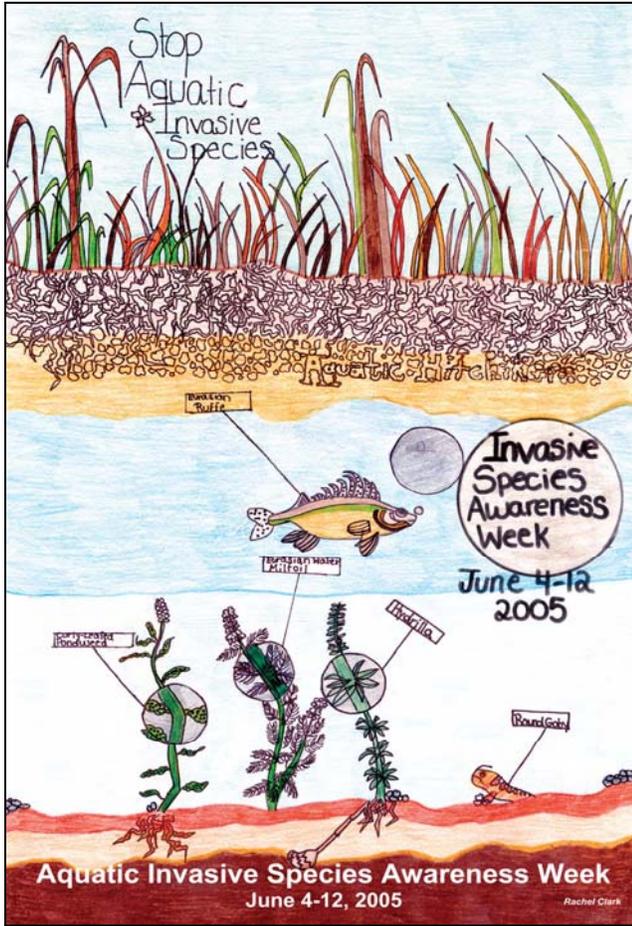
1. Implementation and updating of Michigan's 2002 Plan;
2. Efforts to maximize interdepartmental coordination of existing aquatic nuisance species programs;
3. Issues pertaining to preventing and controlling the spread of aquatic nuisance species within the state for new aquatic nuisance species programs;
4. Information and education activities about aquatic nuisance species; and
5. Research and monitoring activity coordination pertaining to aquatic nuisance species.

Additional activities by the state and others have included:

1. The designating of an annual *Aquatic Invasive*

Species Awareness Week in June in association with Michigan's Summer Free Fishing Weekend;

2. The conducting of an annual student poster contest for students grades six through eight to encourage critical thinking and to demonstrate their knowledge of Great Lakes aquatic invasive species;



3. The conducting of an information and education small grants program to provide seed money to encourage development aquatic nuisance species outreach programs in local communities;
4. The launching of a public outreach campaign to educate the Michigan citizenry about the potential for *Hydrilla spp.*, an aggressive, non-native, aquatic plant, to invade Michigan waters and the need for volunteer citizen monitoring; and
5. The surveying of Michigan boaters on aquatic nuisance species knowledge and behavior practices.

Physical and Chemical Indicators

Ambient Levels of Criteria Air Pollutants

Pollutants, both manufactured and naturally occurring, affect the quality of Michigan's air. Air quality can vary depending upon location, time, and weather conditions. The air quality in Michigan has shown marked improvement over the last 35 years as sources of air pollution have been identified and corrective solutions implemented. However, there remain challenges and room for further improvements.

National Ambient Air Quality Standards have been established for six pollutants referred to as *criteria pollutants*. The criteria pollutants include carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. The MDEQ operates an air monitoring network in 24 counties, which represents the overall air quality in the state. Currently (2005), all areas in Michigan are in compliance with the USEPA criteria pollutant standards implemented for carbon monoxide, lead, nitrogen dioxide, particulate matter less than 10 micrometers in diameter, and sulfur dioxide. In 2004, the USEPA implemented new standards for ozone and particulate matter less than 2.5 micrometers in diameter, and parts of Michigan are not in attainment with these standards. Additional information on Michigan's air quality is available in the MDEQ's Annual Air Quality Report (www.michigan.gov/deqair). A brief summary for



each of the six criteria pollutants is presented below.

Carbon Monoxide. Carbon monoxide is



produced primarily from transportation, fuel burning for space heating, and electrical generation. Industrial processes, as well as wood, agricultural, and refuse burning, also contribute to emissions of carbon monoxide.

Carbon monoxide can exert toxic effects on humans by limiting oxygen distribution to organs and tissues. People with impaired circulatory systems are vulnerable at lower levels than healthy individuals. Exposure to carbon monoxide can impair visual perception, work capacity, manual dexterity, learning ability, and the performance of complex tasks.

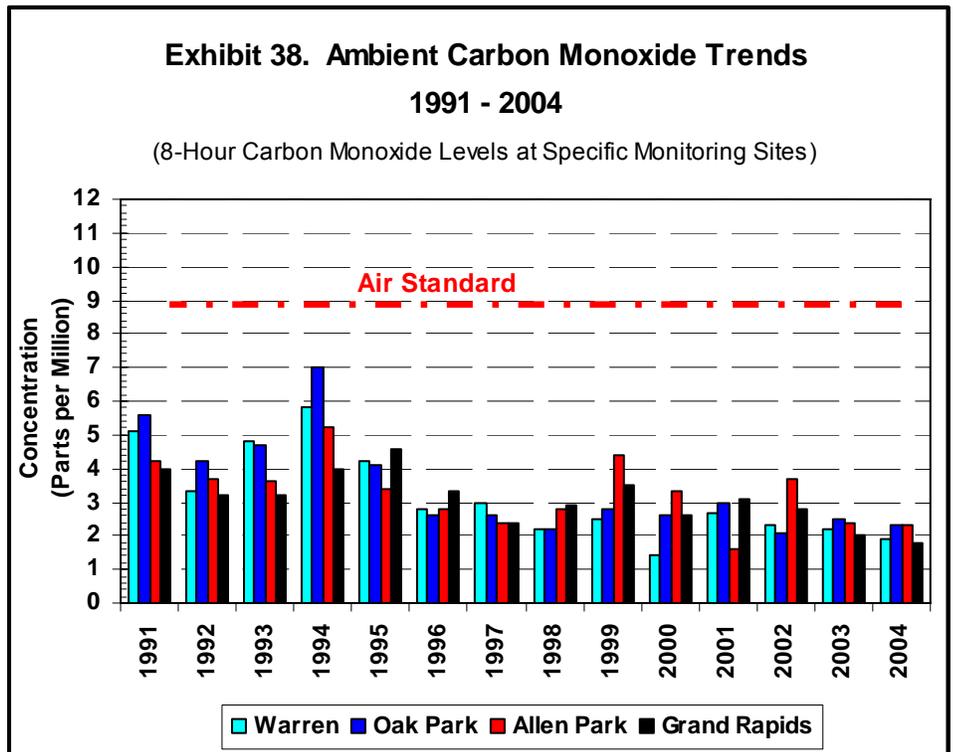
Statewide annual carbon monoxide levels over the last decade have gradually decreased to about one-third of the standard (Exhibit 38). A peak in the statewide average level during 1994 was due to two exceedances of the standard at one air monitoring site in Detroit. No exceedances of either the 1-hour or 8-hour carbon monoxide standards have occurred in the last ten years. At present, all Michigan areas are in attainment with

the 1-hour and 8-hour standards.

Lead. The most common sources of lead emissions are gasoline additives, non-ferrous smelting plants, and battery manufacturing. Historically, lead was added to gasoline as an additive to prevent engine knocking. The lead content of gasoline began to be controlled in the 1970s when legislation was passed to gradually reduce lead levels. Currently, smelters and battery plants are the major sources of lead nationwide.

Human exposure to lead can occur through ingestion or inhalation. The nervous system is most sensitive to the effects of lead and high exposures to lead can result in behavioral and learning disorders. Lead also may be a contributing factor in high blood pressure and heart disease.

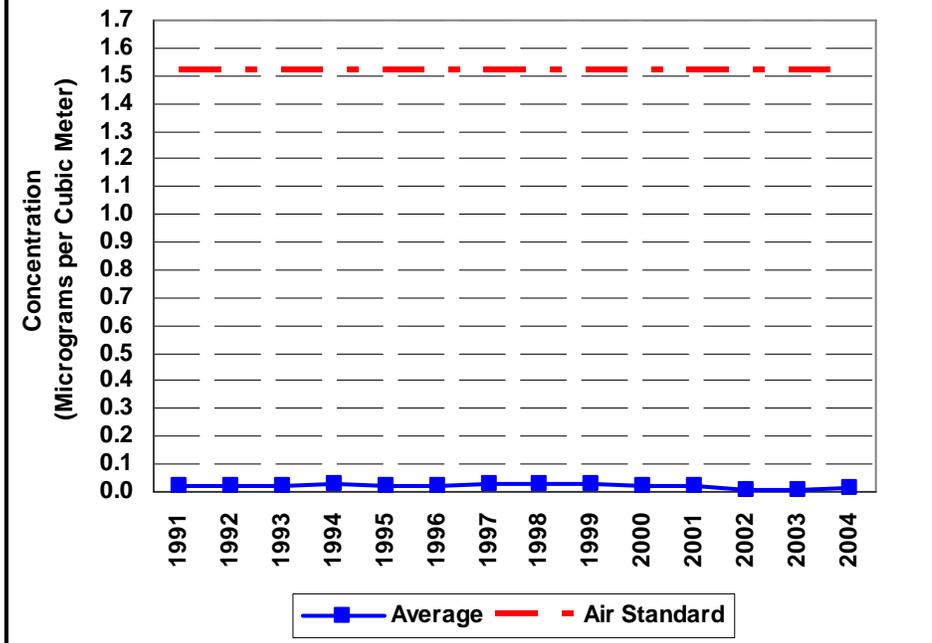
Concentrations of lead in the air decreased steadily in the 1980s after the removal of lead from gasoline. Average quarterly lead levels across Michigan are about 50 times below the air quality standard of 1.5 micrograms per cubic meter



($\mu\text{g}/\text{m}^3$). The air quality standard for lead has been met since 1985 in all metropolitan areas in Michigan (Exhibit 39).

Exhibit 39. Ambient Lead Trends 1991 - 2004

(Statewide Average of Monitored Quarterly Lead Levels)



storage and transfer, paint solvents, and degreasing agents. The primary NOx sources are power plants and motor vehicles. Natural sources of VOCs and NOx include lightning and terpene emissions from pine trees and other vegetation. Sunlight initiates the reaction, which is why elevated ozone concentrations occur during the warmer, sunnier months of the year. In addition to the formation of ozone, these reactions form many other products which, when combined with ozone, are called *photochemical smog*.

Photochemical smog is a brownish, acrid mixture of many gases and particles. The color and odor of smog are due to compounds other than ozone. Ozone irritates the human respiratory system and can

Nitrogen Dioxide. Nitrogen dioxide is formed during combustion processes that create extremely high temperatures, such as those from power plants burning coal, oil, and gas fuels and from burning fuels in motor vehicle engines. Nitrogen oxides contribute to the formation of ground level ozone and can contribute to acid rain.

cause coughing and chest pains upon deep inspiration in exercising individuals. Ozone also is responsible for crop damage and increased deterioration of rubber, dyes, paints, and fabrics. Ground level (ambient) ozone should not be confused with stratospheric ozone, sometimes described as the *ozone layer*, which is beneficial because it protects the earth from the sun's

The human respiratory system is susceptible to effects caused by exposure to nitrogen dioxide. Asthmatics are particularly sensitive to these effects.

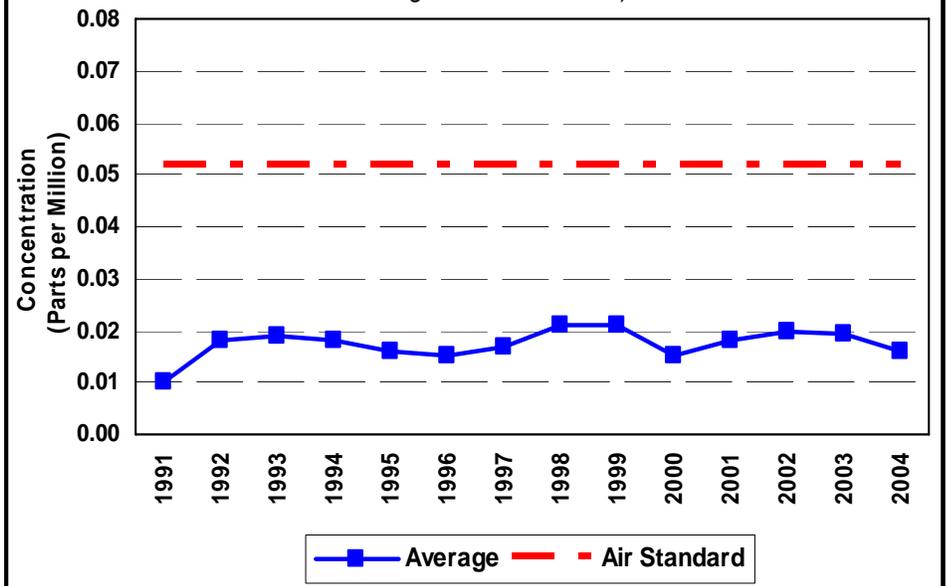
Monitoring results show that ambient nitrogen dioxide levels have remained near the 0.02 parts per million (ppm) level since 1992, which is less than one-half of the standard (Exhibit 40). Michigan has never recorded a violation of the nitrogen dioxide standard.

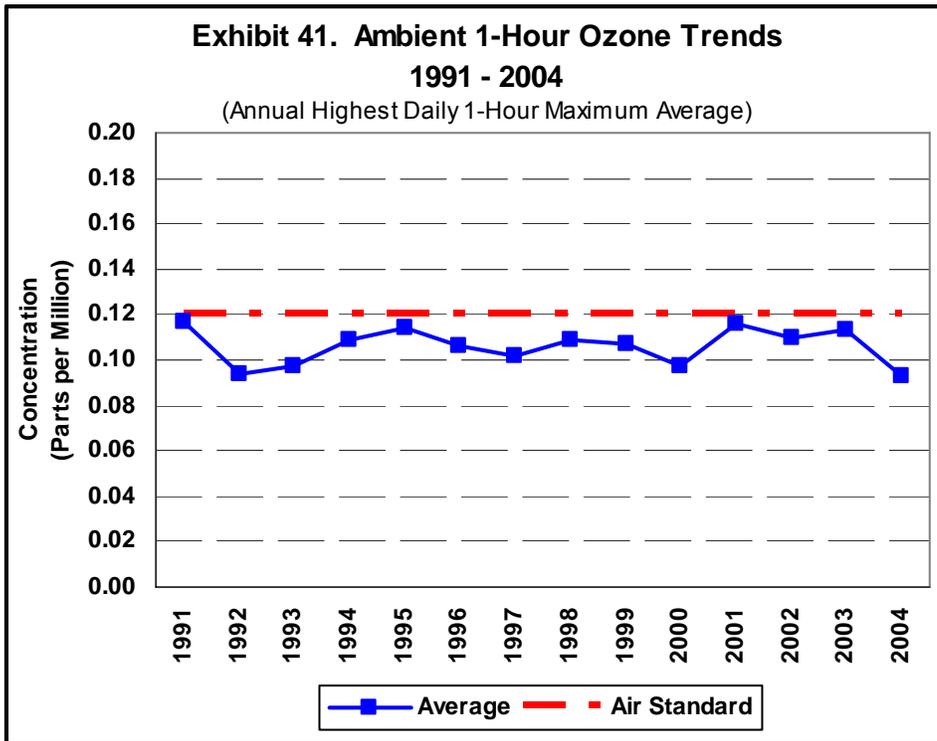
Ozone. Ozone is a colorless gas that is formed at ground level from photochemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs). The primary sources of VOCs include motor vehicle exhaust, gasoline

Exhibit 40. Ambient Nitrogen Dioxide Trends

1991 - 2004

(Statewide Average of Monitored Annual Average Nitrogen Dioxide Levels)





standard at the New Haven, Port Huron, Warren, and Seney stations. The exceedances at New Haven and Port Huron were multi-day events that when coupled with exceedances in 2001, led to violations of the three-year averaged 1-hour standard. In addition, in 2003, 23 of the 27 sites monitoring ozone in Michigan recorded four or more days when the 8-hour standard of 0.08 ppm was exceeded. Conversely, cooler temperatures prevailed in 2004. As a result, only one station (Holland) recorded an exceedance of the 1-hour standard and only four stations measured 8-hour ozone levels above the 8-hour standard in 2004. In each of these cases, all exceedances were single-day events. Exhibit 41 displays 1-hour ozone trends.

harmful ultraviolet radiation.

Ambient ozone levels are influenced by temperature. Extremely hot, dry summer weather is the most conducive to the formation of ozone. For example, during June 2003, extremely warm conditions caused exceedances of the 1-hour

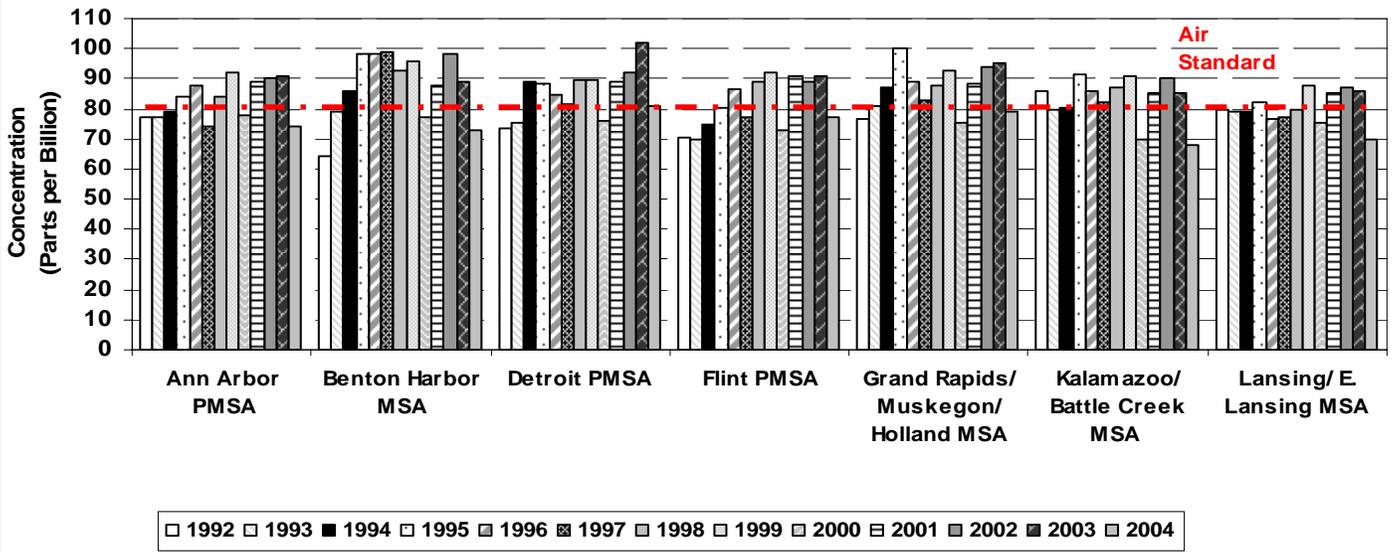
Exhibit 42 shows a comparison between the 8-hour standard and trends in urban areas.

The USEPA replaced the 1-hour ozone standard with a new 8-hour standard, and on June 15, 2004, designated 25 counties in Michigan as nonattainment with the new 8-hour ozone air quality standard. Eight counties in the Detroit-Ann Arbor Metropolitan Statistical Area (MSA), as well as Muskegon and Cass counties, are classified as marginal nonattainment. A marginal classification will require reducing ozone-forming emissions in order to attain the 8-hour standard by 2007. Fifteen counties were designated basic nonattainment and must attain the new ozone standard by 2009. Exhibit 43 shows the 8-hour ozone nonattainment designations.



Particulate Matter. Particulate matter is a broad classification of material that consists of solid particles, fine liquid droplets, or condensed liquids adsorbed onto solid particles. Particulates with a diameter of less than 10 micrometers in diameter are referred to as PM_{10} while very fine particles equal to or less than 2.5 micrometers in diameter are referred to as $PM_{2.5}$. Particulate can be emitted directly (primary) or formed in the atmosphere (secondary). PM_{10} is composed largely of primary particles such as smoke, dust, dirt, soot, fly ash, and condensing vapors.

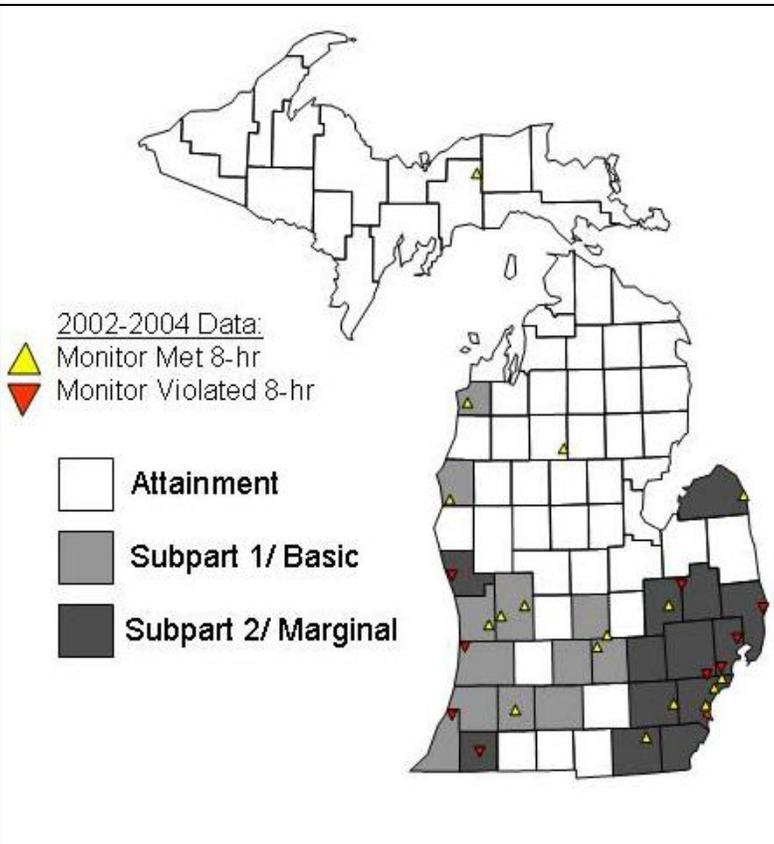
Exhibit 42. Ambient 8-Hour Ozone Trends 1992 - 2004
 (Metropolitan Statistical Areas Annual Fourth Highest 8-Hour Ozone Levels)



Industrial processes that cause these emissions include combustion, incineration, construction, mining, metal smelting, metal processing, and

grinding. Other sources include motor vehicle exhaust, road dust, wind-blown soil, forest fires, and volcanic activity.

Exhibit 43. Eight-hour Ozone Nonattainment Designations



Human exposure to particulate matter can affect breathing and aggravate existing respiratory and cardiovascular disease. More serious effects may occur depending on the length of exposure, the concentration, and the chemical nature of the particulate matter. Asthmatics and individuals with chronic lung and/or cardiovascular disease, people with influenza, the elderly, and children are the most susceptible. PM₁₀ is especially problematic, because it can penetrate deep into the lungs and remain there. Particulate matter can impair visibility, damage materials, and create soiling.

Levels of annual average PM₁₀ have remained well below the annual PM₁₀ standard at most locations (Exhibit 44). The high 2003 value at the Dearborn station was the result of heavy construction performed near the monitor and does not meet data collection criteria. This site has historically measured the highest levels statewide. Michigan is designated as being in attainment with the PM₁₀ standard.

In 2004, the USEPA implemented a new standard for PM_{2.5}. The particles or droplets have many different chemical compositions, depending on the source of the emissions. Also,

chemical reactions can occur in the atmosphere to form new chemical compounds or change the form from gases and liquids into solid particles. PM_{2.5} is composed of many more of these secondary particles. Examples include sulfates formed from power plant emissions and nitrates from power plants and automobiles.

Due to the recent initiation of PM_{2.5} monitoring in

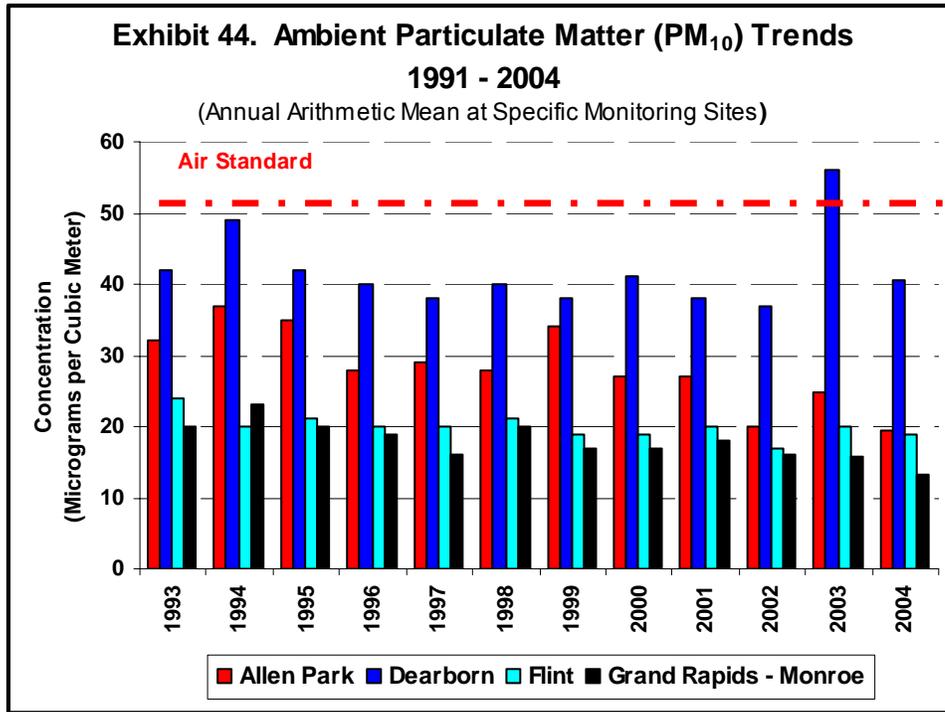
smelters, petroleum refineries, pulp and paper mills, transportation sources, and steel mills. Other sources include residential, commercial, and industrial space heating.

Human exposure to sulfur dioxide aggravates existing respiratory and cardiovascular diseases. Asthmatics and individuals with chronic lung and/or cardiovascular disease, children, and the elderly are most susceptible. Sulfuric acid also is a component of acid rain, which can potentially acidify lakes, streams, and soils and corrode building surfaces.

Levels of sulfur dioxide have fallen to no more than one-fourth of the annual standard (0.030 ppm) since 1991 (Exhibit 47). Monitored levels statewide also have remained well below the 24-hour standard (0.14 ppm not to be exceeded more than once per year). The state has maintained an attainment designation for sulfur dioxide since 1982.

Air Quality Index

The Air Quality Index (AQI) was developed by the USEPA to



1999, long-term historical trend information is unavailable. However, Exhibit 45 shows the PM_{2.5} levels monitored at eight urban areas relative to the annual PM_{2.5} standard. On December 17, 2004, the USEPA designated seven counties in the Detroit-Ann Arbor urban area (Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne) as nonattainment for PM_{2.5}. Exhibit 46 shows the PM_{2.5} nonattainment designations.

Sulfur Dioxide. Nationwide, the largest source of sulfur dioxide is coal-burning power plants. State regulations require that most of the coal burned in Michigan contain low amounts of sulfur. Sulfur dioxide also is emitted from

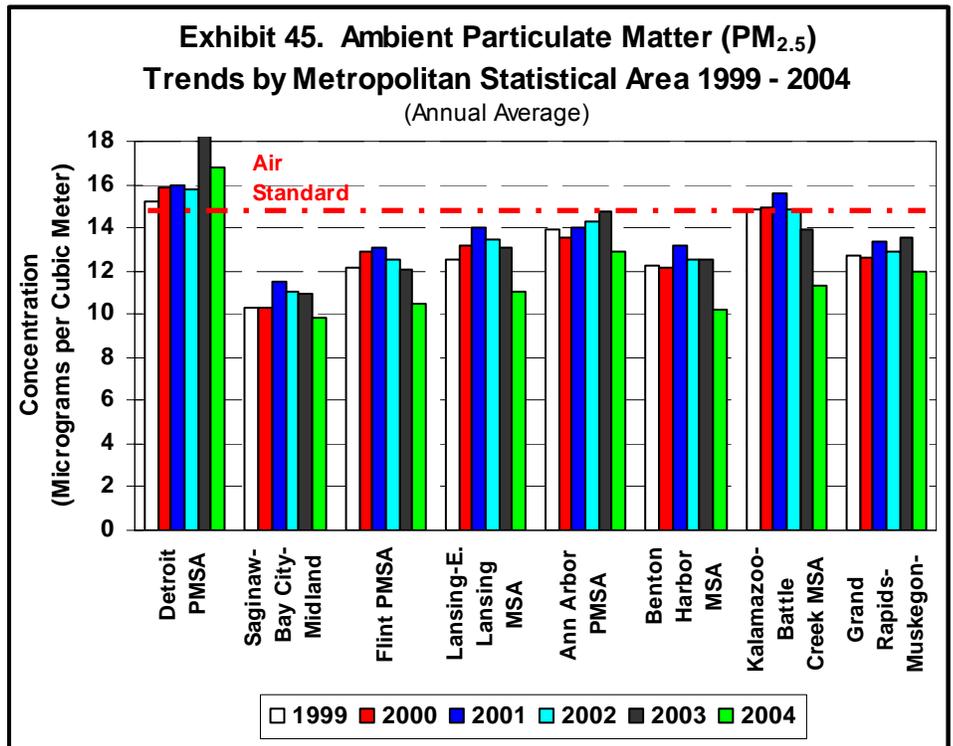
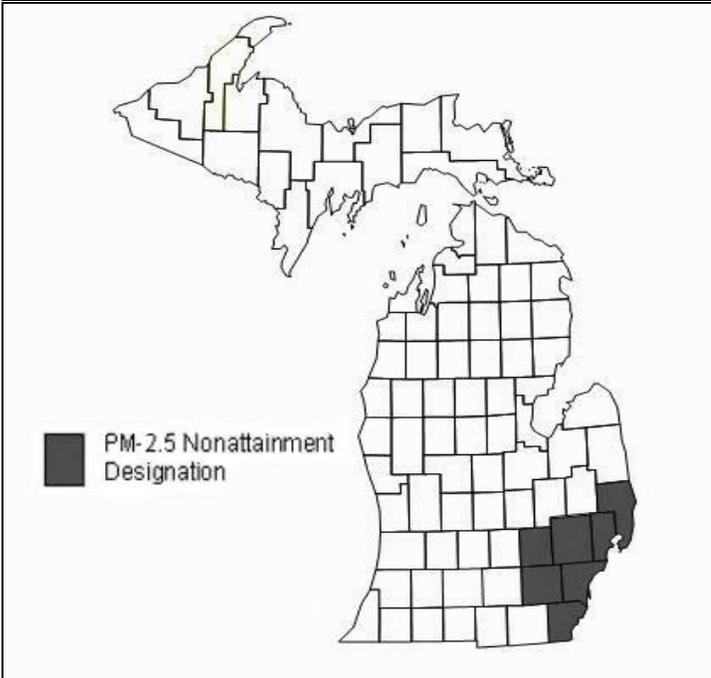


Exhibit 46. PM_{2.5} Nonattainment Designations, December 17, 2004



existing health indicator categories of *good*, *moderate*, *unhealthy*, *very unhealthy*, and *hazardous*. Also in 1999, the USEPA changed the health indicators for the AQI by incorporating the new 8-hour ozone and PM_{2.5} readings. These changes resulted in a substantially higher number of days that were considered to be *unhealthy for sensitive groups*.

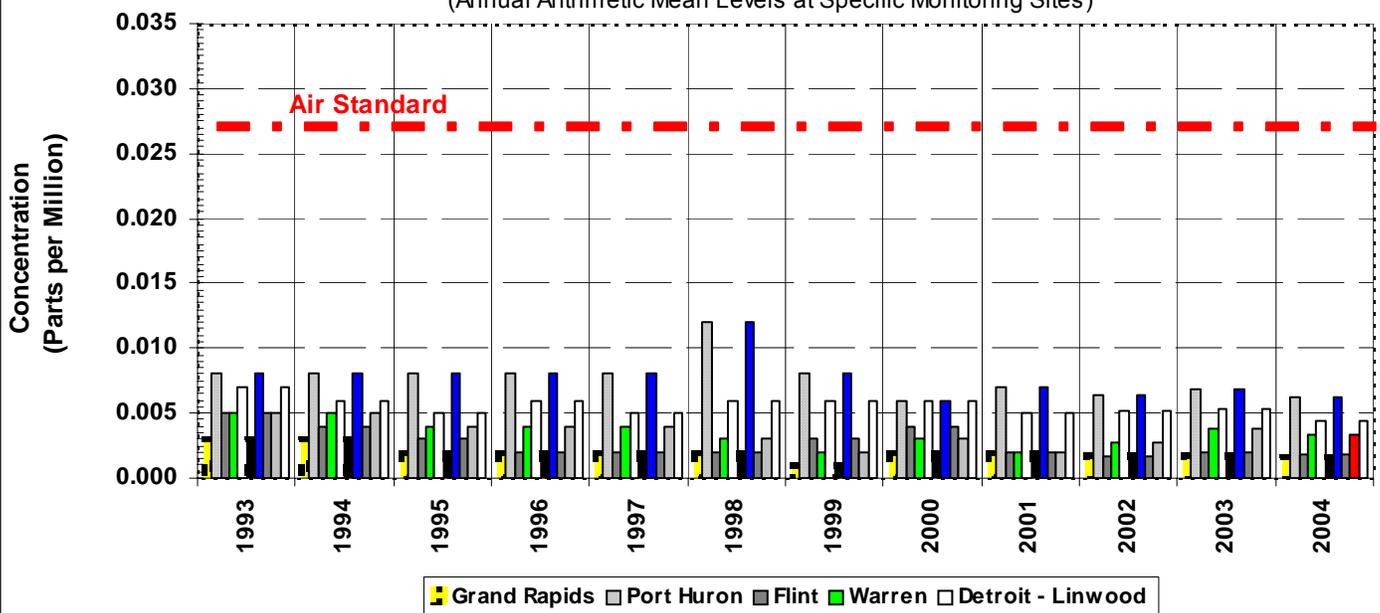
The AQI values are available to the public and news media on the Internet on a near real-time basis for a number of metropolitan areas in Michigan. Exhibits 48 and 49 reflect the current AQI categories and health indicators for the years 1993 – 2004. This was calculated by the USEPA by re-evaluating the earlier years and applying the new health indicators. However, the PM_{2.5} monitoring (and AQI scoring for it) only began in 1999. Over the last several years, AQI values have been mostly *good* and *moderate* air quality levels. However, some metropolitan areas in Michigan have experienced days that were categorized as *unhealthy* for the general population or *unhealthy for sensitive groups*.

provide a simple and uniform way to report daily air quality. The AQI provides advice to the public about the health effects associated with various levels of air pollution, including recommended precautionary steps if conditions warrant. In 1999, the USEPA revised the AQI. The category *unhealthy for sensitive groups* was added to the

While based on actual measurements, caution should be exercised with the use of the AQI, since the health classification labels are quite general and are, therefore, subject to interpretation. Additional information on the AQI, including the daily AQI values for Michigan monitoring sites, is

**Exhibit 47. Ambient Sulfur Dioxide Trends
1993 - 2004**

(Annual Arithmetic Mean Levels at Specific Monitoring Sites)

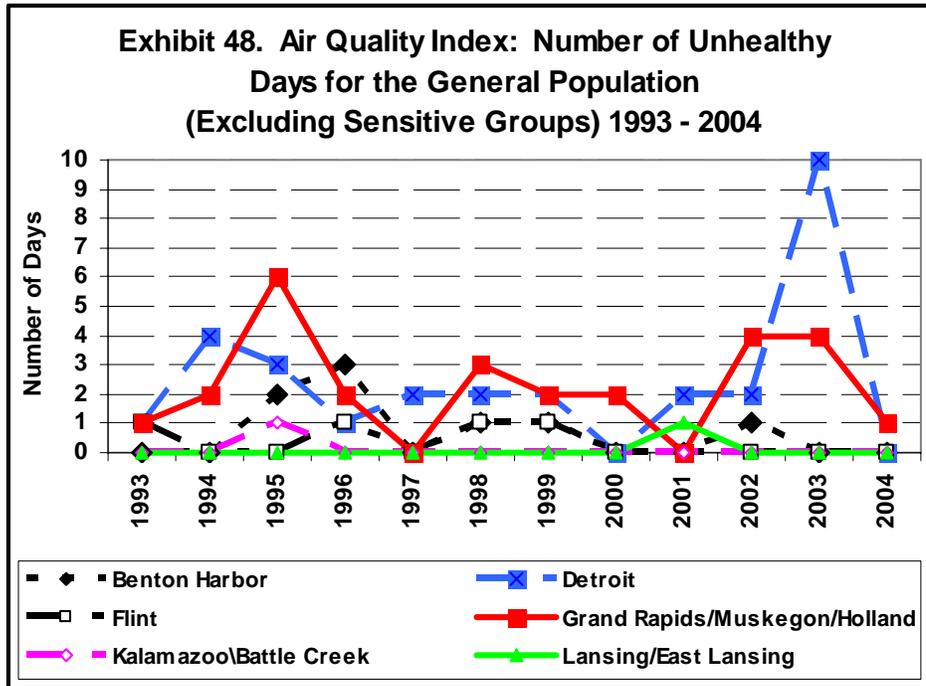


available on the MDEQ's Internet site (www.michigan.gov/deqairqualityindex).

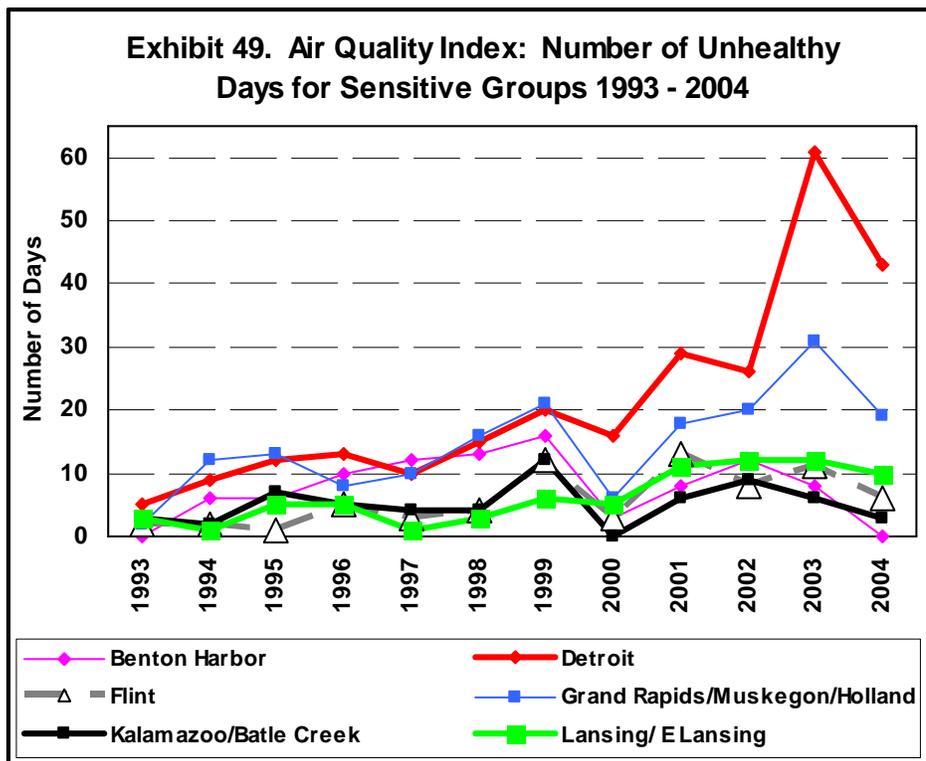
Ambient Levels of Air Toxics Contaminants

There are many more atmospheric contaminants than just the six criteria pollutants. The additional

air pollutants are referred to as *air toxics*. While there are health reference levels for many air toxics, these generally are not as well established as the criteria pollutants' National Ambient Air Quality Standards. The available air toxics monitoring data also are limited. Consequently, air toxics emissions and monitoring data are not as well characterized as are the data for the six criteria pollutants.



The MDEQ's Air Toxics Monitoring Program was established in January 1990. Since the program's inception, approximately 50 toxic organic compounds and 13 trace metals have been monitored at various urban locations throughout the state. Monitoring sites currently include Detroit, Allen Park, Dearborn, River Rouge, Ypsilanti, Flint, Grand Rapids, and Houghton Lake. The air toxics monitored include acetaldehyde, acetone, benzene, chloromethane, formaldehyde, toluene, manganese, and many others. Detailed information on this program is available in the MDEQ's Annual Air Quality Report (www.michigan.gov/deqair).



The USEPA has developed a nationwide air toxics monitoring network. This network is providing measurements of ambient concentrations of air toxics at monitoring sites throughout the United States that can be used in the estimation of human and environmental exposures to air toxics. Dearborn, Michigan, is one of those sites. The MDEQ has developed an air toxics monitoring strategy that, as resources allow, will guide the implementation of further monitoring for air toxics in Michigan. The primary objective of the strategy is to better characterize the air toxics levels and trends across the state. The strategy report is available on the MDEQ's Internet site (www.michigan.gov/deqair).

In 2000, the MDEQ was awarded funding from the USEPA for an air toxics monitoring study in



Detroit. The *Detroit Air Toxics Pilot Project* included monitoring for 18 air toxics of high concern in urban areas, and a total of up to 224 substances at different sites. Monitoring was conducted during the period 2001 – 2002. MDEQ also received a USEPA grant in 2003 to conduct a risk assessment of these monitoring data, with a scheduled completion by September 2005. Information on this project is available on the MDEQ's Internet site (www.michigan.gov/deqair).

While it is not feasible to obtain ambient measurements of air toxics at all locations, emissions data and dispersion models can be used in conjunction with ambient measurements from other locations to estimate population exposure across the nation. The USEPA has recently completed nationwide studies of 1996 and 1999 air toxics emissions, dispersion, ambient concentrations, human exposures, and health risks. The National-Scale Air Toxics Assessment evaluated air toxics of high concern in urban areas and is available on the USEPA's Internet site (www.epa.gov/ttn/atw/nata/).

Rates of Deposition of Persistent and Bioaccumulative Air Toxics

Some air toxics can persist and bioaccumulate in the environment. For these substances,

deposition to the ground and water is a concern because of potential ecological impacts and human exposure. The MDEQ and the University of Michigan are currently conducting a special study of mercury deposition in Michigan. Urban sites are located in Grand Rapids, Detroit, and Flint and rural sites are located in Dexter, Pellston, and Eagle Harbor. Additionally, the USEPA is monitoring for metals, PCBs, pesticides, and polycyclic aromatic hydrocarbons at Eagle Harbor, Sleeping Bear Dunes, and other locations around the Great Lakes Basin. Additional information will be available for the 2007 Biennial Report.



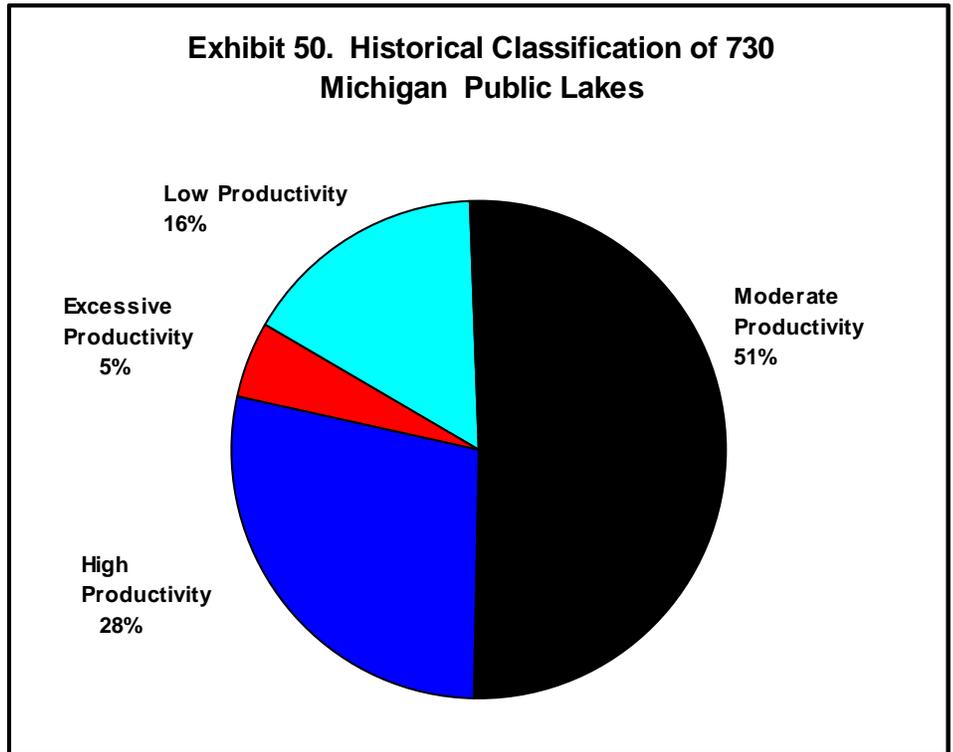
Inland Lake Water Quality

The federal Clean Water Act requires states to assess lake water quality and to categorize lakes according to their *trophic status*, an indicator of biological productivity. Lake trophic status is the level of growth of algae and higher plants, or primary productivity, as measured by phosphorus content, algae abundance, and depth of light penetration in the lake. Low productive lakes, are generally deep and clear with little aquatic plant growth. These lakes are generally very desirable for boating and swimming and may support coldwater fish, such as trout and whitefish. By contrast, highly productive lakes are generally shallow, turbid, and support abundant aquatic plant growth. These lakes commonly support warm water fish, such as bass and pike.

Historically, over 700 public lakes in Michigan have been assessed and classified. The majority (67%) were categorized as moderately productive lakes or low productive lakes. Only five percent of the lakes evaluated were categorized as excessively productive lakes (Exhibit 50).

Currently, the Cooperative Lakes Monitoring Program, a Michigan Clean Water Corps (MiCorps) program, provides for long-term water quality measurement and continues the lake classification process. The MiCorps program enlists citizen volunteers from the public and limited access lakes across the state to monitor lake primary productivity indicators, including water clarity, total phosphorus, and chlorophyll *a*, from which the lakes can be categorized in terms of trophic status. During 2003 - 2004, volunteers monitored these lake productivity indicators on 101 lakes. For these lakes, the majority exhibited moderate (58%) to low (27%) productivity. Fifteen percent of the monitored lakes were categorized as having high productivity and no lakes exhibited excessive productivity (Exhibit 51).

The Cooperative Lakes Monitoring Program is a cost-effective volunteer program for increasing baseline water quality data and lake productivity classifications for Michigan's inland lakes. The long-term monitoring program can provide information to evaluate water quality variability and trends in these lakes. However, results from the

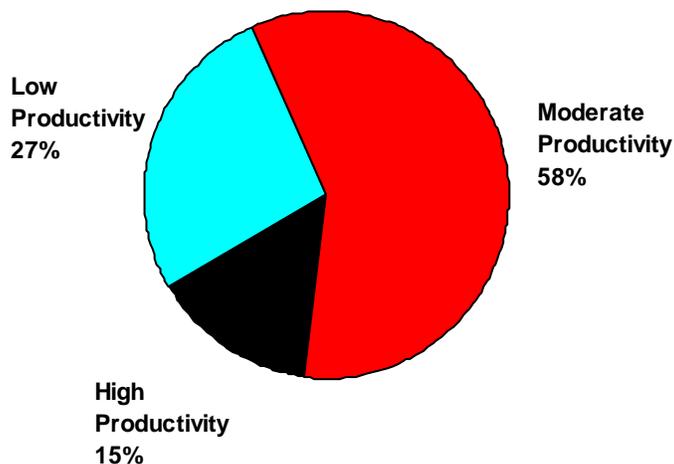


volunteer program alone only provide information on lakes where volunteers choose to participate in the program and may not be representative of lakes statewide. Consequently, the MDEQ is using money from the Clean Michigan Initiative (CMI) Fund to expand the program and to re-establish monitoring of public access lakes across the state. This effort will build upon the historical lake data that exist and supplement the information generated from the volunteer monitoring program.

The MDEQ, in partnership with the USGS, has re-established a Lake Water Quality Assessment Monitoring Program for public access lakes in Michigan. Baseline data for conventional water quality parameters such as plant nutrients (i.e., total phosphorus and nitrogen), chlorophyll *a*, dissolved oxygen, temperature, water clarity, and dissolved ions (i.e., chloride, sulfate, sodium, potassium, and calcium) were collected from 83 public access lakes in 2004. Of the 83 lakes sampled, 9 (11%) were characterized as low productive lakes, 48 (58%) as moderately productive lakes, 20 (24%) as highly productive lakes, and 6 (7%) as excessively productive lakes. This work is continuing on 104 lakes in 2005.

CMI Funds also are supporting work by the USGS to explore the feasibility and practicality of using

Exhibit 51. Classification of 101 Lakes Monitored through Michigan's Cooperative Lakes Monitoring Program during 2003 - 2004



further for statewide application in 2006 along with the inland lakes data collection effort.

Surface Water Chemistry

Consistent with a *Water Chemistry Trend Monitoring Plan* developed by the MDEQ and the USGS, water samples have been collected from 31 major Michigan rivers since 2000. Water samples are collected from Saginaw Bay, Grand Traverse Bay, and the Great Lakes connecting channels. Samples are analyzed for nutrients, heavy metals, and other selected parameters. These data are used to measure spatial and temporal trends in inland rivers, connecting channels, and bays.

remote sensing satellite imagery for lake water quality assessments that will enable the MDEQ to



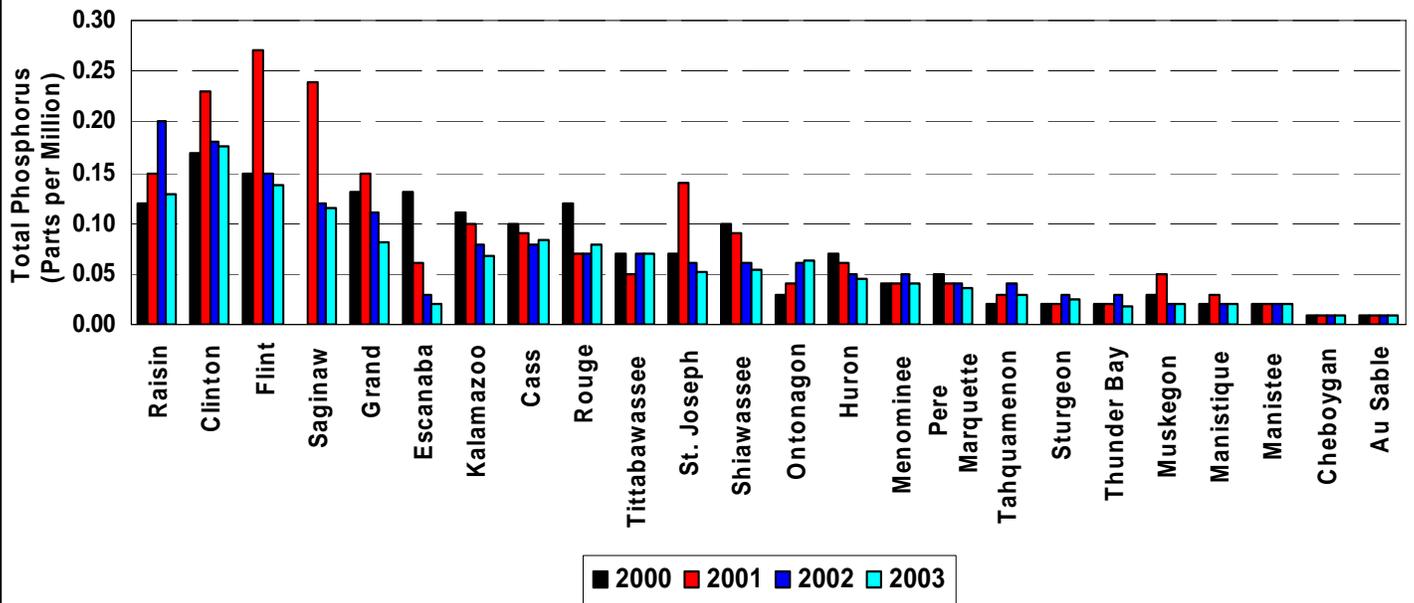
estimate productivity in inland lakes statewide. A statistical model has been developed and tested regionally with data collected from the Cooperative Lakes Monitoring and Lake Water Quality Assessment Monitoring Programs during 2002. The statistical model will be enhanced and tested

Exhibit 52 shows a comparison of total phosphorus concentrations among 24 inland rivers for the period 2000 - 2003. Phosphorus is a key nutrient that affects algal growth and regulates productivity in surface waters. Phosphorus concentrations tend to be generally higher in rivers that drain urban or heavily agricultural areas, and lower in relatively undeveloped, heavily forested watersheds.

Exhibit 53 presents the average annual total phosphorus concentrations from eight locations throughout the inner Saginaw Bay. Between 1993 and 2003, average phosphorus levels were lowest in 1996 (0.15 ppm) and highest in 1998 (0.36 ppm). Overall, these data present no indication of any water quality trend for the Saginaw Bay at this time. The MDEQ has taken a number of actions to reduce phosphorus levels in the Saginaw Bay watershed and will continue to monitor Saginaw Bay to evaluate the effectiveness of these actions.

Exhibit 54 shows average concentrations of total mercury in 24 Michigan rivers for the period 2000 - 2003. The highest average annual mercury concentration occurred in the Raisin River in 2000 (10.1 parts per trillion - ppt), while the lowest concentration was found in the Au Sable River in 2000 (0.2 ppt). Mean mercury levels exceeded the Michigan water quality standard (1.3 ppt) in 16, 19, 19, and 20 of the Michigan rivers sampled in

Exhibit 52 Average Total Phosphorus Concentrations in Selected Michigan Rivers in 2000 - 2003



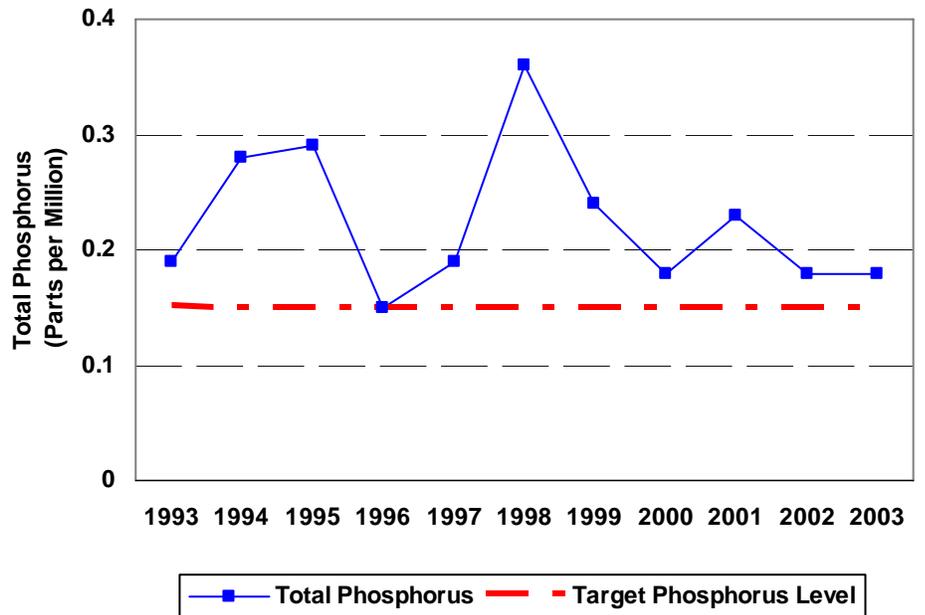
2000, 2001, 2002, and 2003, respectively. As was the case with the phosphorus river data (Exhibits 51 and 52), no clear trend in water quality can be discerned from the collected mercury river data at this time. Additional data will be needed to be collected.

In 1999, a joint initiative between the MDEQ and MSU was begun to monitor inland lake sediments. The project was designed to provide data to evaluate the effectiveness of water quality legislation and the National Pollutant Discharge Elimination System permitting program in reducing contaminant levels in the sediments of waters of

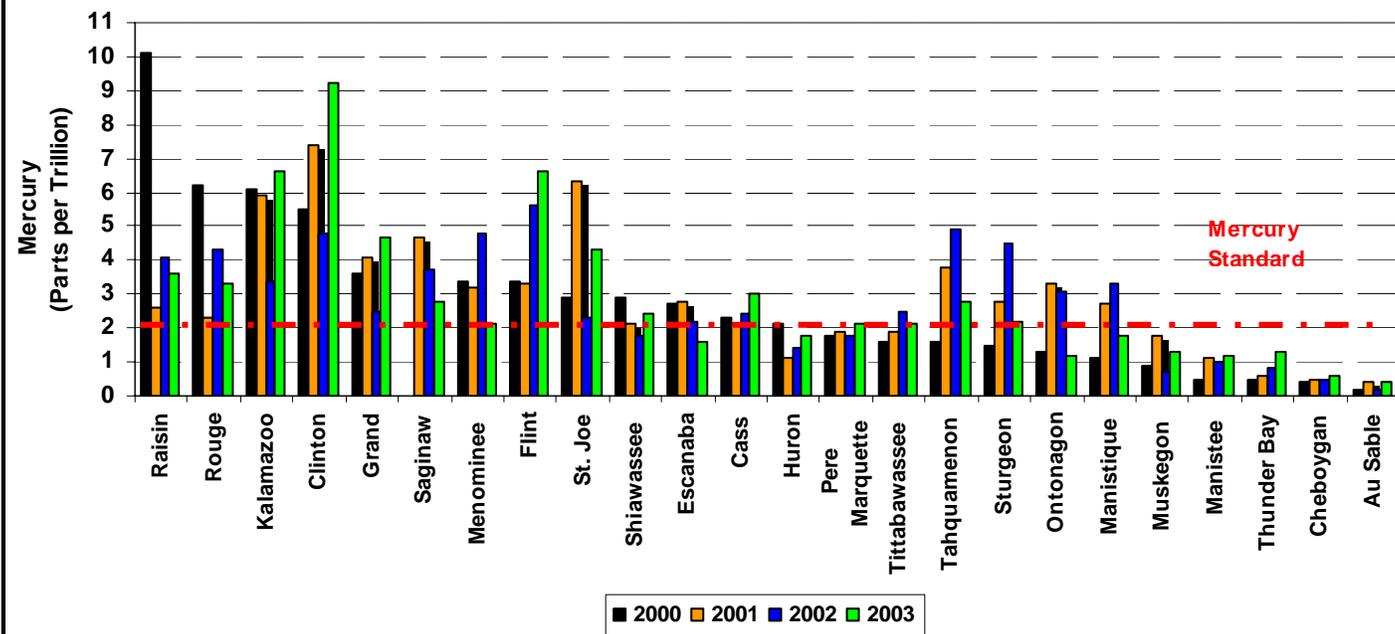
Inland Lake Sediments

Contaminated sediments can directly affect bottom dwelling organisms and represent a continuing source for toxic substances in aquatic environments that may impact wildlife and humans through food or water consumption. Measuring trends in the accumulation of toxic chemicals in sediments is useful to assess the overall quality of aquatic systems. As material is deposited on the bottom of lakes over time, the sediments serve as a chemical recorder of temporal trends of toxic contaminants. Consequently, the assessment of chemical trends in inland lake sediments is an integral component of the MDEQ's overall water quality monitoring program.

Exhibit 53. Average Annual Total Phosphorus Levels in Saginaw Bay 1993 - 2003



**Exhibit 54. Average Total Mercury Concentrations in Selected Michigan Rivers
2000 - 2003**



the state. Since 1999, sediment core samples have been collected from 27 inland lakes in Michigan. Samples were analyzed for mercury, trace metals, and selected organic contaminants, including PCBs and pesticides. Using advanced analytical methods, researchers are able to determine historical concentrations of different contaminants over time. Detail evaluations for this and previous years' investigations are described in annual reports by MSU and the MDEQ (www.michigan.gov/deq).

Exhibit 55 shows the lead accumulation rates in sediment cores in four lakes for the period 1900 – 2000. Lead accumulation rates increased until the 1970s, when leaded gasoline was banned, and then decreased to the present. There also is a



general geographic trend exhibited, with lakes in the more populated southern part of the state typically having higher accumulation rate trends than lakes farther north. Some of these lakes will be scheduled to be sampled again in 2010.

Exhibit 56 shows sediment trend data on copper concentrations in selected Michigan lakes for the period 1805 - 2001.

Sediment core samples show peak values of copper near 500 milligrams per kilogram (mg/kg) in Cadillac Lake; almost tenfold higher than the next highest lake, Whitmore Lake.



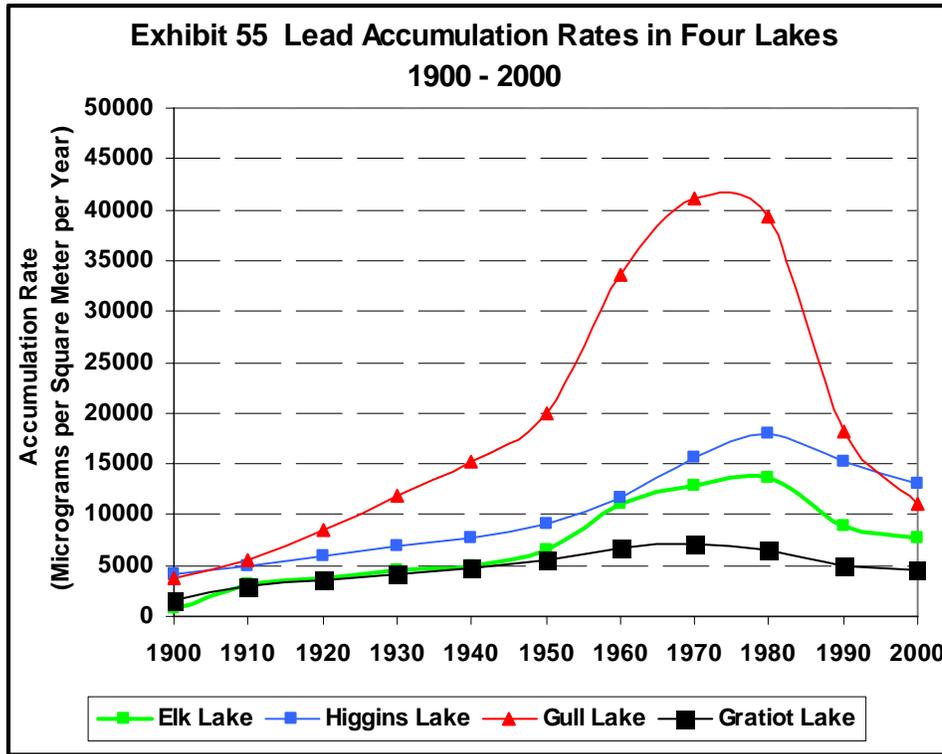
Copper concentrations decreased in Cadillac Lake sediment since the early 1990s, but remain high. The higher concentrations observed in Cadillac Lake are thought to be due to the use of copper sulfate to control algal growth. Sediments from Whitmore and Mullet Lakes show an increase in copper concentrations in the mid-1940s. While concentrations of copper in Mullet Lake have clearly decreased to the present, copper concentrations in Whitmore Lake do not show a decreasing trend.

Exhibit 57 shows concentrations of mercury in sediments from Higgins and Crystal (Benzie County) Lakes during the period 1825 - 2000. Common among many Michigan lakes are

II), while others are a possible indication of watershed-scale sources of mercury loadings (e.g., Higgins Lake). Many Michigan lakes also exhibit accumulation rates that increase to the

sediment surface, indicating a current yet undefined source of mercury to the lake (e.g., Crystal Lake).

In general, preliminary results for mercury concentration in Michigan Lakes show background (i.e., pre-industrial revolution) mercury concentrations ranging from 0.015 – 0.1 mg/kg (similar to those found in the Great Lakes), and peak mercury concentrations ranging from 0.16 – 1.1 mg/kg. For comparison purposes, sediments with mercury concentrations at or exceeding 2 mg/kg are considered to have a high probability of causing severe effects on bottom-dwelling organisms (sediment clean-up efforts often have a goal of 1.0 mg/kg of mercury in sediment). Final results from this



episodic mercury accumulation events that occur over short time periods (years) with regularity. Some of the events can be attributed to historical increases in mercury deposition (e.g., World War

sediment monitoring effort are anticipated in the fall of 2005.

In addition to the lake sediment assessment program, the MDEQ also participates in the removal of contaminated sediments from lakes and streams. Exhibit 58 shows the cubic yards of sediment that have been removed from Michigan's lakes and streams annually since 1995. Steady progress in sediment removal has been made since 1997. Twenty-five million dollars from the CMI Fund have been allocated for contaminated sediment cleanup.

Stream Flow

Natural flow regimes play a significant role in maintaining stream channel configuration, wetland and riparian vegetation, and stream-dependent biological communities. Stream flow is an

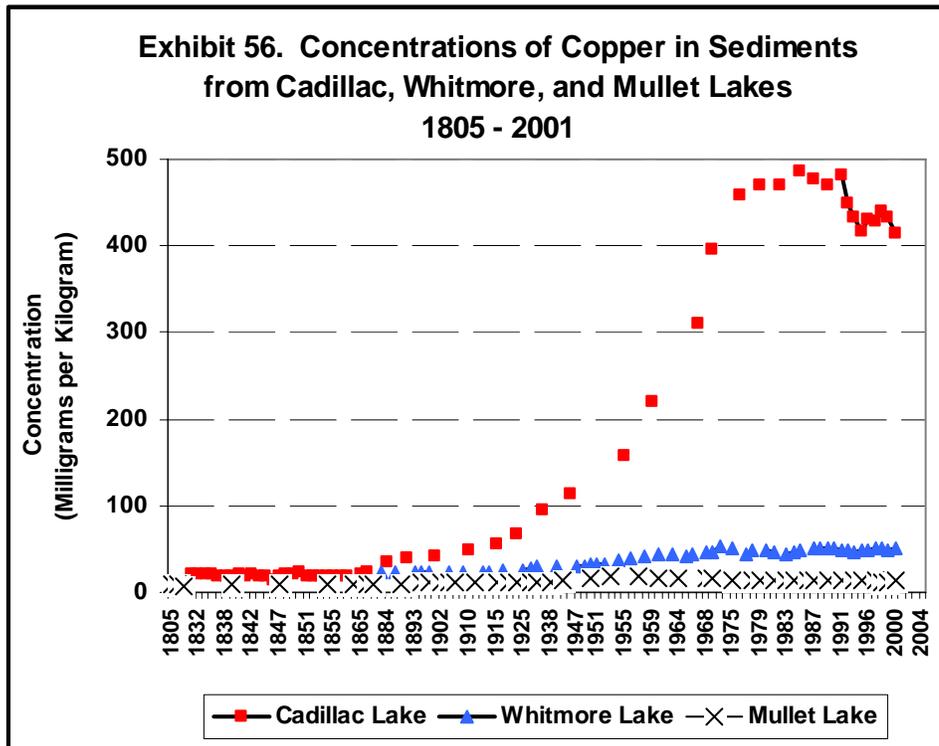
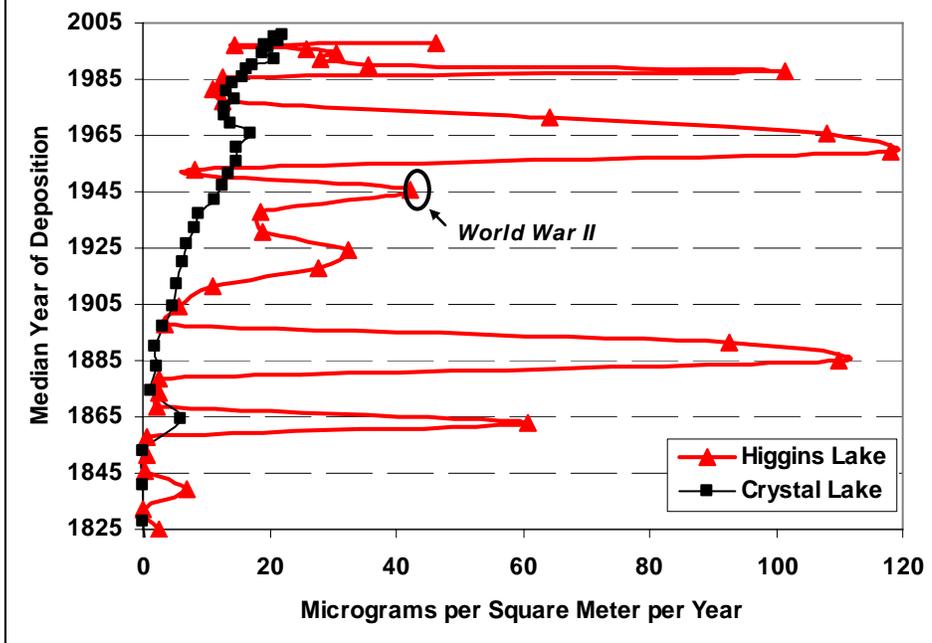


Exhibit 57. Concentrations of Mercury in Sediment from Higgins and Crystal Lakes (Benzie County) 1825 - 2000



The status of flow is determined by comparing recent flow patterns to a benchmark. This benchmark can be based on presettlement flows or from the earliest period of record. Models have been developed that predict stream flow as a function of geology, stream size, and current land cover characteristics. These models can be used to estimate baseline flow patterns by substituting current land cover data with presettlement land cover data.

The primary source of flow data comes from USGS gauging stations. At present, the USGS maintains approximately 150 stations statewide (Exhibit 59). However, the 150 existing gauges are currently not considered to be representative of all stream types in Michigan and there are a limited number of gauges that have 30

plus years of data.

indicator of the amount and type of habitat available for fish and other aquatic organisms. It also is an indirect measure of water quality in streams and in lakes and reservoirs occurring in stream systems.

Analysis of Michigan's stream flow data to provide the necessary information for development of baseline flow patterns and selection of reference

Changes in flow patterns reflect changes in runoff from land, ground water level, water extraction, discharge from upstream reservoirs (if present), and climatic variability. Several common stream flow measures are used to monitor and assess status of flow patterns. These include measures of the magnitude of high (10% exceedance frequency), median (50% exceedance frequency), and low (90% exceedance frequency) flows. High and low flow measures can be standardized by the median flow to facilitate comparisons among different rivers. An additional measure of runoff (mean annual discharge/ mean annual precipitation) also is evaluated.

Exhibit 58. Cubic Yards of Contaminated Sediments Removed from Surface Waters 1995 - 2004

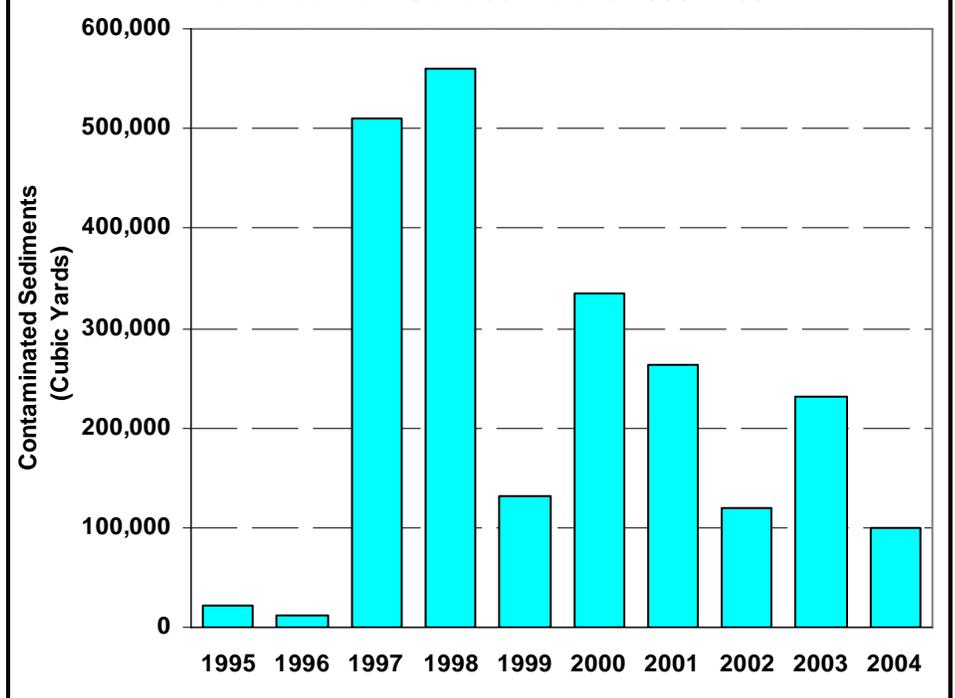


Exhibit 59. Geographic Distribution of Active Stream Gauging Stations Overseen by the United States Geological Survey



States states and two Canadian provinces and comprises the lakes, connecting channels, tributaries, and ground water that drain through the international section of the St. Lawrence River. Lake levels are determined by the combined influence of precipitation (the primary source of natural water supply to the Great Lakes), upstream inflows, ground water, surface water runoff, evaporation, diversions into and out of the system, consumptive uses, dredging, and water level regulation. Because of the vast water surface area, water levels of the Great Lakes remain relatively steady, with a normal fluctuation ranging from 12 to 24 inches in a single year.

Climatic conditions control precipitation (and, therefore, ground water recharge), runoff, and direct supply to the lakes, as well as the rate of evaporation. During dry, hot weather periods, inflow decreases and evaporation increases, resulting in lower lake levels and reduced flows. During wet, colder periods, higher levels and increased flows occur. Exhibit 60 shows the monthly mean water levels of the Great Lakes for the period 1865 – 2004.

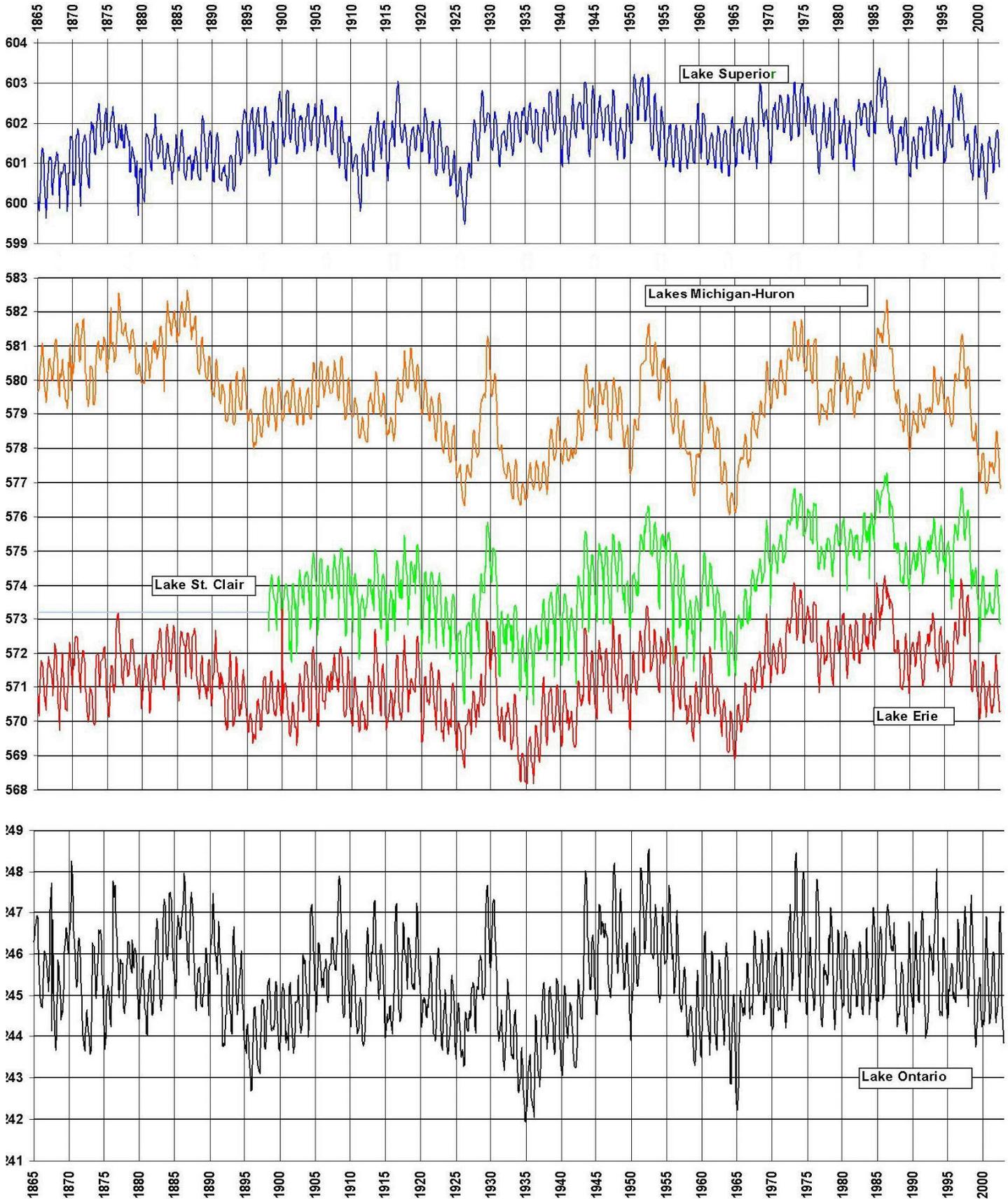
gauging stations is an ongoing task, and the results of this work are not yet available.

Great Lakes Water Level Trends

The Great Lakes Basin lies within eight United



Exhibit 60. Monthly Mean Great Lakes Water Levels 1865 – 2002 (In Feet)



Between 1918 and 1998, there have been several periods of extremely high and extremely low water levels and flows. Exceptionally low levels were experienced in the mid-1920s, mid-1930s, and early 1960s. High levels occurred in 1929 - 1930, 1952, 1973 - 1974, 1985 - 1986, and 1997 - 1998. Studies of water level fluctuations have shown that the Great Lakes can respond relatively quickly to periods of above average or extreme precipitation, water supply, and temperature conditions.

Great Lakes levels are highly sensitive to weather fluctuations, as illustrated by the impact of high water levels in the early 1950s and mid-1980s and of low water levels in the 1930s and mid-1960s. Significant and cyclic climatic variability will continue regardless if human intervention is superimposed or not on natural fluctuations. An example of how quickly water levels can change in response to climatic conditions occurred during 1998 - 1999, when the water levels of Lakes Michigan and Huron dropped 22 inches in 12 months.

The hydraulic characteristics of the Great Lakes Basin are the result of both natural fluctuation and, to a lesser extent, human intervention. Despite this, human activities, such as control work obstructions, dredging, and diversions, still can have an impact on lake levels. For example, dredging in the connecting channels can have a significant impact on lakes above the point of dredging. Out-of-basin diversions or other large removals and large consumptive uses, by contrast, can reduce water levels both above and below the actual point of withdrawal and also reduce flows in the system.

Great Lakes Ice Cover Trends

The State of the Lakes Ecosystem Conference (SOLEC) currently has developed over 80 indicators designed to assess the overall quality of and track the changing conditions of the Great Lakes over time. The indicator that is currently used by the SOLEC to assess extent of Great Lakes ice during the winter months is Indicator #4858: *Ice Duration on the Great Lakes Indicator*.

Changes in water and air temperatures will influence ice development on the Great Lakes and, in turn, affect coastal wetlands, near shore aquatic environments, and inland environments. Air

temperatures over a lake are one of the few factors that control the formation of ice on that surface. Colder winter temperatures increase the rate of heat released by the lake, thereby increasing the freezing rate of the water. Milder winter temperatures have a similar controlling effect, only the rate of heat released is slowed and the ice forms more slowly.

Globally, there are data to suggest that some smaller inland lakes appear to be freezing up later and breaking up earlier, than the historical average. However, current observations of the Great Lakes ice formation data do not show a similar trend with respect to the dates of freeze-up or break-up. Better data may become available in the near future with the greater use of satellite imagery. Sufficient data have been collected, however, from the ice charts to demonstrate that there appears to have been a decrease in the maximum ice cover per season over the last 30 years. The trends on each of the Great Lakes show that during this time span, the maximum amount of ice forming each year has been decreasing, which can be correlated to the average ice cover per season observed for the same time duration. Between the 1970s and



1990s, there was at least a 10 percent decline in the maximum ice cover on each Great Lake, and almost as much as 18 percent in some cases, with the greatest decline occurring during the 1990's (Exhibit 61).

Based on current data, it is anticipated that ice formation on the Great Lakes may continue to decrease in total cover if current predictions of milder winters hold true. However, because only a small number of data sets have been collected, this is not conclusive. Additional years of ice

Exhibit 61. Great Lakes Mean Ice Coverage 1970 – 1999

Lake	1970 - 1979	1980 - 1989	1990 - 1999	Change from 1970s to 1990s
Erie	94.5%	90.8%	77.3%	-17.2%
Huron	71.3%	71.7%	61.3%	-10.0%
Michigan	50.2%	45.6%	32.4%	-17.8%
Ontario	39.8%	29.7%	28.1%	-11.7%
Superior	74.5%	73.9%	62.0%	-12.6%

Source: Ferris, G. 2003. Ice duration on the Great Lakes indicator #4858, pp 71-72. In *State of the Great Lakes 2003*. State of the Lakes Ecosystem Conference, Environment Canada and U.S. Environmental Protection Agency. 102p.

formation data on the Great Lakes will need to be gathered.

Climate and Weather Trends

Knowledge of the state’s climate and weather is important to help interpret observed changes in air and water quality environmental indicators, but also in many of the programmatic measures. Michigan’s climate has fluctuated for thousands of years and will continue to fluctuate with time. The change from glacial conditions occurred about 11,300 years ago when warm dry Pacific air masses became more frequent. Warm air masses dominated from 9,500 to 4,700 years ago. The tendency since then has been toward cooler and wetter conditions with a brief warming period from 1200 to 1400. Cooler temperatures and greater precipitation dominated again from around 1550 to 1850. From the period 1890 to the 1930s, summer temperatures increased and precipitation decreased. Winter temperatures continued to rise into the 1950s and there was a wet, cool trend from the late 1950s into the 1970s. The 1980s, 1990s, and 2000s (thus far) have tended to provide slightly warmer temperatures as compared to the 1950s through 1970s.

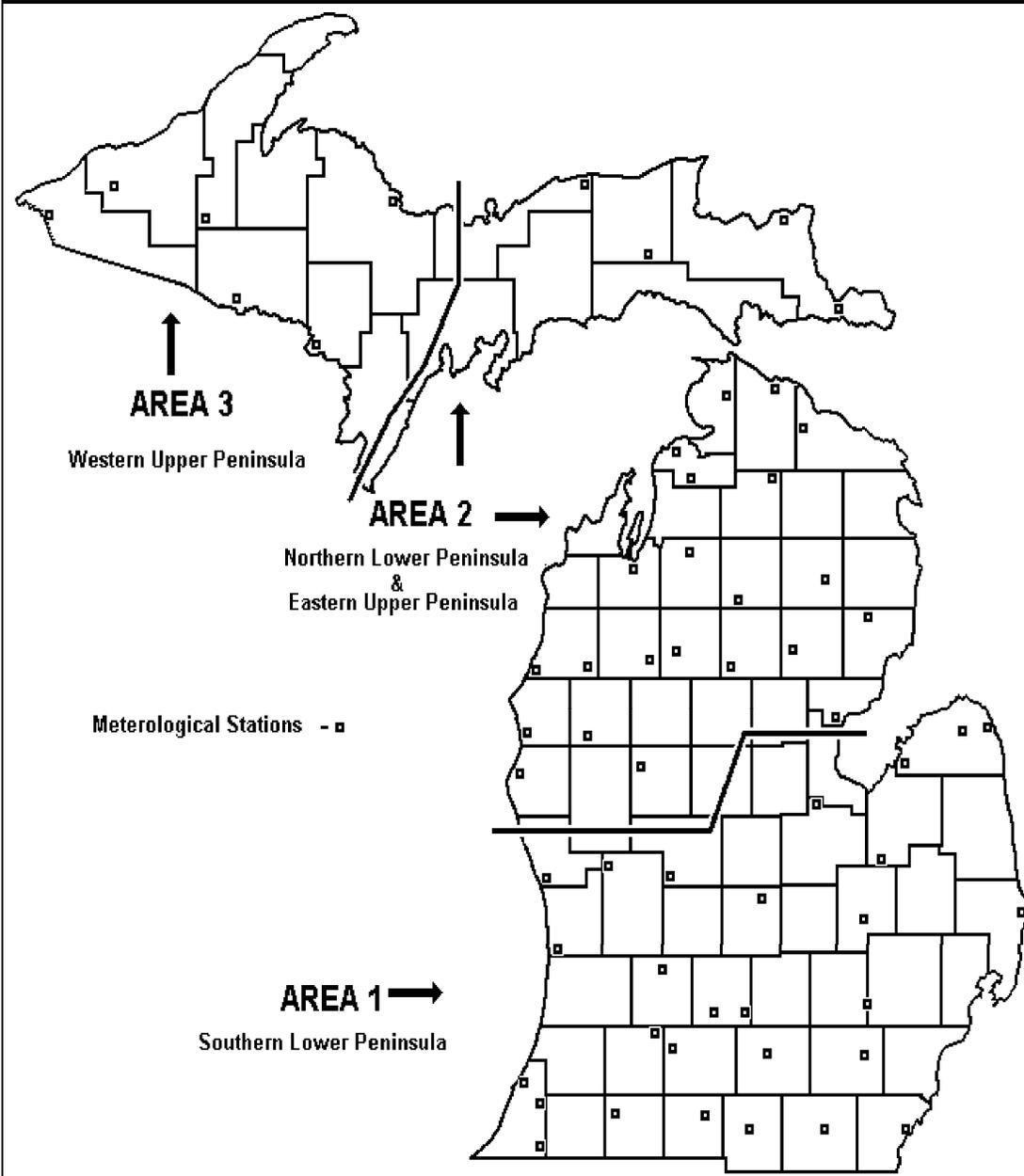
Michigan’s current climate may be broadly characterized as being dominated by three general weather patterns. The two most dominant patterns originate from west to north and from west to south, influencing weather in northern Michigan and southern Michigan, respectively. The approximate boundary or tension line between these areas runs along an east-west line at about the latitude of Bay City. In general, the southern Lower Peninsula is warmer with a long frost-free season, has more rain in the springtime, less rain in the fall, and more thunderstorms, tornadoes, hail, and freezing rain than the north. The climate of the northern Lower



Peninsula and eastern Upper Peninsula tends to be cooler with a shorter frost-free period, greater snowfall and influenced more by the presence of the bordering Great Lakes. A third weather pattern occurs in the western portion of the Upper Peninsula (Exhibit 62). Due in part to the generally higher elevations and more northerly location, cooler temperatures, severe thunderstorms and high winds are common.

The weather data referenced in this Biennial Report were obtained from the National Climatic Data Center. These data were initially compiled from 60 sites across the state and then aggregated to the three areas to be representative of the southern Lower Peninsula, the combined northern Lower and eastern Upper Peninsulas, and the western Upper Peninsula (Exhibit 62). Nine meteorological measurements (average annual temperature, average annual daily maximum temperature, average annual daily minimum temperature, average diurnal temperature, length of growing season, heating degree days, cooling degree days, total annual

Exhibit 62. Meteorological Station Locations in Michigan



located in large cities and additional rural stations only added gradually over time). To ensure that no seasonal bias was introduced into the analyses, only those sites having at least 50 percent statistically defensible data were included in the analysis. Consequently, it was determined that sufficient quality data only exist for all the Michigan climatic regions from 1949 to 2004 despite the fact some stations have data as far back as 1895. This verification was completed for each of the nine individual meteorological measurements.

Exhibits 63a to 63i present the nine meteorological measurements and trends for the southern Lower Peninsula, the combined northern Lower and eastern Upper Peninsulas, and the western Upper Peninsula. Based on a statistical analysis of these meteorological data, there is currently

precipitation, and total annual snowfall) are tracked and evaluated for each of the three Michigan areas.

During the development for this environmental measurement, a statistical analysis was conducted on the available climatological data. It was the initial intent to report climate data from 1895 to the present; however based on a statistical analysis of the data, such a report would not have been valid since the climate data collected from 1895 to 1948 carries with it a statistical sampling bias (due to the fact that most of the early sampling stations were

no compelling evidence to date to infer that Michigan's climate, although continuing to exhibit cyclic behavior, has changed significantly over the last 55 years. Michigan's meteorological measurements will continue to be collected and reported on in each subsequent Biennial Report.



Exhibit 63a. Meteorological Measurements 1949 - 2004

(Area 1- Average Annual Temperature)

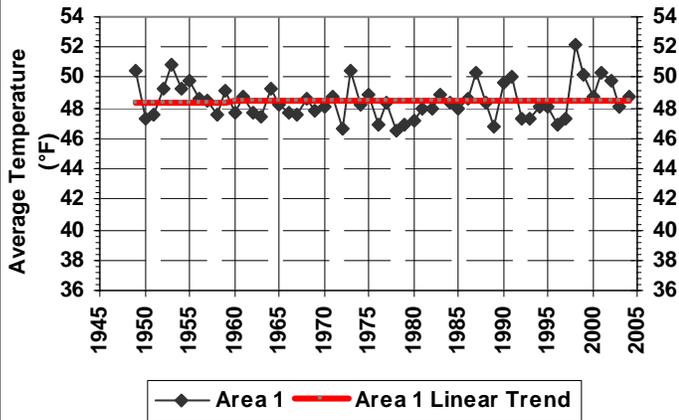


Exhibit 63b. Meteorological Measurements 1949 - 2004

(Area 1 - Average Annual Daily Maximum Temperature)

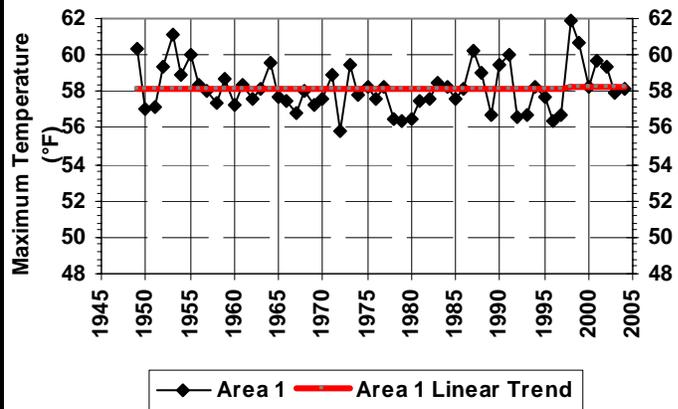


Exhibit 63a. Meteorological Measurements 1949 - 2004

(Area 2- Average Annual Temperature)

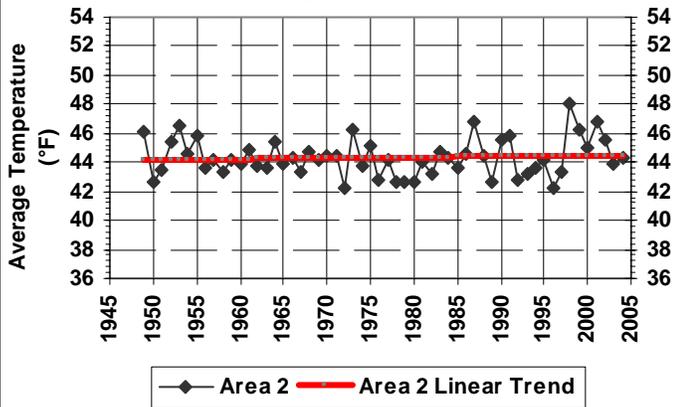


Exhibit 63b. Meteorological Measurements 1949 - 2004

(Area 3- Average Annual Daily Maximum Temperature)

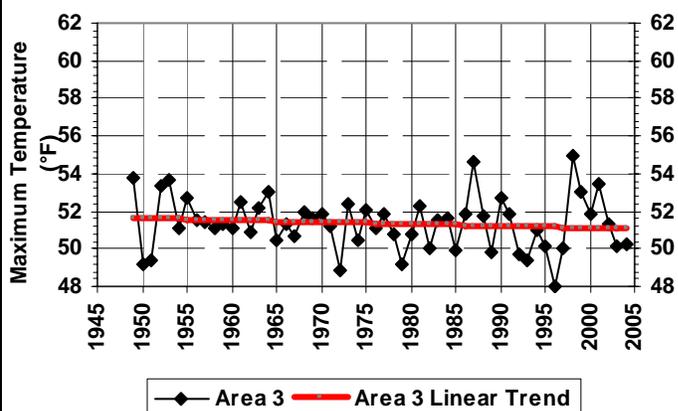


Exhibit 63a. Meteorological Measurements 1949 - 2004

(Area 3- Average Annual Temperature)

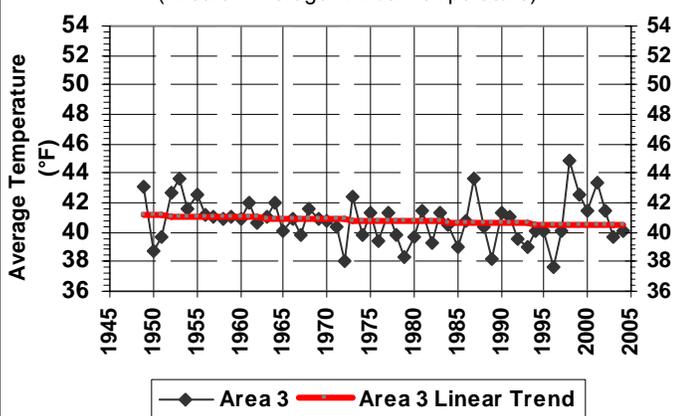
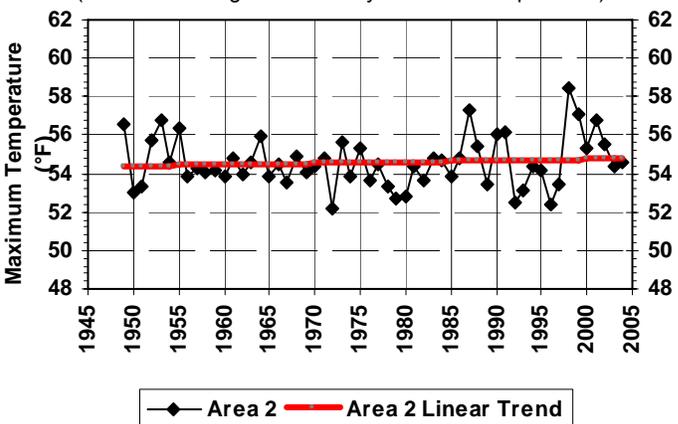
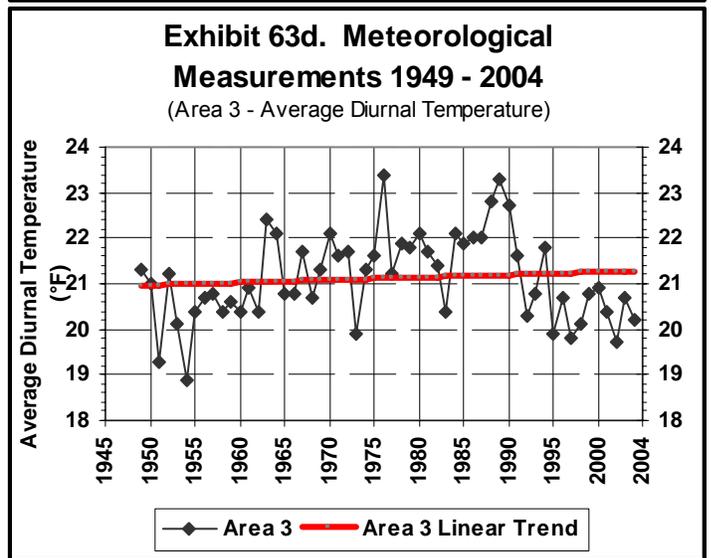
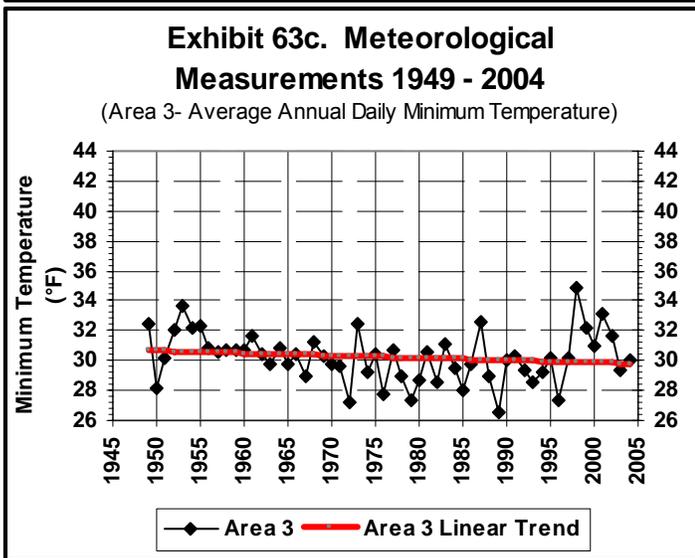
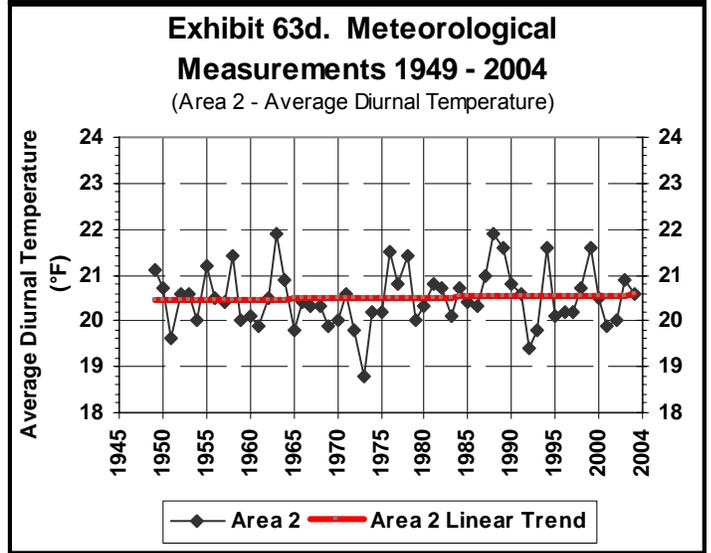
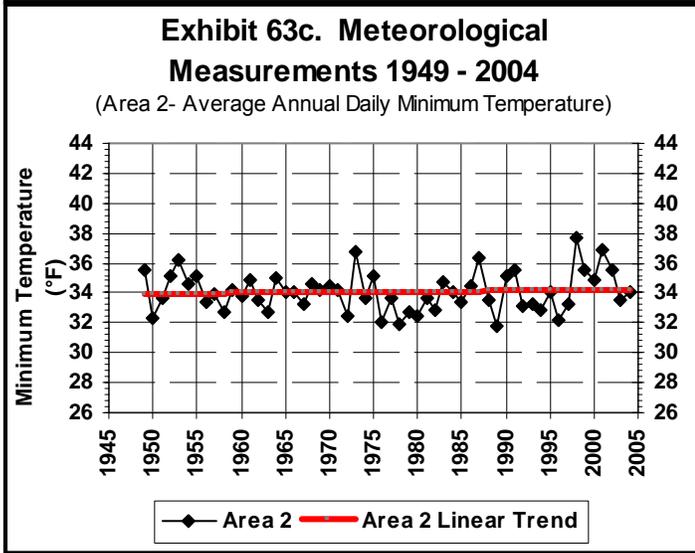
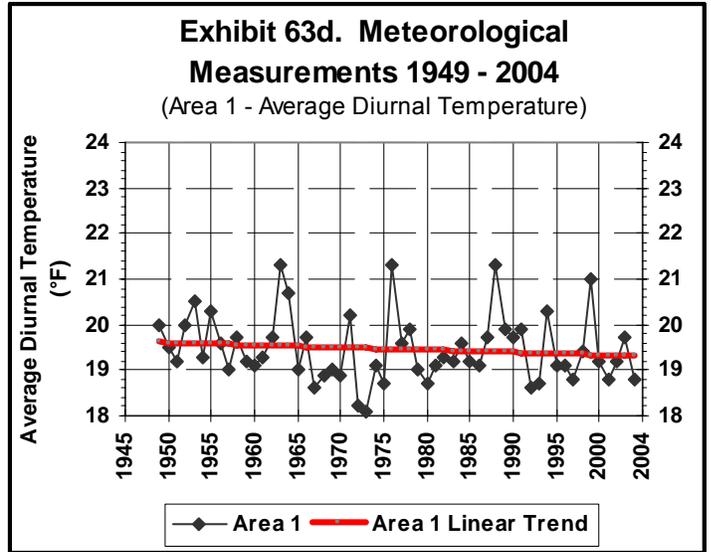
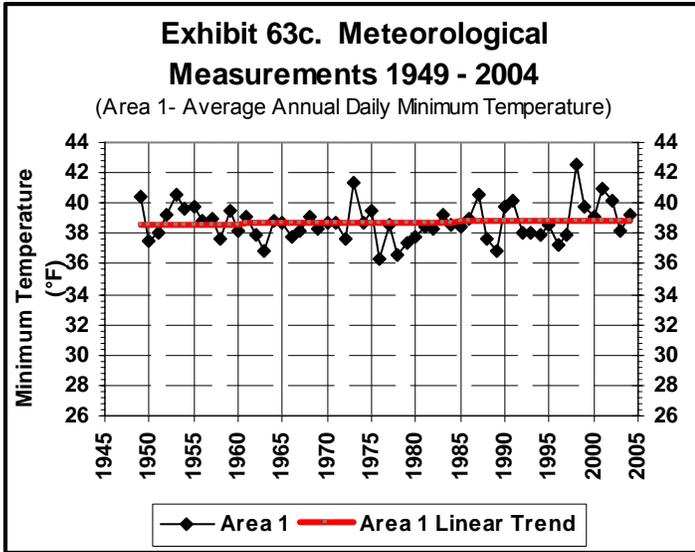
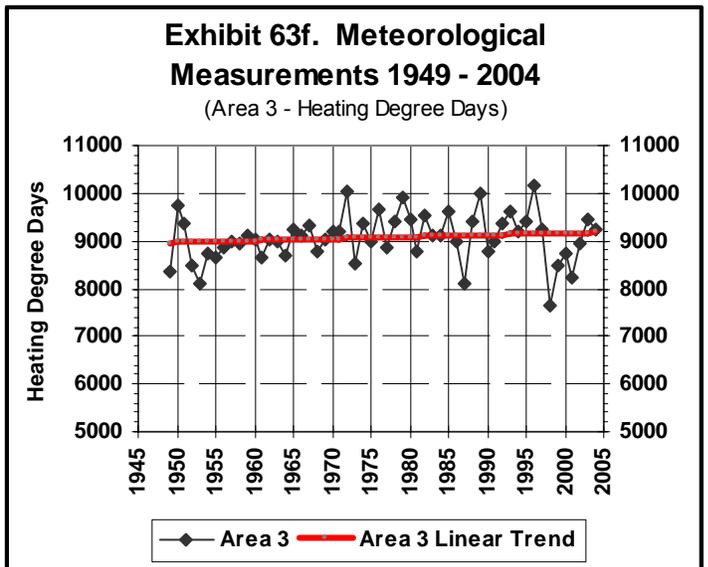
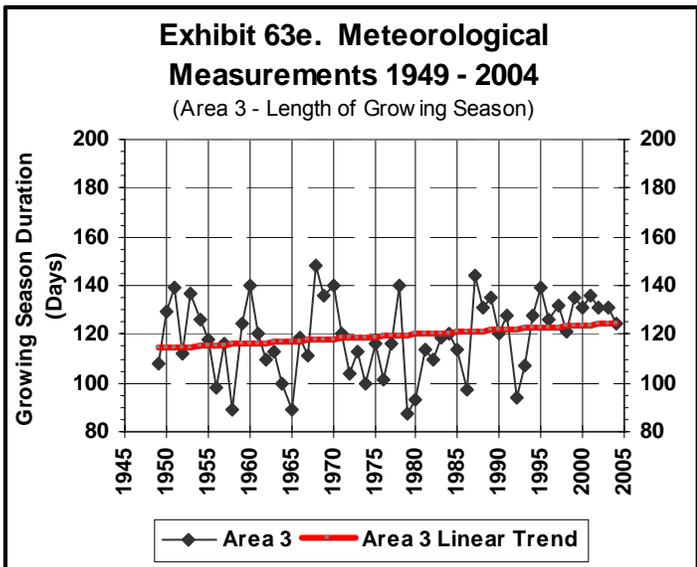
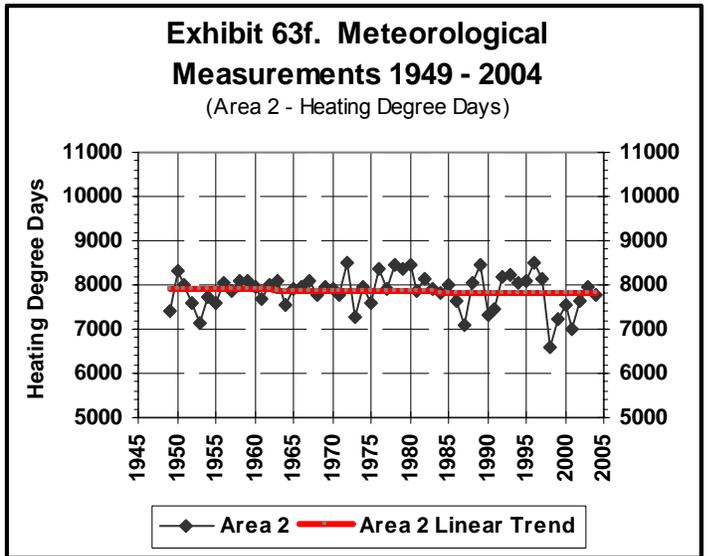
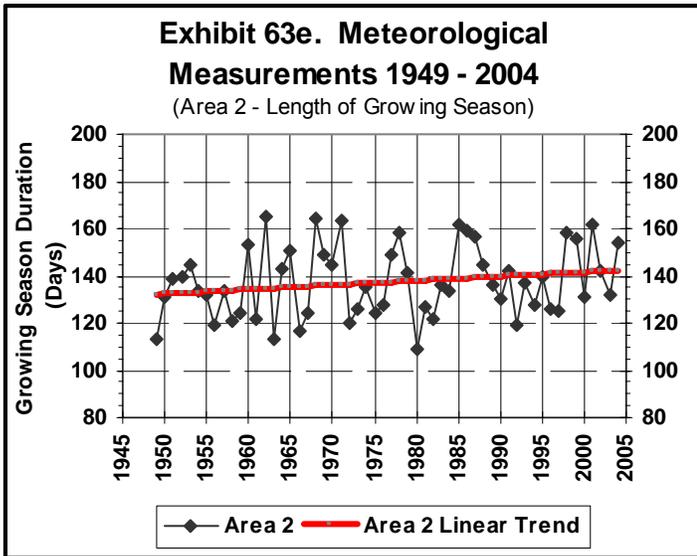
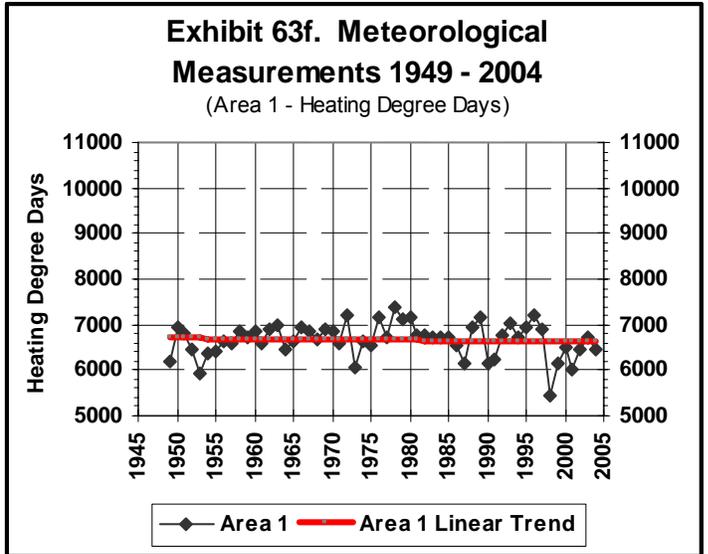
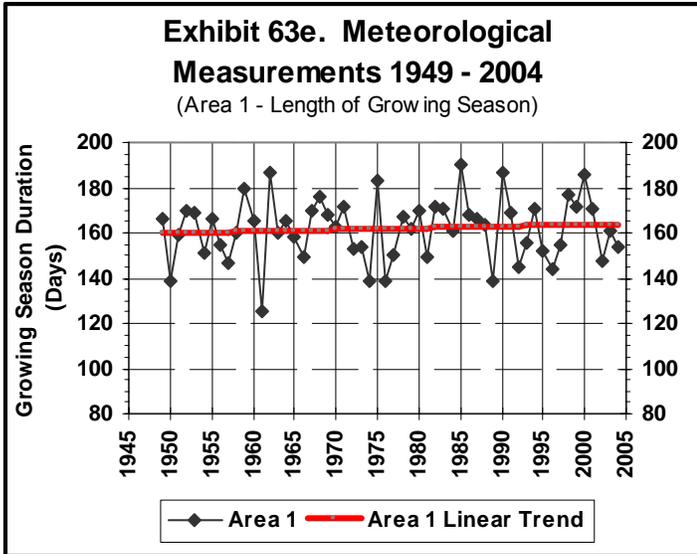


Exhibit 63b. Meteorological Measurements 1949 - 2004

(Area 2- Average Annual Daily Maximum Temperature)







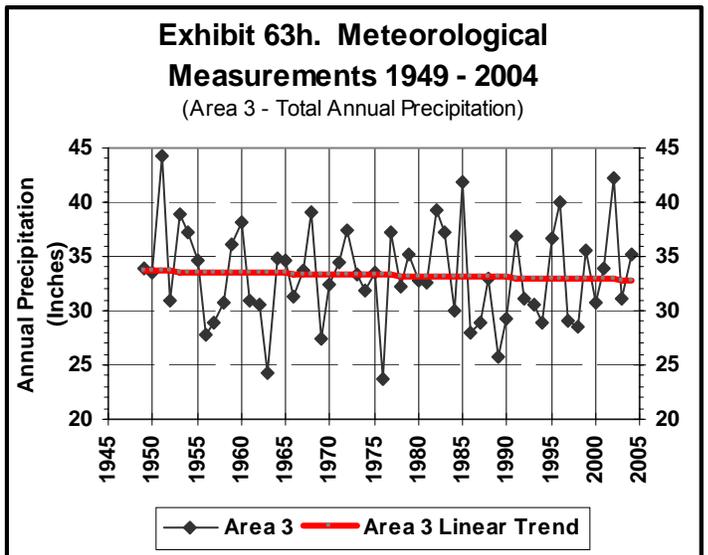
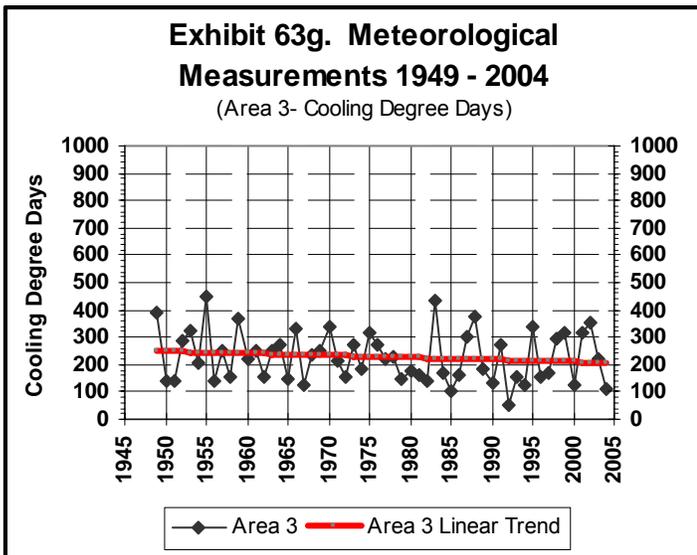
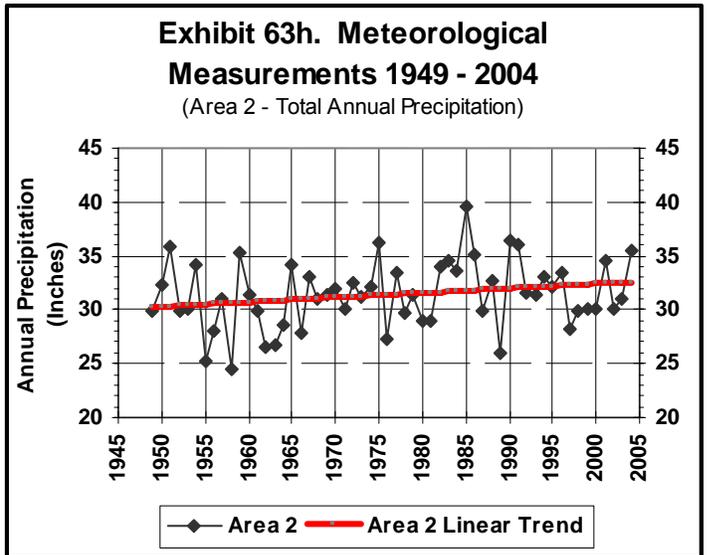
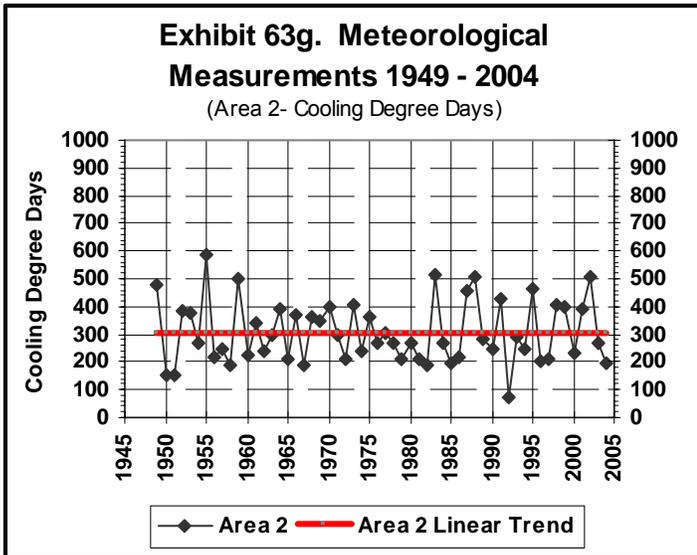
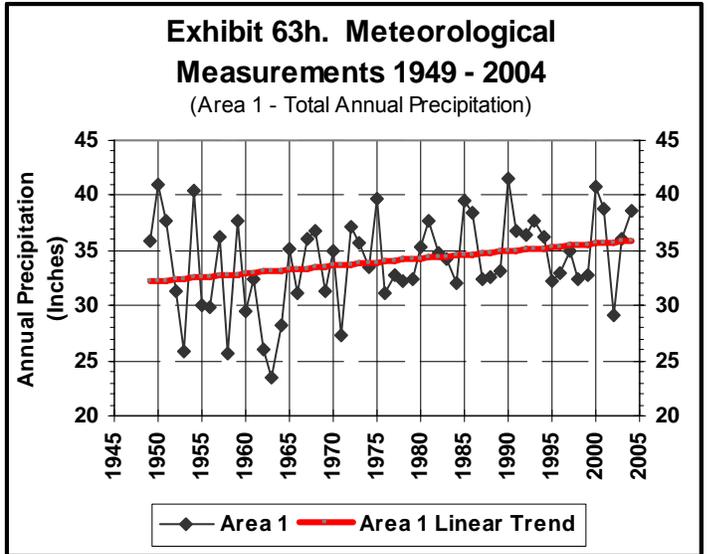
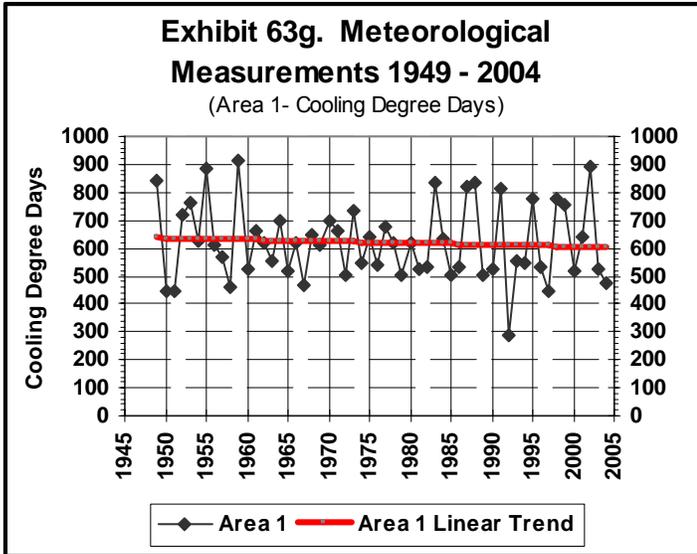


Exhibit 63i. Meteorological Measurements 1949 - 2004

(Area 1 - Total Annual Snowfall)

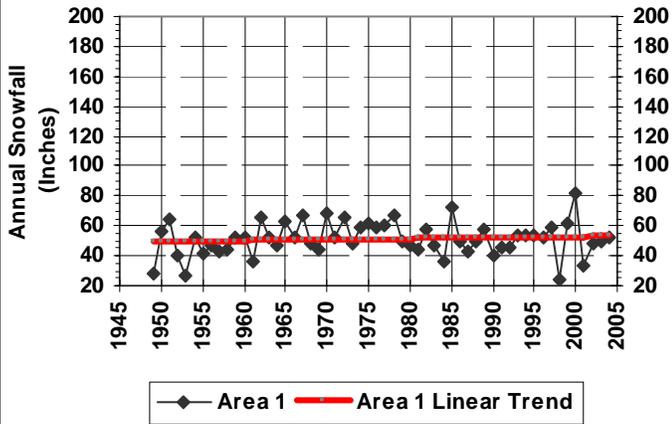


Exhibit 63i. Meteorological Measurements 1949 - 2004

(Area 2 - Total Annual Snowfall)

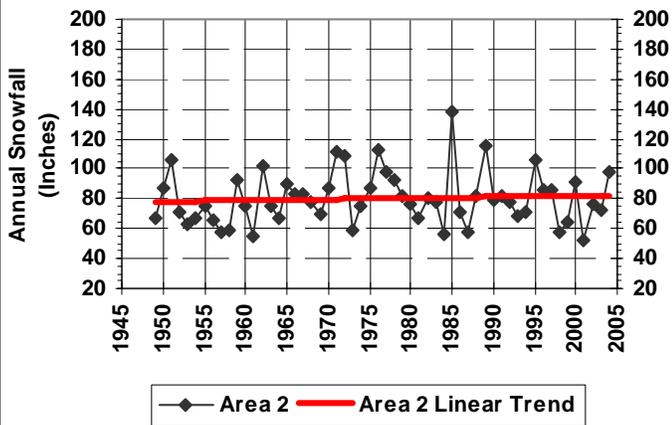
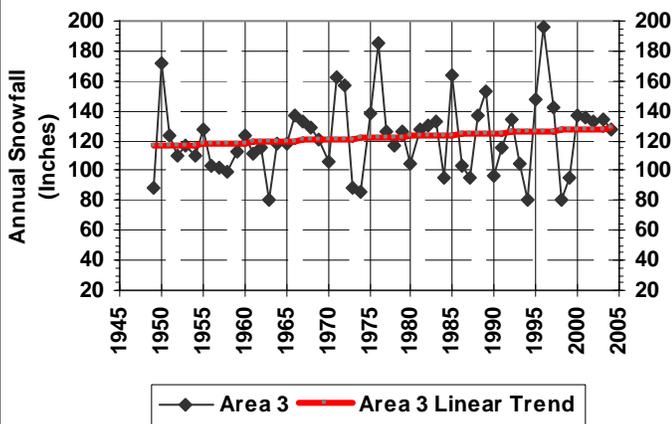
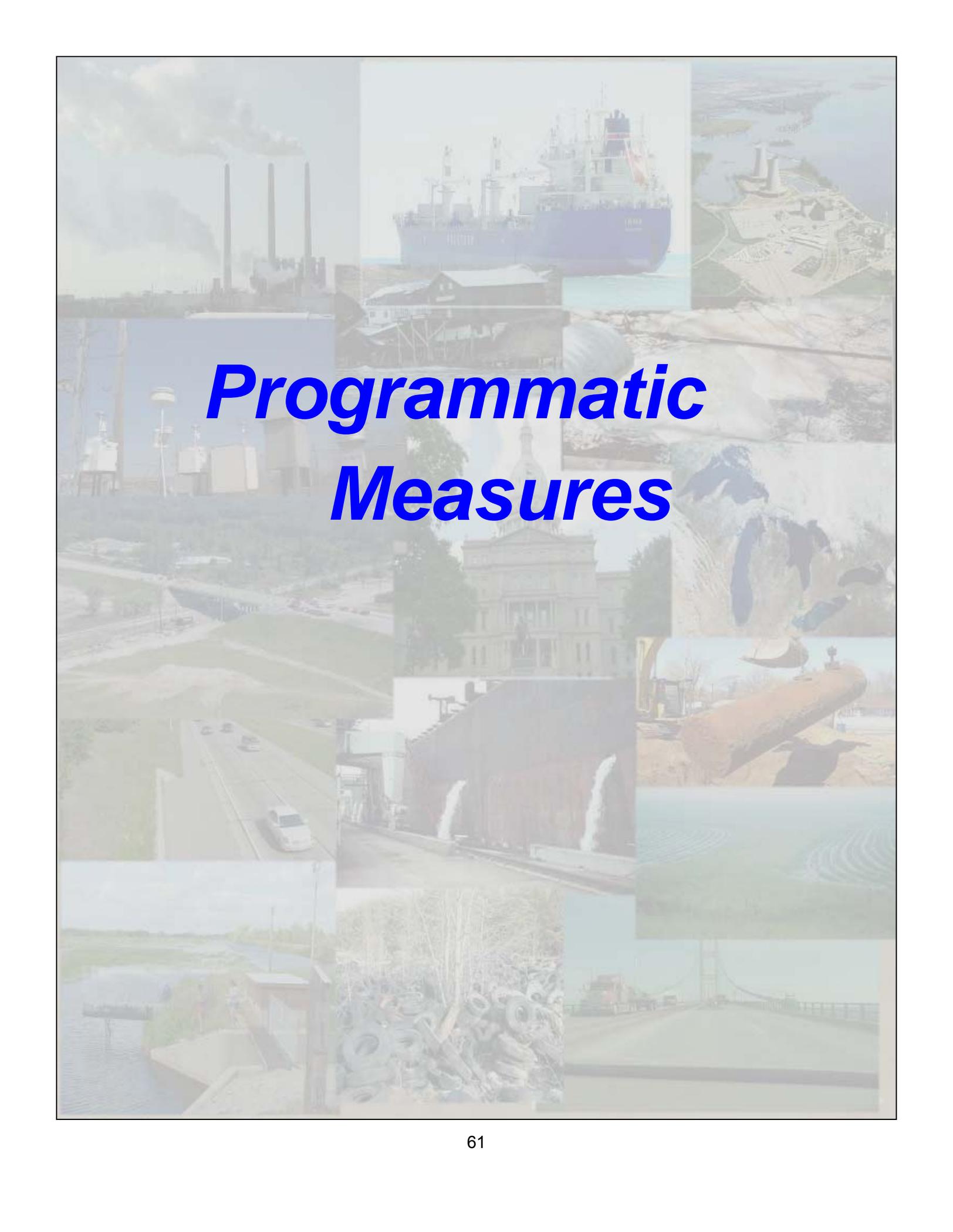


Exhibit 63i. Meteorological Measurements 1949 - 2004

(Area 3 - Total Annual Snowfall)





Programmatic Measures

Programmatic Measures

Air Quality

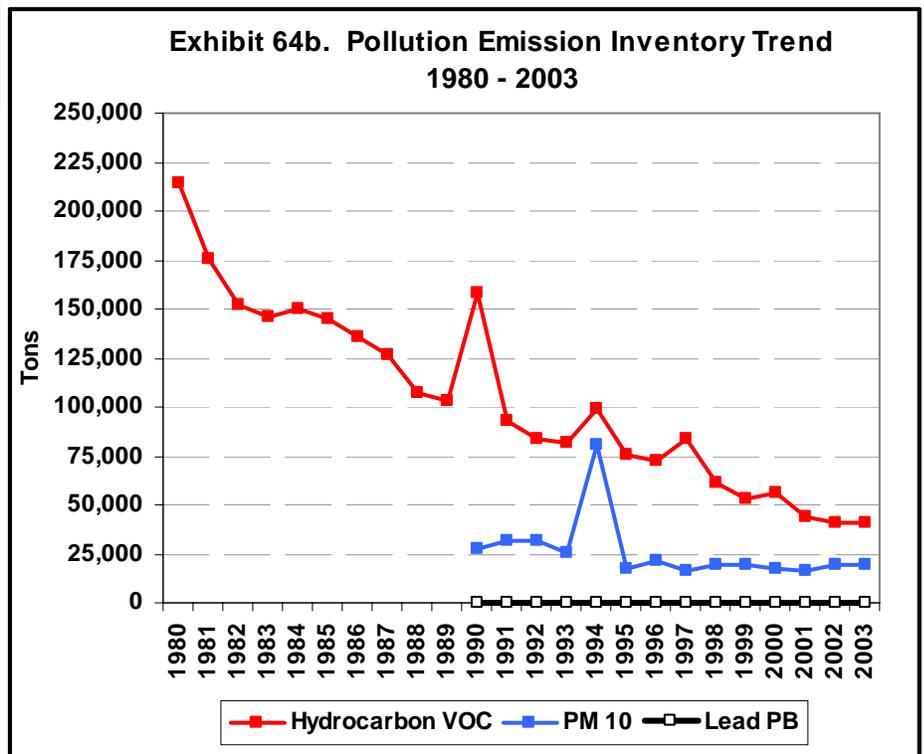
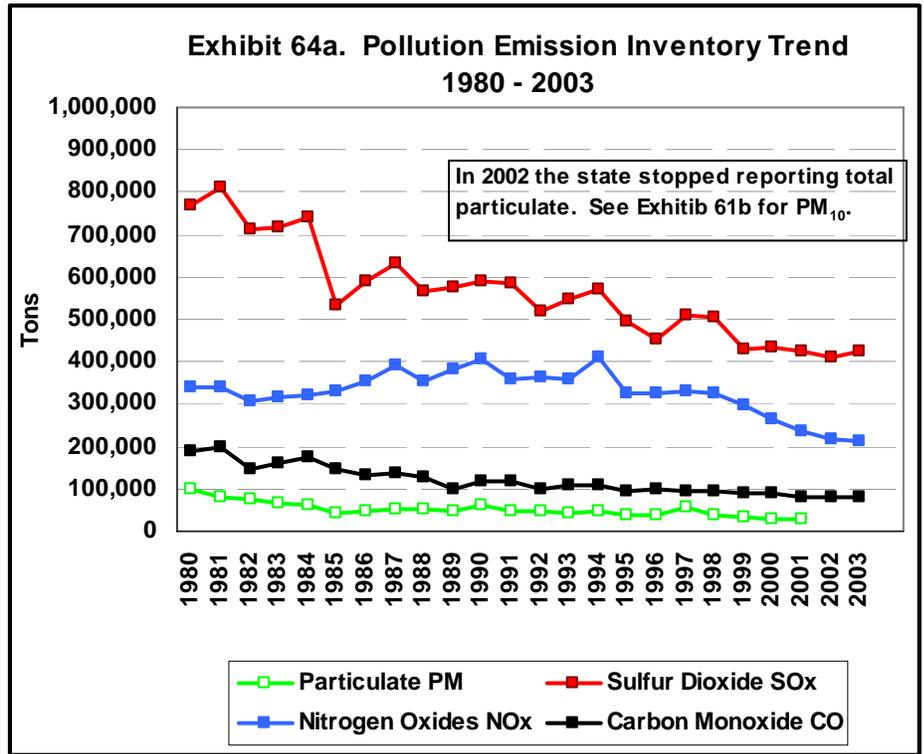
Air Emissions Estimates

The federal Clean Air Act requires states to prepare and maintain inventories of emissions from major pollutant sources. Emissions from large stationary sources are calculated for particulates, sulfur dioxide, nitrogen oxides, carbon



monoxide, volatile organic chemicals (VOCs), and lead. The MDEQ compiles information from over 1,800 facilities. In 2001, the USEPA required states to report PM₁₀ rather than total particulate matter when reporting to the USEPA. The MDEQ then began collecting PM₁₀ emissions data from stationary point source facilities that report annually and began estimating PM₁₀ emissions for all other source categories. Exhibits 64a and 64b presents a summary of this information for the six contaminants.

Air pollutant emission sources are categorized as mobile sources, large facility point sources, and area sources (small industries, boats, farm equipment, etc.). The relative percentage that these sources contributed to the overall emissions



of VOCs and nitrogen oxides is shown in Exhibits 65 and 66, respectively (based on 2002 emission

data, the latest available). Motor vehicles contributed 32 percent of the VOC emissions and 46 percent of the nitrogen oxides. Photochemical reactions between nitrogen oxides and VOCs form ground level ozone.

the combined greenhouse gases make up less than one percent of the chemical composition of the Earth's atmosphere. These gases are vital for life systems on Earth because they absorb and reemit the infrared radiation (felt as heat) that the Earth emits as a result of radioactive heating by

the sun. Without greenhouse gases in the atmosphere, the Earth's temperatures during nighttime hours would drop below a level that would allow for survival of terrestrial life.

The current concern of increased greenhouse gases and global climate change can be described as the *enhanced greenhouse gas effect* where due to the increased concentrations of CO₂, N₂O, CH₄, and other greenhouse gases, more heat is retained in the atmosphere. With greater heat energy in the atmosphere, dramatic changes are more likely to occur in the coming decades concerning the earth's global climate and oceanic circulation system.

In April 2005, the first inventory report of Michigan greenhouse gas emissions (*Michigan Greenhouse Gas Inventory 1990 and 2002*) (Inventory Report) was released. The Inventory Report provides estimates of anthropogenic (human-caused) greenhouse gas emission sources and sinks in Michigan in 1990 and 2002. The purpose of the inventory is to establish an emissions baseline and begin to look at trends across economic sectors within the state. The Inventory Report estimated that total greenhouse gas emissions in Michigan during 2002 amounted to 62.59 million metric tons carbon equivalent (MMTCE)

(Exhibit 67). This amounted to a nine percent increase over the 1990 emissions baseline of 57.42 MMTCE.

Carbon dioxide is the dominate greenhouse gas emission in Michigan, accounting for 87 percent of

Exhibit 65. Estimated Levels of Volatile Organic Compound Emissions by Source Category

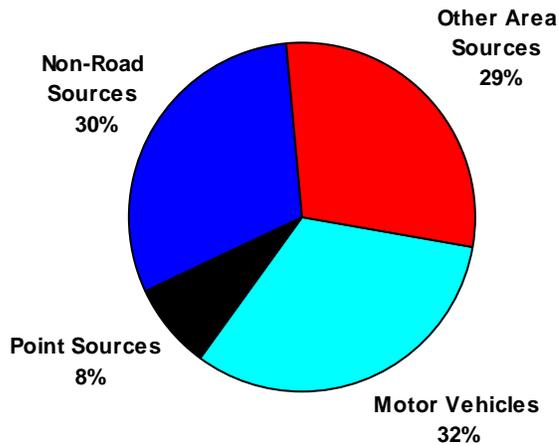
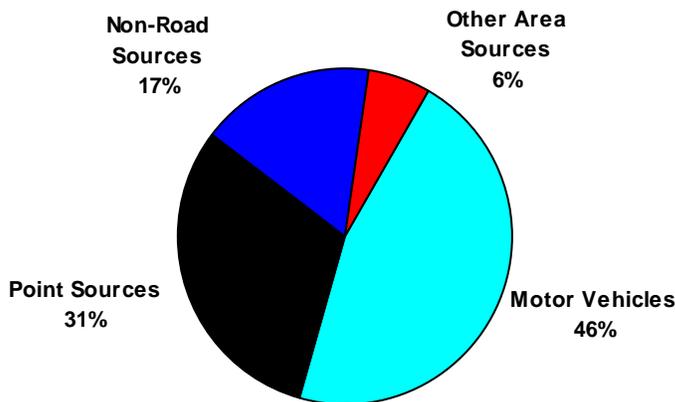


Exhibit 66. Estimated Levels of Nitrogen Oxides Emissions by Source Category



Greenhouse Gas Emissions Inventory

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Excluding water vapor,

Exhibit 67. Summary of Estimated Michigan Greenhouse Gas Emissions and Sinks (Excluding Forestry) 1990 and 2002

Gas/Activity	Million Metric Tons Carbon Equivalent 1990	Million Metric Tons Carbon Equivalent 2002
Carbon Dioxide	49.58	54.15
Methane	5.16	5.18
Nitrous Oxide	2.12	2.13
Hydrofluorocarbons, Perfluorocarbons, and Sulfur Hexafluoride	0.30	1.13
Total	7.42	62.59
Net Emissions (Sources & Sinks ⁽¹⁾)	57.07	62.48

1. Sinks are calculated as 0.35 and 0.11 Million Metric Ton Carbon Equivalent for 1990 and 2002, respectively, and are included in the "Net Emissions (Sources and Sinks) values.

all the estimated greenhouse gas emissions in 2002. Electricity generation, the largest contributor, accounted for 33 percent of the total emissions in 2002 (Exhibit 68). The transportation sector was the second largest contributor. Additional information on the inventory can be found on the MDEQ's Internet site (www.michigan.gov/deqair).

Planning and Community Right-to-Know Act of 1986. Under this law, facilities in designated industrial sectors are required to report their process-related releases to air and other media and wastes of specific toxic chemicals. Only facilities that exceed activity thresholds for manufacturing, processing, or otherwise use of chemicals on the registry are required to report.

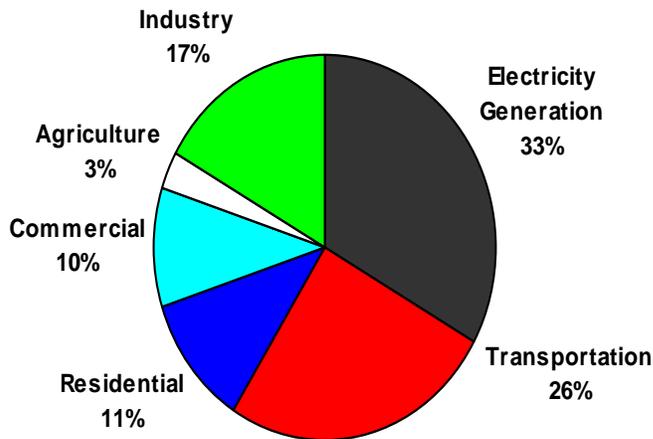
Reports must be sent to the state and the USEPA, which compiles the information into the Toxics Chemical Release Inventory and makes it available to the public.

The air Toxics Chemical Release Inventory information frequently is used to provide trends on particular media releases because of its availability and its longevity. For 2003, reported air releases in the state totaled 50 million pounds, which is a decrease of nine percent compared to 2002. Exhibit 69 shows a steady decline in statewide air releases since 1999.

The Toxics Chemical Release Inventory information presented in this Biennial Report is a statewide total of the data for specific

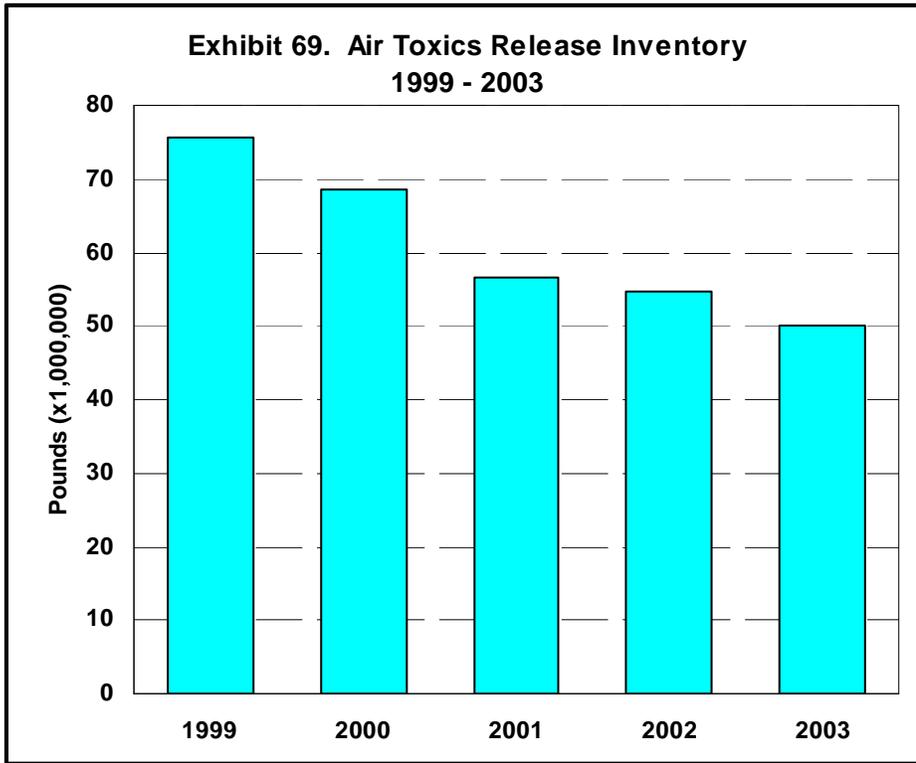
reporting years and does not indicate upward or downward trends for individual pollutants or facilities. Caution also must be used with this measurement because the values are

Exhibit 68. Distribution of Michigan Greenhouse Gas Emissions by Economic Sector 2002



Air Toxics Release Inventory

Air releases of toxic chemicals are reported annually as required by the federal Emergency

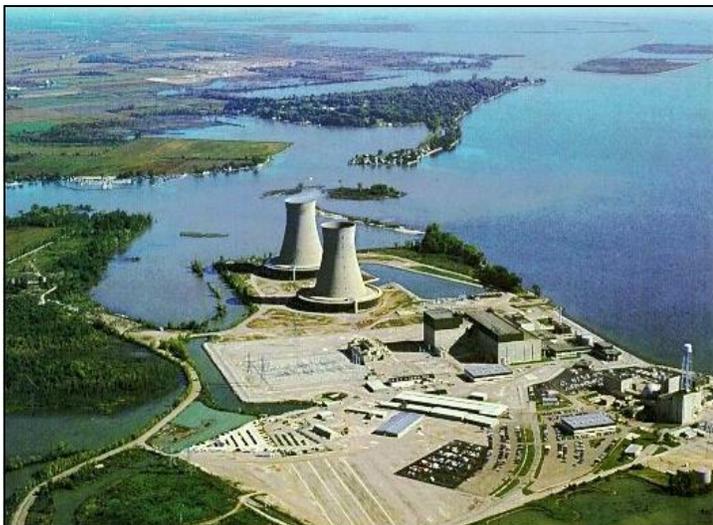


Baseline radiological data for the four nuclear power plant sites in Michigan (Enrico Fermi, Big Rock Point, Palisades, and D.C. Cook) were established a minimum of one to three years prior to plant operation, which dates back to 1958 for the Enrico Fermi Nuclear Plant site. To date, off-site environmental impacts attributable to the operation of nuclear power plants in Michigan have not been detected. The data monitored by the MDEQ include radioactivity in air particulates, radioactivity in milk, and, as discussed later in this report, radioactivity in surface waters. Annual reports on the overall quality of the radiological environment may be obtained by contacting the MDEQ.

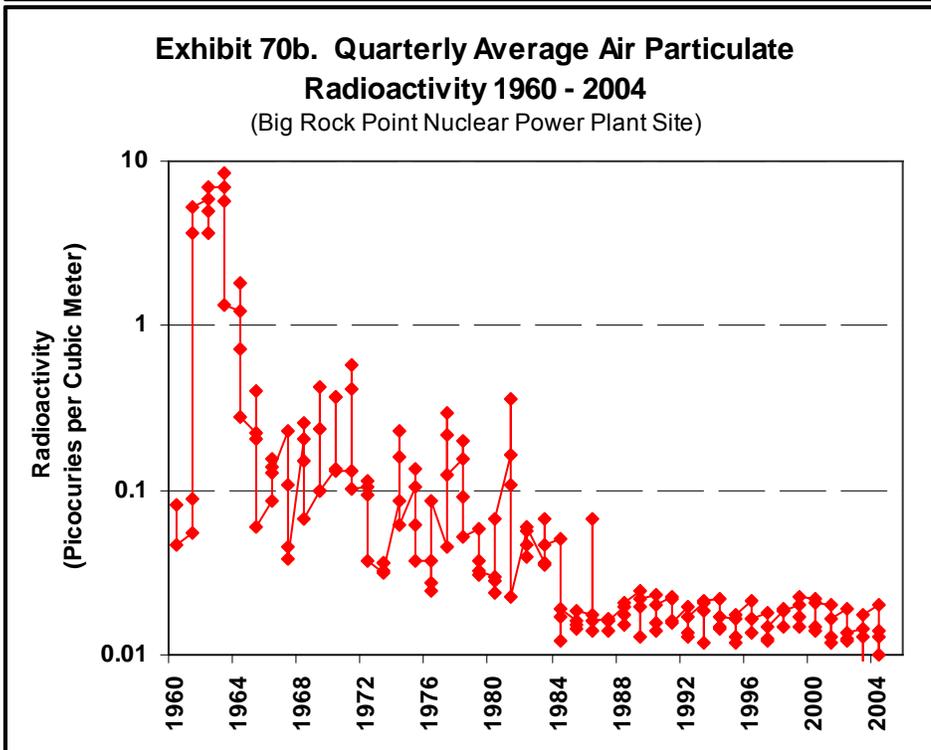
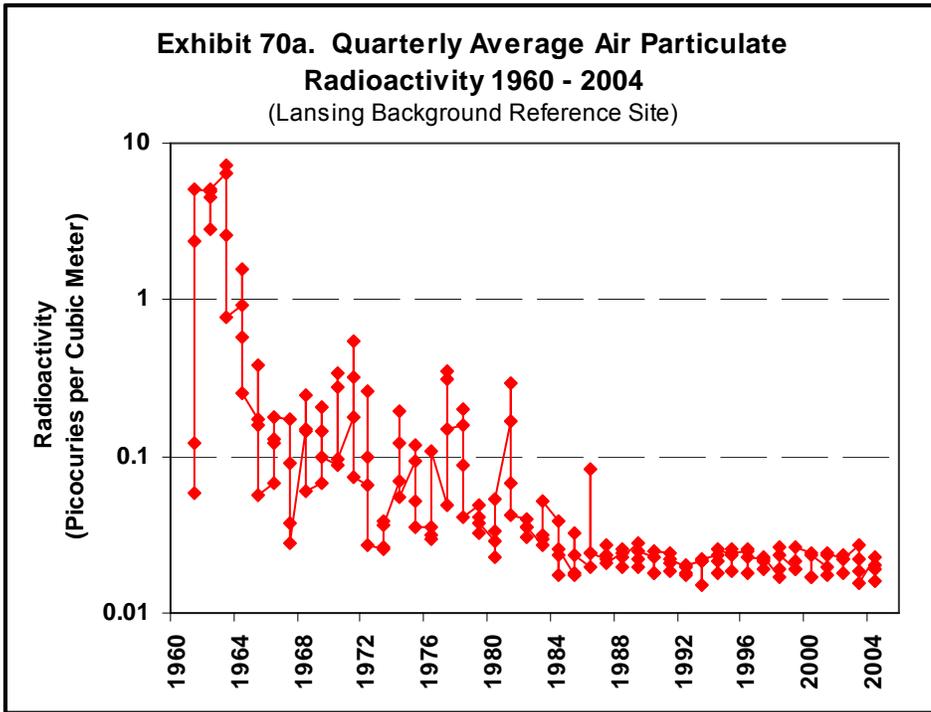
self-reported, may be estimates rather than actual measurements, and are not inclusive of all Michigan industries. Air toxics release data cannot be used to infer relative risks, absolute risks, or temporal trends for risk. Additional information on individual chemicals and facilities, including historical information is available on the MDEQ Internet site (www.michigan.gov/deq/sara).

Air Radiation Monitoring

The MDEQ is responsible for monitoring the potential for environmental impact due to the operation of nuclear power plants in Michigan.



Since the inception of the program in the early 1980s, a general trend of decreasing levels of radioactive fallout from atmospheric testing of nuclear weapons has been observed, with the radioactivity associated with air particulates. A brief exception to this downward trend was observed in 1986 as a result of radioactive fallout from the Chernobyl Nuclear Power Plant accident in the former Soviet Union. Since 1986, the quarterly radioactivity levels associated with air particulates have returned to natural radiation background levels of 0.01 to 0.03 picocuries per cubic meter. A level of concern would be a quarterly average exceeding one picocurie per



monitoring locations demonstrate that radioactivity levels have continued to remain at natural background levels.

The MDEQ also monitors the level of radioactivity found in milk in order to assess the potential impact of radioactivity on the environment and human food chain. The radioactivity is characterized by determining the level of a radioactive isotope of cesium (cesium-137). Cesium-137 is a radionuclide resulting from nuclear fission. It is highly suitable for this measurement since its chemical behavior is similar to that of potassium.

Exhibits 71a and 71b present radioactivity measurements taken from the Monroe and Lansing Milk Stations, respectively, which are representative of other milk monitoring locations in the state. Over the past 20 to 25 years, cesium-137 annual averages have remained below minimum detectable activity levels. Prior to 1980, but especially during the early 1960s, radioactivity levels in milk were significantly higher due to atmospheric nuclear testing. A level of concern would be an annual average exceeding 20 picocuries per liter.

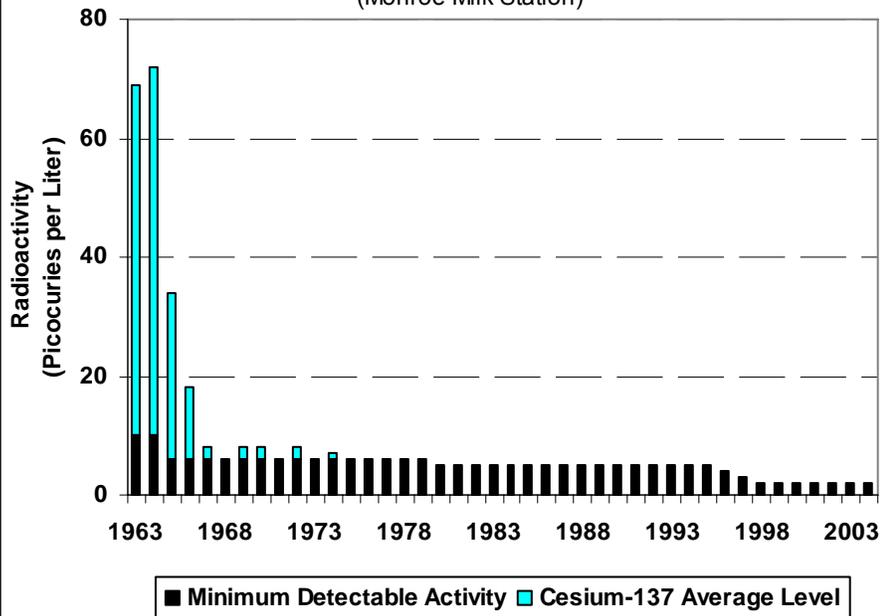
Water Quality

Combined, Sanitary, and Storm Water Sewer Systems

cubic meter or several consecutive quarters exceeding 0.1 picocurie per cubic meter. A total of five sites are monitored throughout the state. Exhibits 70a and 70b present measurements for the Lansing Background Reference and the Big Rock Nuclear Power Plant sites, respectively, and may be considered representative for the other three monitoring locations. Data for 2004 from the

Over the years, the MDEQ has worked closely with municipalities to eliminate untreated sewage discharges from combined, sanitary, and storm water sewer systems. As a result, all cities have either corrected their combined sewer overflow problems or have an approved program in place that will lead to adequate control. Additionally, the MDEQ has worked with municipalities and

Exhibit 71a. Annual Average Cesium-137 Radioactivity in Milk 1963 - 2004
(Monroe Milk Station)



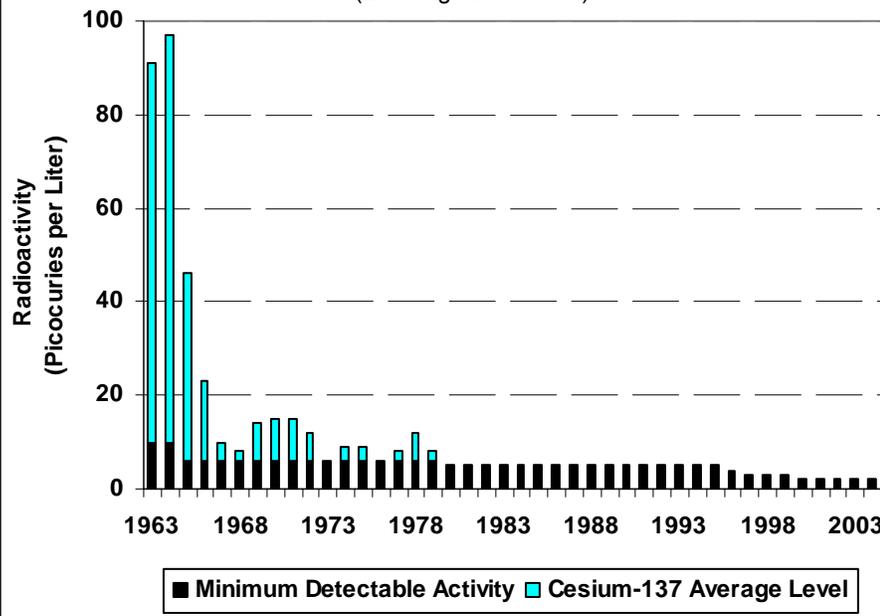
Sanitary sewer overflows are discharges of untreated or partially treated sewage from municipal sanitary sewer systems. These systems are designed to carry domestic sewage, but not storm water. When a sanitary sewer overflow occurs, untreated or partially treated sewage is released into city streets and low land areas, including, in some cases, parks and other areas of public contact and surface waters, such as drainage ways, streams, and lakes, rather than being transported to a treatment facility. Sanitary sewer overflows are illegal and can constitute a serious environmental and public health threat.

Additional health threats occur when sewage from a public sewer system backs up into structures, such as residential basements, as a result of excess wet weather flow in the sewer system. Other sewer system deficiencies, such as mechanical or electrical failures at pump stations or structural failure of sewers due to age or accidents, also can result in discharges threatening the environment and public health.

In 1999 and early 2000, the MDEQ identified municipalities throughout the state that experienced discharges of sanitary sewage into waters of the state. In May 2000, the MDEQ announced a statewide strategy to identify and correct the discharge of untreated or inadequately treated sanitary sewage. The strategy emphasized the implementation of corrective action programs for those

municipalities identified as a sanitary sewer overflow community with the goals of eliminating illegal sanitary sewer overflows and preventing new ones from occurring. In December 2002, the MDEQ adopted a statewide sanitary sewer overflow policy statement for implementation to accomplish these goals.

Exhibit 71b. Annual Average Cesium-137 Radioactivity in Milk 1963 - 2004
(Lansing Milk Station)



industrial facilities to minimize the discharge of pollutants to surface water from storm water discharges. Both of these efforts have resulted in a continued reduction of nutrients, biological, heavy metal, and industrial pollutants to the waters of the state.



The MDEQ is keeping the public informed of the identified overflows in their communities by posting on the Internet a listing of untreated or partially treated sewage discharges and the waters to which the discharge occurs as the reports are received. The reporting of the discharge of untreated or partially treated sewage and the public posting are required by state statute.

Dischargers also are required to promptly notify local county health departments, potentially impacted neighboring municipalities, and the local media of such incidents. The MDEQ is taking actions to establish immediate control measures, where necessary, and require corrective action programs to eliminate illegal sewer discharges. An annual report of the discharge of untreated or partially treated sewage identifying the quantity of sewage discharge reported, and the corrective programs being undertaken is available on the MDEQ's Internet site (www.michigan.gov/deq).

Surface Water and Beach Monitoring

All of Michigan's surface waters are designated and protected for total body contact recreation (swimming) from May 1 to October 31. In Michigan, a water body is considered suitable for total body contact recreation when the number of the indicator bacteria, *Escherichia coli* (*E. coli*), per 100 milliliters of water is less than or equal to 130, as a 30-day average. The MDEQ works in partnership with local county health departments and other local entities to ensure that Michigan's surface waters are monitored for *E. coli* and protected for total body contact recreation.

Several activities have been initiated through this partnership, including:

1. The award of 19 grants totaling \$244,873 in 2004 and the award of 21 grants totaling \$278,158 in 2005 to support *E. coli* monitoring at public beaches located along the Great Lakes shoreline. These grants, awarded by the MDEQ with federal funds, provided assistance to effectively monitor 216 public beaches for *E. coli* in 33 counties in 2004 and 36 counties in 2005. Additional public beach monitoring grants are expected to be awarded to local entities in future years;
2. The award of eight grants totaling \$61,882 in 2004 will support *E. coli* monitoring at public beaches located on inland lakes. These grants, awarded by the MDEQ with CMI Fund and Clean Water Fund (CWF) monies, provided assistance to effectively monitor 173 public beaches in 26 counties in 2004 for *E. coli*. Additional public beach monitoring grants will be awarded to local entities in 2005 and future years; and



3. The award of \$2.6 million in grants to nine local entities from 2001 – 2004 to identify and require the correction of illicit connections to separate storm sewer systems. These grants will be completed in 2005. Additional illicit connection correction grants are expected to be awarded in future years.



unsafe for swimming.

In 2003, there were 4,105 daily mean *E. coli* samples reported in the beach monitoring database for 321 public beaches located in 38 counties. Of these samples, 121 daily means for 73 beaches exceeded the water quality standard of 300 *E. coli* per 100 ml (daily standard). In 2004, there were 6,486 daily mean *E. coli* samples reported in the beach monitoring database for 488 public beaches located in 53 counties. Of these samples, 201 daily means for 119 beaches exceeded the water quality standard of 300 *E. coli* per 100 ml (daily standard). In summary, for both 2003 and 2004, three percent of the daily mean samples exceeded water quality standards and 24 percent of the monitored beaches reported at least one exceedance (Exhibit 72).

Conservation Reserve Enhancement Program

The MDEQ has been working closely with the MDA to implement a federal-state-local conservation partnership program, referred to as the *Conservation Reserve Enhancement Program* (CREP), to reduce significant environmental effects related to agriculture. Michigan is implementing conservation practices under the CREP in three critical watersheds (Saginaw Bay, Macatawa, and River Raisin) that have intense agricultural land use. The objectives of the program are to improve and protect water quality and to promote and enhance wildlife habitat by providing incentives to Michigan citizens for

In addition, the MDEQ monitors Michigan's surface waters for *E. coli* contamination as part of the five-year rotating basin schedule. Water bodies determined to be in nonattainment of the *E. coli* standard are scheduled for corrective action through the MDEQ's *Total Maximum Daily Load (TMDL) Development and Implementation Program*. There are 78 streams, lakes, or beaches listed for pathogen exceedances. Currently, the MDEQ is developing *E. coli* TMDLs on eight water bodies. In 2005, approximately 5,600 water samples will be collected from selected surface water sites and analyzed for *E. coli* to support the TMDL development efforts. The MDEQ has a Beach Monitoring Internet site (www.deq.state.mi.us/beach/) where county health departments can post *E. coli* data and notify the public immediately when the water at a beach is

Exhibit 72. Summary of *Escherichia coli* Beach Monitoring Program 2003 and 2004

Description	2003	2004
Number of Counties with Beach Monitoring Programs	38	53
Number of Daily Mean <i>Escherichia coli</i> Samples Collected	4,105	6,486
Number of Samples that Exceeded the Daily Standard	121	201
Percent of Samples that Exceeded the Daily Standard	3	3
Number of Beaches with <i>Escherichia coli</i> Samples Collected	321	488
Number Beaches with Samples that Exceeded the Daily Standard	73	119
Percent of Beaches with Samples that Exceeded the Daily Standard	23	24

implementing conservation practices for a period of 15 years. Eligible conservation practices include filter strips, riparian buffer strips, field windbreaks, and wetland restorations. The MDEQ



has agreed to supply CMI-CWF monies and CMI-Nonpoint Source (NPS) Pollution Control funds for the establishment of a livestock exclusion program, cost share for the implementation of Natural Resources Conservation Service approved conservation practices, technical assistance from conservation districts in the CREP watersheds, and permanent conservation easements.

There are currently over 58,000 acres of conservation practices that are either under contract or pending in Michigan. With recently secured CMI-NPS funds, Michigan will reach 80,000 acres of CREP practices in the three watersheds. Over \$7.5 million in CMI funds are being utilized to acquire permanent conservation easements on over 4,000 acres of the CREP practices, with nearly 450 acres currently under permanent conservation easements. The success of the CREP will be measured in reduced sediment, phosphorus, nitrogen, pesticide, and pathogen inputs to surface waters resulting in improved

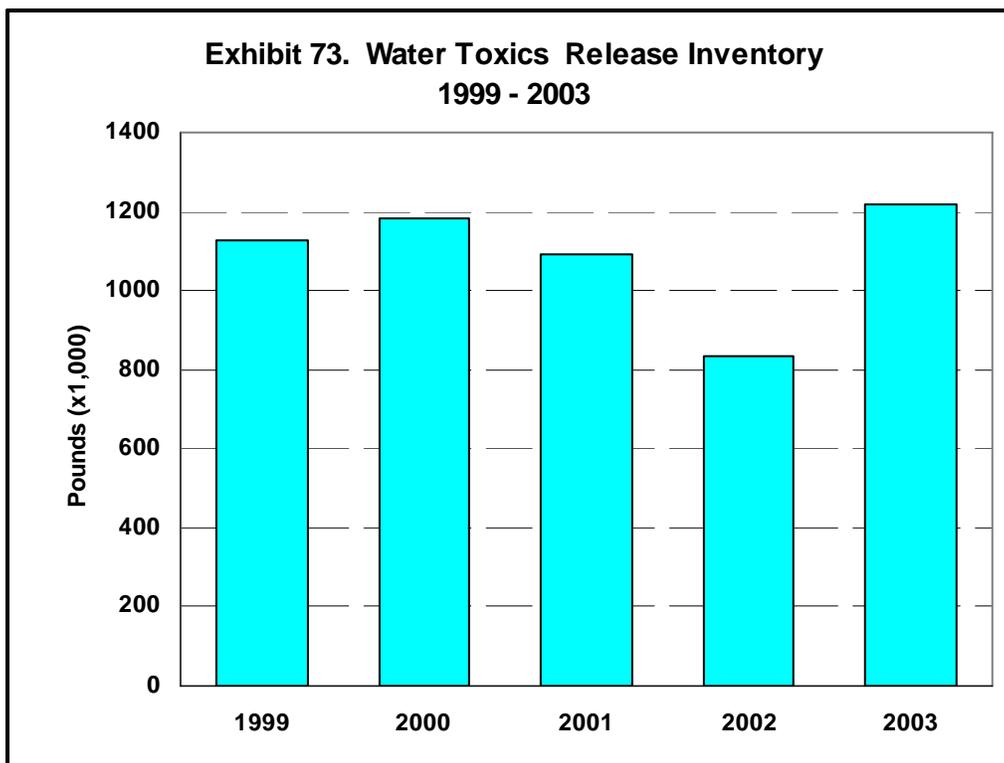
water quality in Michigan. Additional information will be available on the progress of this initiative in the 2007 Biennial Report.

Water Toxics Release Inventory

The federal Emergency Planning and Community Right-to-Know Act of 1986 requires facilities in designated industrial sectors to annually report their process-related releases of specific toxic chemicals to surface waters and other media. Only those water facilities that exceed activity thresholds for manufacturing, processing, or otherwise use of chemicals on the registry are required to report. Reports must be sent to the state and the USEPA, which compiles the information into the Toxics Chemical Release Inventory and makes it available to the public.

The water Toxics Chemical Release Inventory information frequently is used to provide trends on particular media releases because of its availability and its longevity. For 2003, releases of toxic chemicals to surface waters in the state totaled 1.2 million pounds compared to 832,000 pounds reported for 2002. Exhibit 73 shows statewide water releases since 1999.

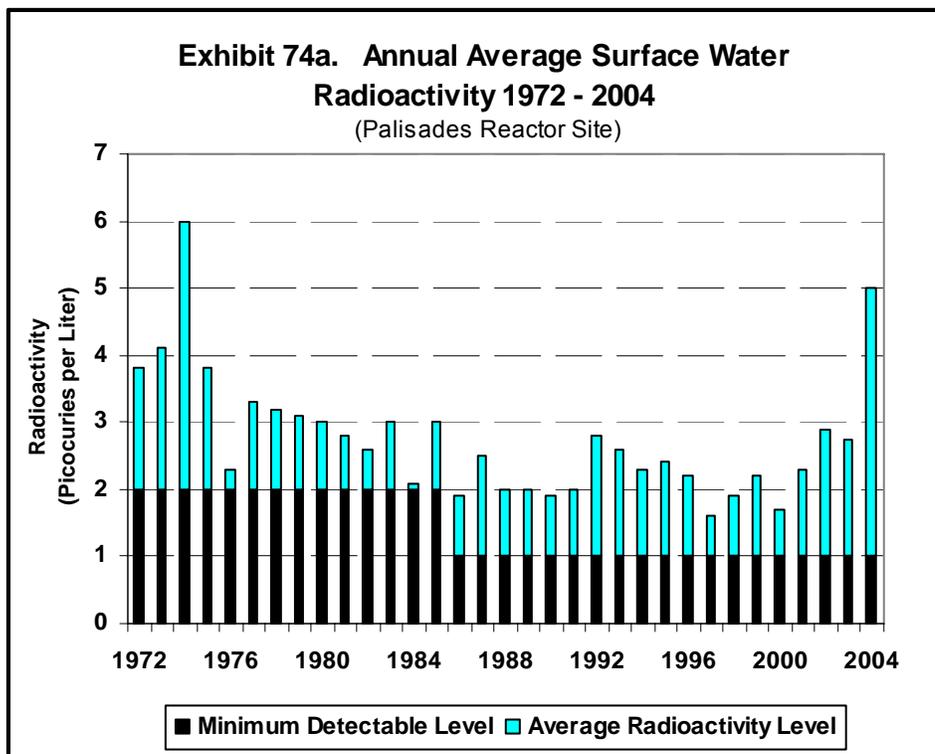
The Toxics Chemical Release Inventory information presented in this Biennial Report is a



statewide total of the data for specific reporting years and does not indicate upward or downward trends for individual pollutants or facilities. Caution also must be used with this measurement because the values are self-reported and may be estimates rather than actual measurements, and are not inclusive of all Michigan industries. Water toxics release data cannot be used to infer relative risks, absolute risks, or temporal trends for risk. Additional information on individual chemicals and facilities, including historical information is available on the Internet (www.michigan.gov/deq/sara).

Surface Water Radiation

The MDEQ is responsible for monitoring the potential for environmental impact due to the operation of nuclear power plants in Michigan. One of the factors monitored is the level of radiation associated with nearby surface water. Surface water radioactivity averages have remained in the natural background range of one to six picocuries per liter since the inception of the monitoring program in 1972. A level of concern would be an annual average exceeding 50 picocuries per liter. Exhibits 74a and 74b



present the annual radioactivity measurements for the monitoring stations near the Palisades and

Fermi Nuclear Power Plants, respectively. These results are representative of what has been measured at the two other nuclear power plant locations in Michigan. Annual reports on the overall quality of the radiological environment may be obtained by contacting the MDEQ.

Drinking Water

Microbiological, chemical, and radiological contaminants can enter water supplies. These contaminants may be produced by human activity or occur naturally. For instance, chemicals can migrate from disposal sites or underground storage systems and contaminate sources of drinking water. Animal wastes, pesticides, and fertilizers may be carried to lakes and streams by rainfall runoff or snow melt. Nitrates from fertilizers also can be carried by runoff and percolate through soil to contaminate ground water. Arsenic and radon are examples of naturally occurring contaminants that may be released into ground water as it travels through rock and soil.

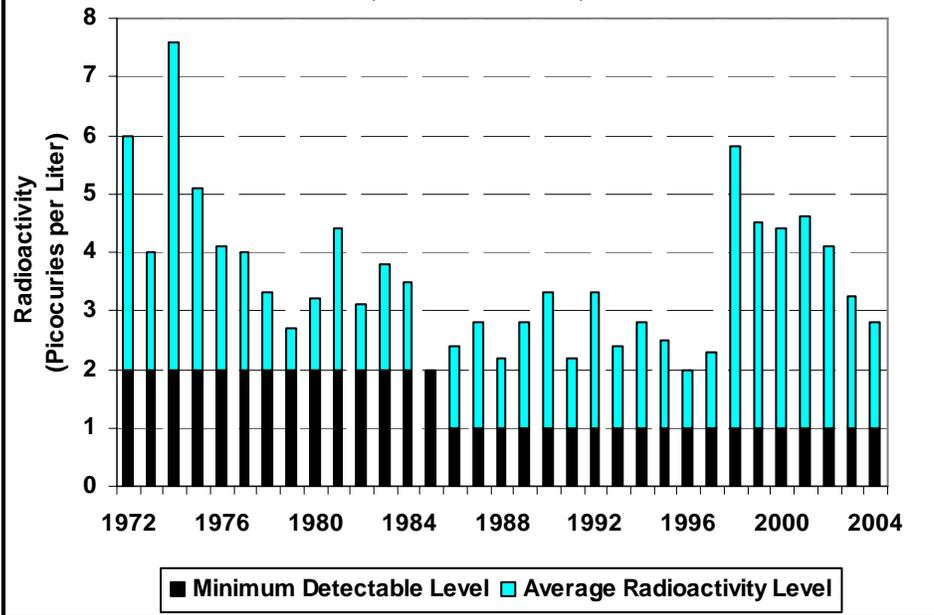
Effects of exposure to contaminants in drinking water will vary depending on many factors, including the type of contaminant, its concentration in drinking water, and how much contaminated water is consumed over what period of time. As of 2003, approximately 90 contaminants were regulated in drinking water under the federal Safe Drinking Water Act.

The MDEQ oversees public water systems by emphasizing early detection and correction of sanitary defects and ensuring that the systems have trained and certified operators in accordance with state law. Competent operators are critical to identifying potential problems and making corrections before problems develop.

The MDEQ maintains data on populations served by community water supplies that receive drinking water meeting all health-based standards. These data are derived

from state reports of drinking water violations to the USEPA's national data system. Community

Exhibit 74b. Annual Average Surface Water Radioactivity 1972 - 2004
(Fermi Reactor Site)



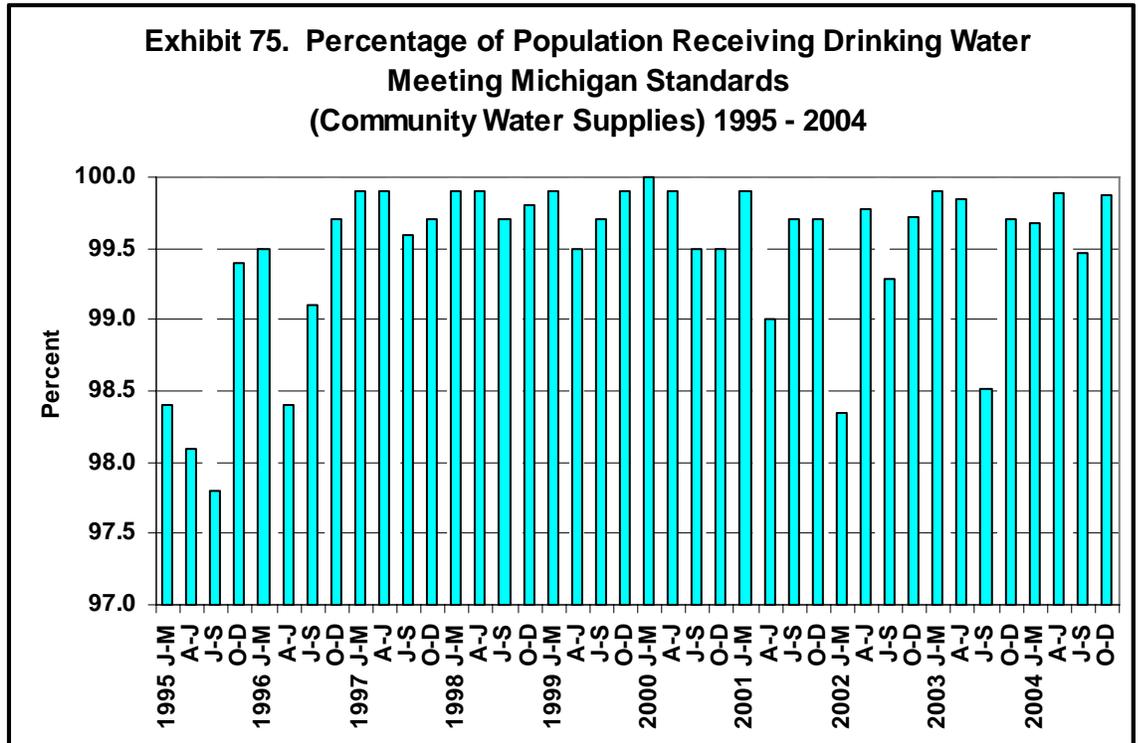
treatment. Consequently, during the period beginning October 1996 to the present, the population served by community water supplies meeting all health standards increased to a high of 99.9 percent and, except for slight deviations during the first quarter of 2002 and third quarter of 2003, has remained between 99.0 and 99.9 percent (Exhibit 75).

Lead. In 1992, the USEPA promulgated a national drinking water treatment program to control lead in drinking water. The standard requires community public water suppliers to monitor lead content in their customers' water supplies, install corrosion control treatment, and initiate a program of lead service line replacement if the lead cannot be

reduced below the action level established by the USEPA (15 micrograms of lead per liter of water). Normally, lead is not present in surface water or water systems are those systems furnishing drinking water year-round to residential populations of 25 or more. The Michigan inventory consists of approximately 1,450 community water systems, including municipal systems, mobile home parks, nursing homes, public institutions, and housing developments, such as subdivisions and condominiums.

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During the first three quarters of 1996, the percentage of populations served by community water supplies meeting all health-based standards ranged from a low of 98.4 percent to a high of 99.5 percent. After the summer of 1996, the city of Ann Arbor came into compliance with surface water treatment regulations through the installation of advanced



ground water used for public water supply sources. However, lead can be introduced into the drinking water at customer taps through contact with

plumbing materials. Common sources of lead in water distribution and plumbing systems include lead service lines in old urban areas; lead as a component of the solder used to join copper plumbing; and lead as an additive in brass used in

parts of the governing regulation at different times, monitoring variations exist in the current database. For example, the increase in lead action level exceedances seen in Exhibit 76 during 1997 is due to the resumption of lead monitoring in many water systems following the installation of corrosion control treatment. Similarly, the implementation of rule revisions during 2000 required many water systems that were previously exempt from the lead regulations to begin monitoring.

Arsenic. Arsenic is an element that occurs naturally and that is widely distributed in the earth's crust. Arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is referred to as *inorganic arsenic*. Arsenic combined with carbon and hydrogen is referred to as *organic arsenic*. Organic arsenic is less of a health concern than is inorganic arsenic.

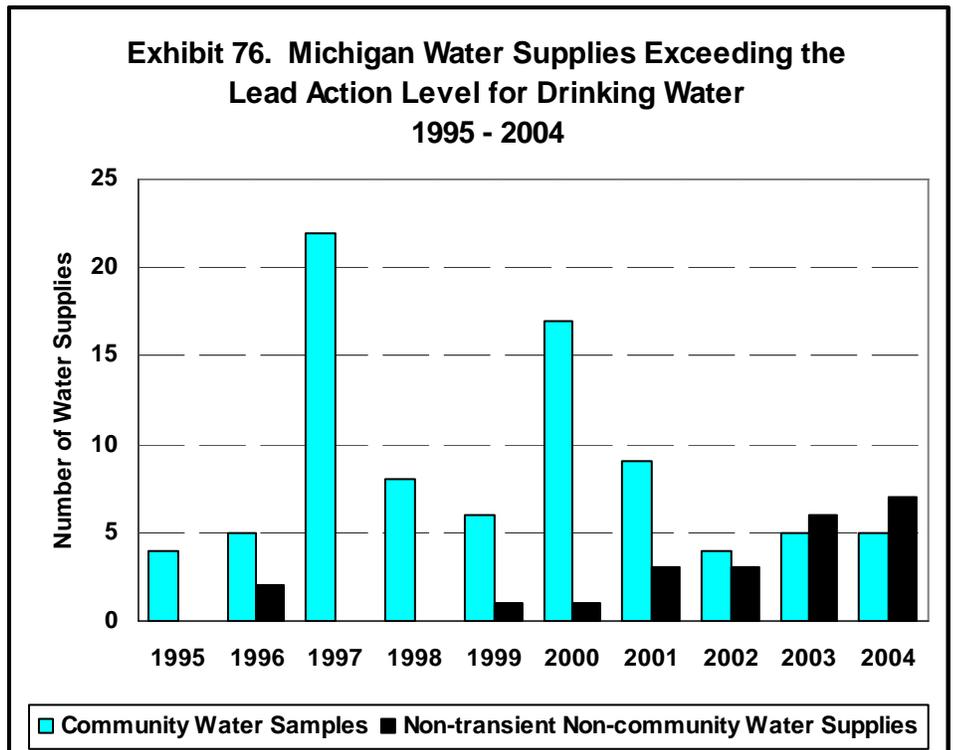
Ground water is far more likely to contain high levels of arsenic than surface water. Arsenic may be dissolved by, and absorbed into the drinking water that is withdrawn from the ground. Surveys of United States drinking water indicate that about 80 percent of water supplies have less than two micrograms per liter ($\mu\text{g/L}$) of arsenic, but two percent of supplies exceed 20 $\mu\text{g/L}$ of arsenic.



plumbing fixtures, including faucets and valves.

The USEPA action level for lead was established based upon the concern that the blood lead level for children must remain very low to prevent potential neurological development problems. While drinking water is not normally the primary route of exposure, it can contribute to the total body burden and aggravate problems for children with lead exposure from other sources.

The MDEQ monitors lead in both community and nontransient noncommunity water supplies. Non-transient non-community water supplies provide drinking water to schools, day care centers, and places of employment that own and operate their own wells. Due to a need to phase in different



The most common form of human exposure to arsenic is from ground water used for drinking and cooking. The manner in which arsenic affects humans is not fully understood. Studies of exposed populations in the United States have not shown clear proof of health problems caused by drinking contaminated water at levels similar to those found in Michigan well water. Based on studies from other countries, long-term exposure to high arsenic levels (generally, greater than 30 µg/L) in drinking water has caused the following effects:

1. Thickening and discoloration of the skin; and
2. Stomach pain, nausea, vomiting and diarrhea; and numbness in the hands and feet.

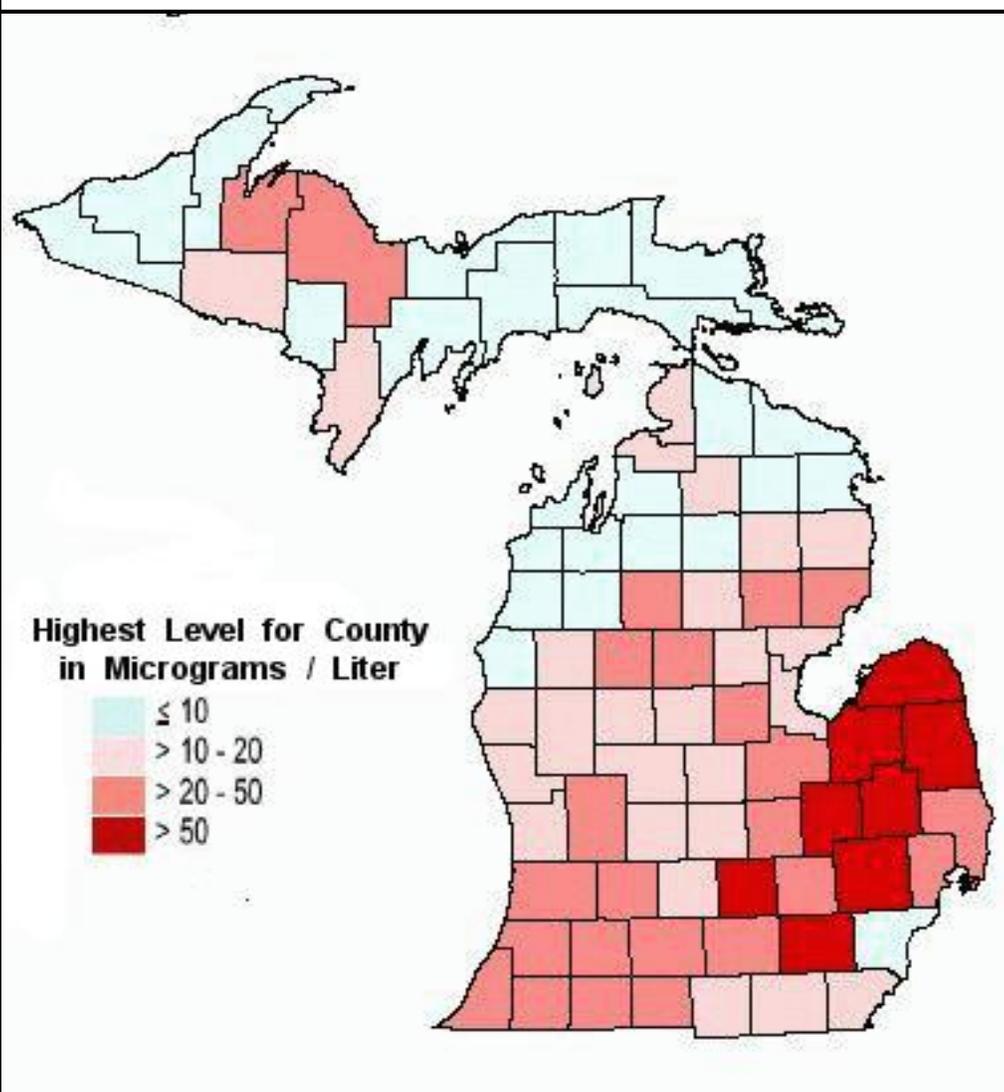
Many of the symptoms of exposure to high levels of arsenic also are seen with other common illnesses, which makes it difficult for physicians to recognize. Some people may be affected by lower levels of arsenic while others remain unaffected. Young children, the elderly, people with long-term illnesses, and unborn babies are at greater risk since they can be more sensitive to chemical exposures. Babies are not exposed to arsenic through breast milk at levels of concern even when their mothers have been exposed.

The federal Safe Drinking Water Act requires the USEPA to revise the existing 50 µg/L standard for arsenic in drinking water. On January 22, 2001, the USEPA adopted a new drinking water standard for public water systems of 10 µg/L. The new standard will go into effect on January 23, 2006. Exhibit 77 presents ground water arsenic levels from Michigan counties. More precise locations of the sample locations within each county may be

found on the MDEQ's Internet site (www.deq.state.mi.us/documents/deq-wd-gws-ciu-as.htm).

Nitrate. Nitrate is a form of nitrogen combined with oxygen. It can be converted in the body to nitrite. The major adult intake of nitrate is from

Exhibit 77. Arsenic Levels in Michigan Ground Water by County



food rather than water, but sometimes excessive amounts of nitrate get into drinking water.

Nitrate can get into water if a well is improperly constructed or located where it is subject to contamination sources. Typical sources of nitrate contamination include:

1. Wastes from livestock operations;
2. Septic tank/drainfield effluent;
3. Crop and lawn fertilizers;

4. Municipal wastewater sludge application; and
5. Natural geologic nitrogen.

Shallow water wells in sandy unconfined aquifers are more vulnerable to nitrate contamination than deeper wells protected by overlying clay strata.

Elevated nitrate in drinking water can cause a disease called *methemoglobinemia*, a blood disorder primarily affecting infants under six months of age. Methemoglobinemia reduces the ability of the red blood cells to carry oxygen. The acutely poisoned person will have a blue discoloration of the skin due to the reduction of oxygen in the blood. The condition can be fatal if not attended immediately by a physician.

The USEPA has established a drinking water maximum contaminant level for nitrate (as nitrogen) at ten milligrams per liter (mg/L) and nitrite at one mg/L. Michigan has adopted these standards.

Private water supply owners who find that they have excessive nitrate or nitrite levels should contact their local health department. Although, nitrate can be removed from drinking water using a complex process, it is generally recommended that, initially, an alternate source of drinking water be developed away from any contaminating sources and that bottled water be used for preparing infant formula. Further consultation with the local health department may be needed to develop more permanent, longer-term alternatives.

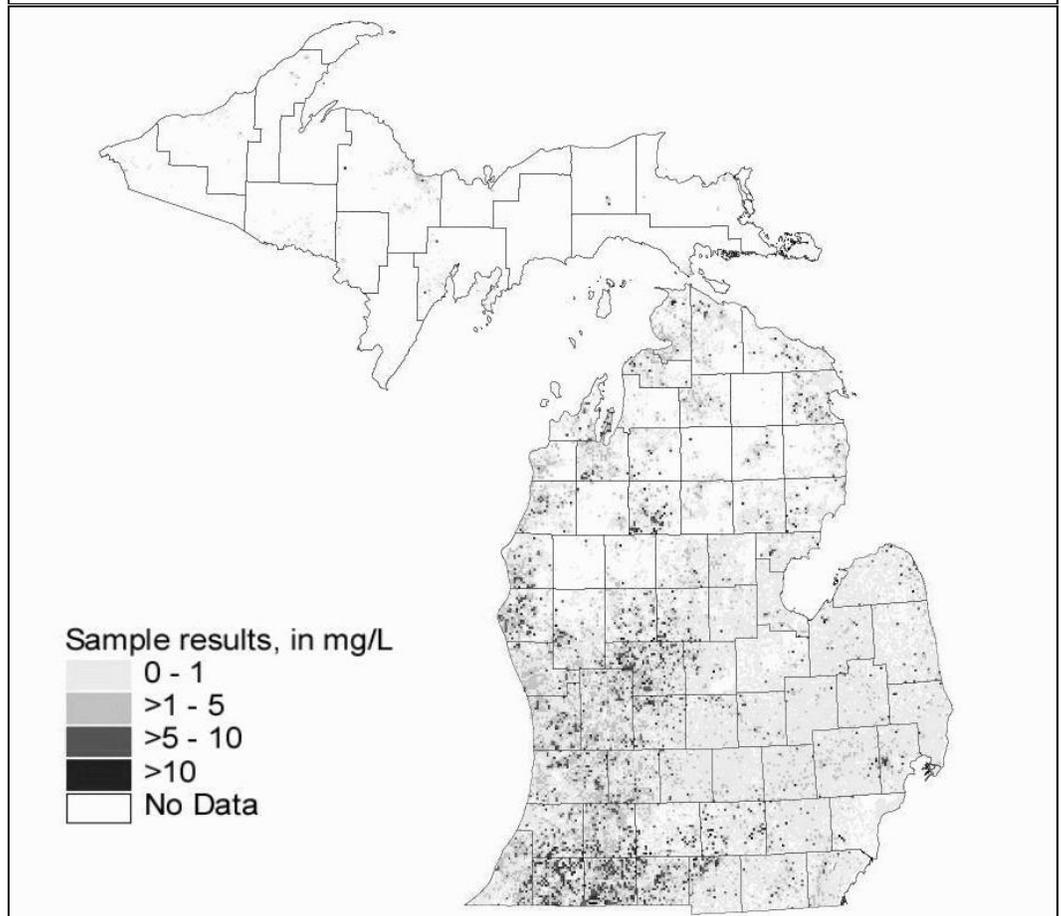
Exhibit 78 graphically presents averaged nitrate levels in ground water from Michigan counties. More precise locations of the sample locations within each county may be found on the MDEQ Internet site (www.deq.state.mi.us/documents/deq-wd-gws-ciu-no3.htm).

[wd-gws-ciu-no3.htm](http://www.deq.state.mi.us/documents/deq-wd-gws-ciu-no3.htm)).

Volatile Organic Chemicals. When found in drinking water, the source of VOCs is generally associated with an industrial solvent release, landfill leachate, chemical transportation spill, a fuel spill and leak, illegal waste disposal, etc. VOCs do not generally occur naturally in ground water.

Twenty-one VOCs that can pose a physical and/or biological risk to drinking water resources are

Exhibit 78. Averaged Nitrate Levels in Ground Water from Michigan Counties (Averaged over One Square Mile)



currently monitored by the MDEQ. Exhibit 79 presents the location of ground water samples where the volatile organic chemicals have been found from Michigan counties. More precise locations of the sample locations within each county may be found on the MDEQ's Internet site (www.deq.state.mi.us/documents/deq-wd-gws-ciu-voc.htm).

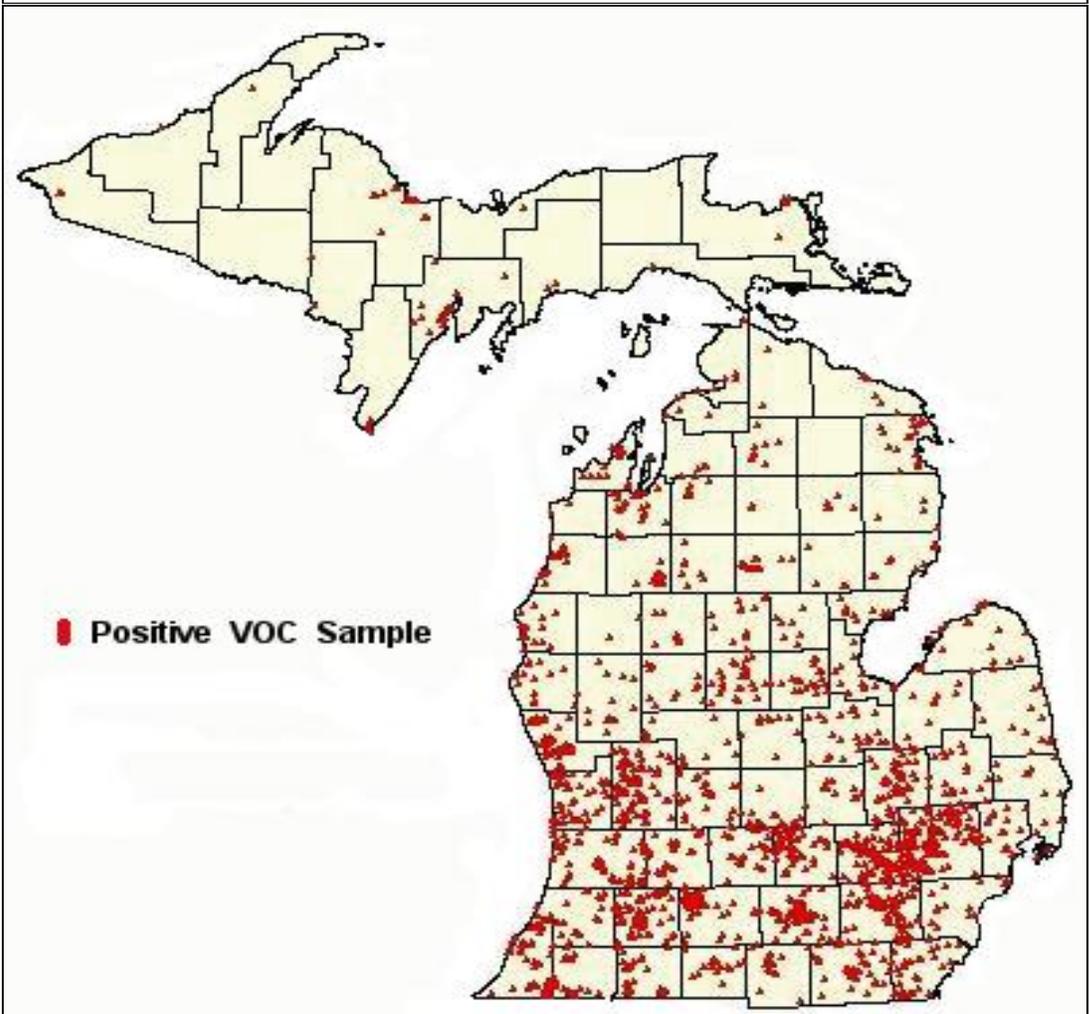
Water Diversions and Consumptive Use

Under the Great Lakes Charter of 1985, the Governors of the Great Lakes States and the Premiers of the Canadian Provinces of Ontario and Québec notify and consult with each other on proposals for diversions and consumptive uses of waters within the Great Lakes Basin of over five million gallons per day. Additionally, the Governors have direct authority over the waters of the Great Lakes within the United States through the federal Water Resources Development Act of 1986, as amended. Under this Act, no bulk export or diversions of water from the Great Lakes Basin can take place without the unanimous approval of the Great Lakes Governors.

On June 18, 2001, the Great Lakes Governors and Premiers of Ontario and Québec signed the Great Lakes Charter Annex 2001 (Annex) in Niagara Falls, New York. The Annex is an amendment to the federal Great Lakes Charter of 1985. In the Annex, the Governors and Premiers outlined a framework for a set of more binding agreements among the Great Lakes States and Canadian Provinces and established a series of principles for a new standard for reviewing proposed withdrawals of water from the Great Lakes.

The Governors and Premiers charged the Council of Great Lakes Governors' Water Management Working Group (Working Group) with the development of a draft proposal to implement Annex 2001. On July 19, 2004, the draft proposal

Exhibit 79. Positive Volatile Organic Chemical Ground Water Sample Locations in Michigan



was released for a 90-day public comment period. More than 10,000 public comments were received.

The public comments reflected a broad support for the goal of protecting the Great Lakes. Nearly all comments reflected support for the objectives included in Annex 2001 and support for all or some of the elements in the draft agreements. In response to the comments, the draft agreements were revised and released for an additional 60-day review.

The revised draft Annex 2001 agreements were signed by the by the Governors of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin and the Premiers of Ontario and Québec on December 13, 2005. The agreements include the following points:

1. There will be a ban on new diversions of water from the Great Lakes Basin. Limited exceptions could be allowed, but exceptions would be strictly regulated;
2. The States and Provinces will use a consistent standard to review proposed uses of Great Lakes water;
3. The collection of technical data will be strengthened, and the States and Provinces will share the information, which will improve decision-making by the governments;
4. Regional goals and objectives for water conservation and efficiency will be developed and reviewed every five years. Each State and Province will develop and implement a water conservation and efficiency program;
5. Lasting economic development will be balanced with sustainable water use to ensure Great Lakes waters are managed responsibly; and



6. There is a strong commitment to continued public involvement in the implementation of the agreements.

The ground water inventory and mapping project is complete and available to the public on the Internet (www.michigan.gov/deq/0,1607,7-135-3313-86262--,00.html). The Ground Water Conservation Advisory Council has issued an interim report to the Legislature, and the final report will be completed in February 2006.

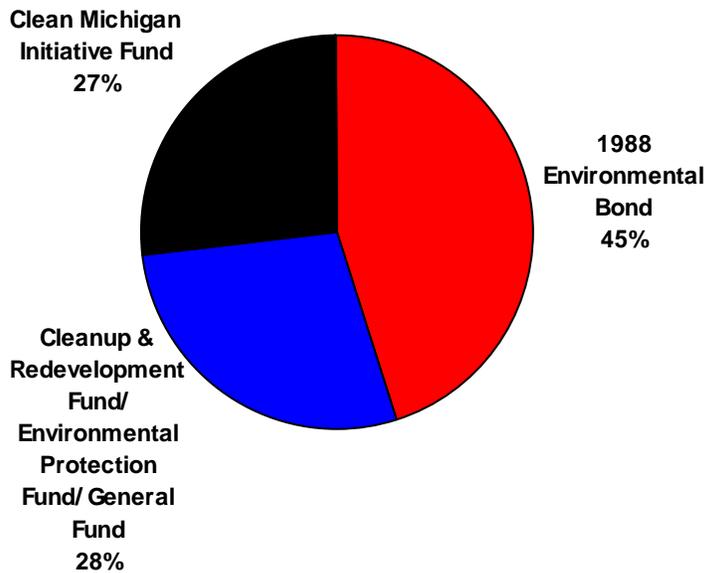
Land Quality

Environmental Cleanups

Remediation (cleanup) of environmentally contaminated land is accomplished through state funded actions and through actions conducted by liable parties and property owners. The sources of public funds that have been used for cleanup since 1989 are shown in Exhibit 80. Prior to passage of the CMI in November 1998, the MDEQ cleanup program was funded primarily by an Environmental Bond approved in 1988. Most of the 1988 Environmental Bond money was directed at performing cleanups to protect public health and the environment. Under the 1998 CMI, the primary focus was and continues to be preparing contaminated sites for redevelopment. Cleanup and Redevelopment Fund monies and the CMI Fund monies have supported the majority of the cleanups since 1998.

A total of \$335 million has been earmarked from the CMI Fund for cleanup of environmentally contaminated sites, including leaking underground storage tank sites. To date, \$142 million have been appropriated for work on 566 redevelopment related projects. The MDEQ's goal is to complete projects within 18 months after they are initiated. A portion of the \$335 million is set aside to address serious health and environmental problems at contaminated sites that do not have redevelopment potential. A total of \$58 million has been appropriated for action at 145 sites in this category. An additional \$37 million is earmarked for redevelopment related projects and to address sites with serious health and environmental problems. Twelve million dollars of the \$335 million will be used for local units of government to address municipal landfills on the federal Superfund National Priorities List and to clean up

**Exhibit 80. Environmental Cleanup Funding Sources
1989 - 2004**



58 percent of the sites where work has been undertaken. Cleanup systems have been constructed and operation and maintenance activities are ongoing at 35 sites. Cleanup work is in progress at 422 additional sites.

In 1995, Michigan's cleanup law was changed. One of the goals of the change was to promote redevelopment of contaminated property (referred to as *Brownfield sites*). Up until the time of the 1995 changes, any person who owned or operated contaminated property was responsible for cleaning up the contamination, regardless of whether they caused the problem. This was a serious impediment to the purchase and re-use of contaminated property that resulted in many new

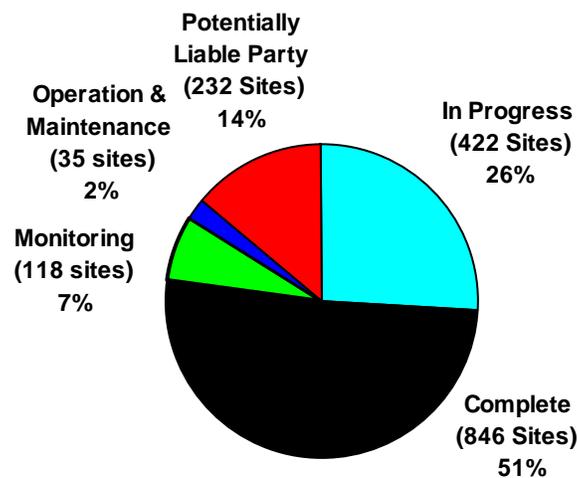
sites where a specific redevelopment proposal exists. Seventy-five million dollars will be used for Brownfield Redevelopment Grants to local units of government. The remaining \$11 million of the \$335 million will be used for administrative support costs. In addition to the \$335 million, another \$50 million from the CMI Fund was awarded for 62 projects through a competitive grant process for waterfront improvements to promote economic development.

development projects going to undeveloped land or open space. In an effort to reduce this problem and to put contaminated property back into productive use, liability for property owners was changed to a *causation standard*. Under the 1995 changes to the state cleanup law, the person who caused contamination, rather than the person who

A total of 1,653 sites has been targeted for cleanup with public funds, beginning with the 1988 Environmental Bond program. At 232 of those sites, liable parties have come forward to perform necessary cleanup actions and are currently in the process of doing so. The current status of the cleanup work at publicly funded sites is presented in Exhibit 81.

Cleanup activities are complete at 846 sites. At 118 additional sites, monitoring is being conducted to assure that further state funded actions are not required. The two categories combined represent

Exhibit 81. Environmental Sites Cleanup Status 2004



buys or owns the contaminated property, is responsible for conducting the cleanup. In addition to cleanups conducted by these liable parties, non-liable property owners may still elect to conduct cleanups to increase their property value. They must, however, assure the safety of people who work or live at these sites.



Before Redevelopment

Double Tree Hotel & Conference Center: Bay City



After Redevelopment

Double Tree Hotel & Conference Center: Bay City

*Private Investment: \$14 Million
Local Investment: Over \$4 Million
State Investment: \$1.5 Million
Federal Investment \$1.5 Million*

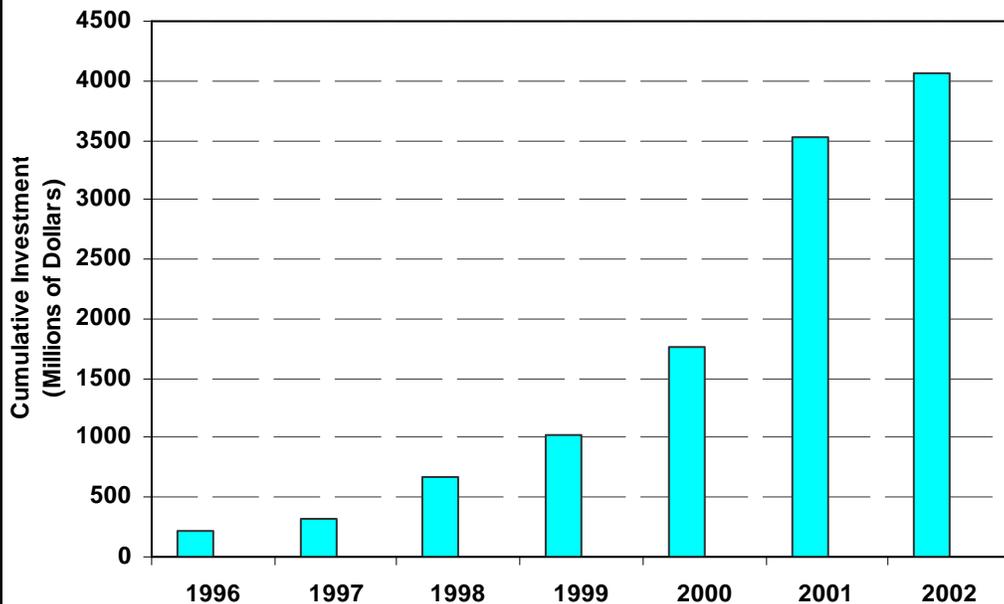
Another change established in the 1995 amendments to the state cleanup law was the creation of risk-based cleanup criteria that are linked to land use. The use of these criteria helps to ensure that cleanups can be conducted in a cost effective manner. The risk-based system accounts for the fact that the use of a property dictates the

type of exposures that will occur, and that risk depends on exposure. For example, industrial sites do not have children present and workers spend only a portion of the day at the workplace. Because of these differences in exposure, different levels of cleanup may be allowed, while still providing the same degree of protection at residential, commercial, and industrial sites. Site-specific cleanups allow the MDEQ and property owners to account for special circumstances at a site. The MDEQ has approved cleanup plans for 164 sites in land use categories other than residential. Cleanups meeting residential criteria have been completed at many more sites, including sites where spill response activities undertaken by liable parties have eliminated unacceptable risks to public health and the environment. Property owners and other liable parties have conducted cleanup work at additional sites for which the MDEQ does not maintain statistics.

Between 1996 and 2002, the MDEQ periodically surveyed 33 communities to determine the effectiveness of the 1995 cleanup program changes in helping those communities meet their redevelopment goals. The communities were asked to identify the amount of investment and job creation that has occurred at Brownfield sites within their community as a result of the 1995 amendments. Based on the surveys, there has been a continued increase in private investment and job creation through 2002 (Exhibits 82 and 83). A new survey is currently being created and will be distributed to communities during 2005. The results of the 2005 survey will be included in the 2007 Biennial Report.

Michigan currently has a total of 130 municipal solid waste, industrial waste and construction and demolition waste landfills. This total includes landfills that are closed and others that are open and accepting waste, but it does not include facilities that operated before 1979, which are addressed under the broader Environmental Cleanup Program, described above. Sixty-six of these landfills have been found to be contaminating ground water. Of these, 45 landfills (68%) have been cleaned up or have a corrective action ongoing. Corrective action sites fall into one of two categories: either the MDEQ is using enforcement authorities to force the landfill owner/operator to address ground water contamination or

**Exhibit 82. Investment in Brownfield Properties
1996 - 2002**



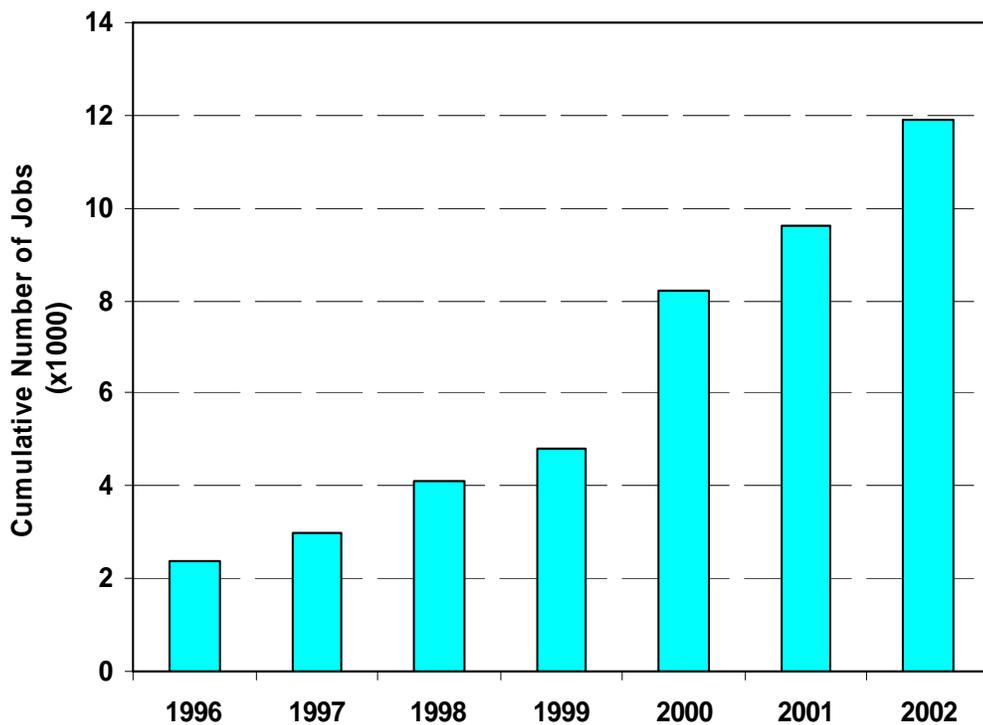
All of these latter sites are closed and no longer operating. Exhibit 84 shows the cumulative number of ground water contaminated landfills returned to compliance since 1990.

State-Owned Sites Cleanups

In addition to ensuring the cleanup of contaminated sites of others, the state is responsible for the cleanup of sites that it has contaminated as a result of its own operations. The state has identified a total of 158 such sites where it is responsible, as either the owner or operator, for environmental remediation. Of the 158 sites, 125 are underground or above ground storage tanks, 15 are old landfills, dumps or storage pits, 7 are shooting ranges, 7 are surface spills, 2 involve either asbestos removal or radioactive license decommissioning, and 2 have multiple sources of contamination.

In July 1996, a States Sites Cleanup Fund was established, into which a total of \$30 million was made available to help the state fulfill its own environmental cleanup responsibilities. Currently, 155 of the 158 sites have been funded. Of the 155 funded sites, 86 have been cleaned up and closed; 30 have been cleaned up and are in the process of being

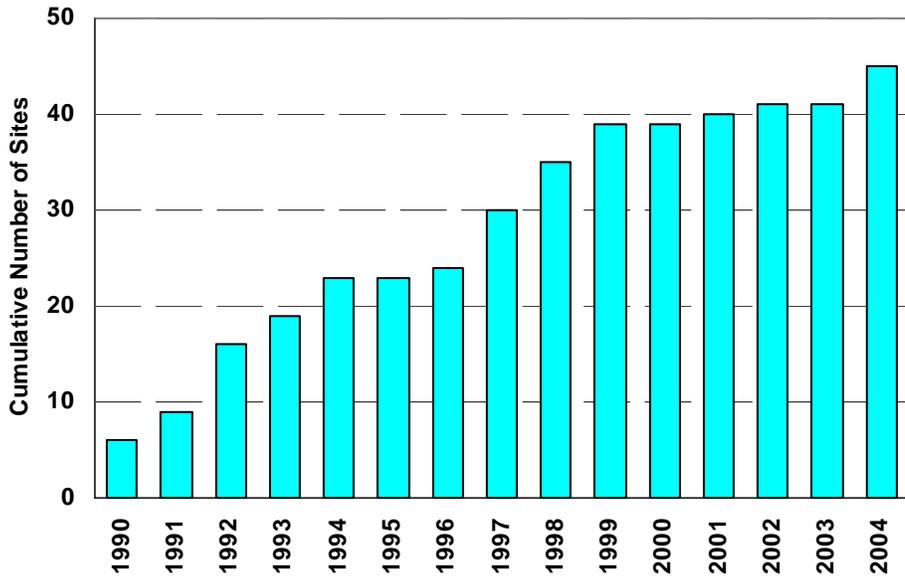
**Exhibit 83. Number of Jobs Created at Brownfield Properties
1996 - 2002**



closed; 17 are into long-term treatment to reduce the level of contamination; 11 are being investigated or are in the process of having a treatment design developed; and 11 sites are

the MDEQ is using public funds to clean up the site because a liable party is no longer available. This leaves 21 sites (32%) at which no actions to correct ground water contamination are underway.

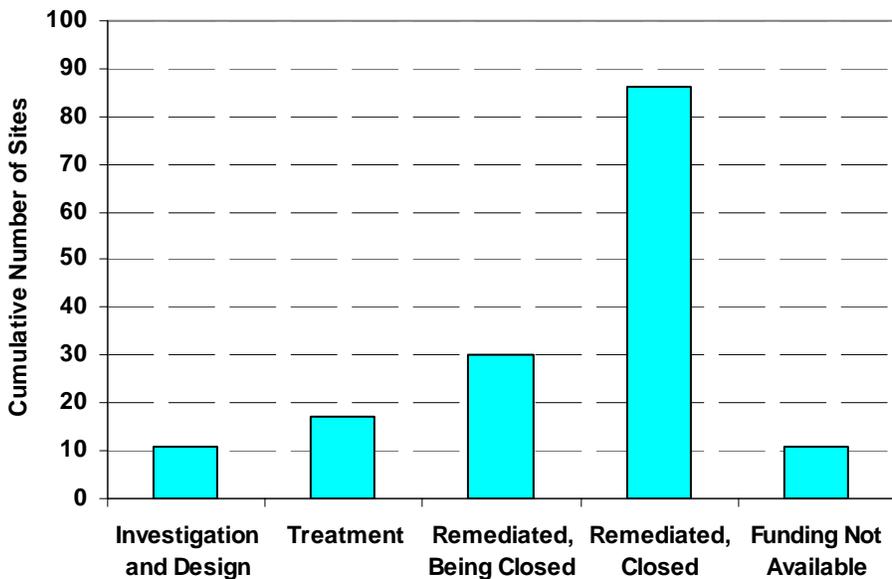
Exhibit 84. Ground Water Contaminated Solid Waste Landfills Returned to Compliance 1990 - 2004



treatment, storage, and disposal sites in Michigan are subject to corrective action requirements. The corrective action requirements have been in effect under Michigan law since 1995. Similar requirements have been in effect under federal law since 1984. In 1998, the USEPA delegated to Michigan the administration of the federal corrective action requirements at licensed facilities. The MDEQ has primary



Exhibit 85. Status of Funded Cleanups at State-Owned/Operated Sites July 1996 - December 2004



responsibility for overseeing the completion of corrective action at the licensed facilities.

Hazardous waste treatment, storage, and disposal facilities are subject to corrective action based on an assessment of the environmental contamination present and the risks each site poses to human health and the environment. Of the 235 identified sites, 74 have been ranked as *high priority* (i.e., sites having the worst contamination or risks). The environmental contamination problems at the remaining 161 sites are not as significant as those

partially cleaned, but currently inactive due to lack of available funding (Exhibit 85).

Hazardous Waste Treatment, Storage, and Disposal Sites

Two hundred thirty-five hazardous waste

at the 74 high priority sites. To date, significant corrective action that has been taken at the high priority sites includes eliminating or controlling human exposure to contaminants such that there remains no unacceptable human health risk (40 sites), eliminating or controlling ground water contamination (38 sites), or completing the



benzene, ethylbenzene, toluene, xylenes, and polynuclear aromatic hydrocarbons. These constituents can pose acute and chronic human health risks, with benzene being a known human carcinogen.

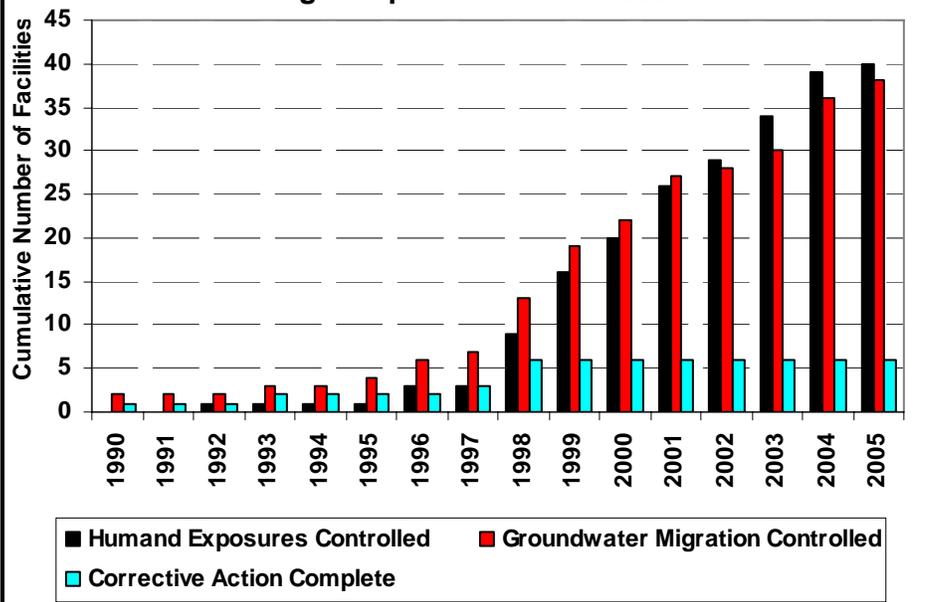
Leaking underground storage tanks can contaminate both the surrounding soil and the underlying ground water. Of the two, ground water contamination is much more difficult to clean up and may impact drinking water wells. Most of the water supplies known to be affected have been replaced with alternate water supplies.

Since 1995, the number of active leaking underground storage tank releases has remained steady, in the range of 9,000 releases, due to new releases being discovered as old ones are being cleaned up. It is estimated that about half of these releases will require the use of state cleanup funds

due to non-viable and recalcitrant owner/operators. The cumulative closure of releases has increased from 4,530 in 1995 to 11,539 by the end of 2004 (Exhibit 87). This is a result of the MDEQ's risk-based cleanup program and its efforts in assisting, providing information, and where required, taking appropriate enforcement action to ensure that owners/operators meet their regulatory obligations. However, while there have been over 550 closures of releases since the 2003 Biennial Report, there also have been an additional 800 new releases reported.

In the early 1990s, a Michigan Underground Storage Tank Financial Assurance (MUSTFA) program was established to assist owners with the cleanup of

Exhibit 86. Corrective Actions Taken at High Priority Hazardous Waste Management Treatment Storage Disposal Facilities 1990 - 2005



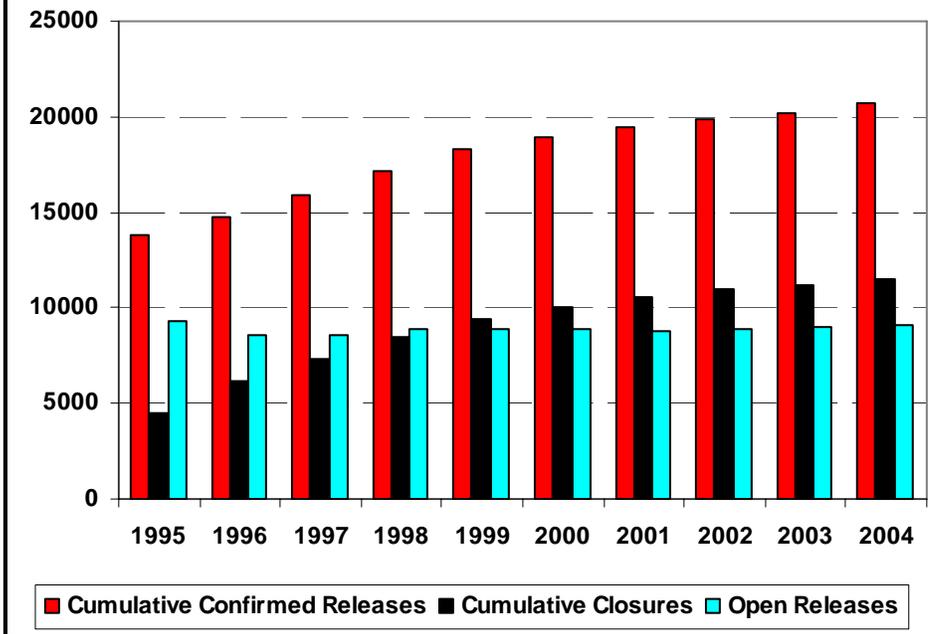
cleanup such that no further corrective action is required (6 sites) (Exhibit 86).

Leaking Underground Storage Tanks

The predominant hazardous substances stored in underground storage tanks are petroleum products (gasoline and diesel fuel) and used oil. The primary constituents of petroleum include

releases from underground storage tanks. That program was funded with a 7/8 cent fee on refined petroleum products. However, the fee collection rate was quickly found to be insufficient for the large number of release sites. Three hundred thirty million dollars in bonds were sold to pay claims and invoices submitted through June 1995, at which time no further claims or invoices could be accepted based on anticipated revenue

Exhibit 87. Number of Leaking Underground Storage Tank Releases 1995 - 2004



legislative process, a significant portion of the continuing fee collection will go towards addressing the backlog of petroleum contaminated sites.

State and federal rules require that owners/operators of underground storage tank systems comply with new technical standards. The technical standards require that underground storage tanks be equipped with corrosion protection, overfill prevention, and spill protection to protect ground water from leaking tanks. In addition, owners/operators are required to monitor for leaks. December 22, 1998, was set as the deadline for removal, replacement, or upgrading of existing tanks failing to meet the technical standards. In 1999, the MDEQ launched an

shortfalls. Since the 2003 Biennial Report, sufficient revenue has been collected from the 7/8 cent fee to pay off those MUSTFA bonds. Due to the large number of releases that will need to be

initiative to assure that substandard underground storage tanks were no longer used. This led to approximately 3,000 tanks being removed from use. An enforcement initiative was begun in 2000 to compel reluctant owners/operators to properly remove any remaining substandard underground storage tanks so that they no longer pose a threat to the environment. The owners of the remaining substandard underground storage tanks have been referred to the MDEQ's Office of Criminal Investigations for follow-up action. Where there is no liable or viable owner, the MDEQ uses state funds for tank closure, if funding is available.



Gasoline Additive Methyl Tertiary-butyl Ether

addressed with public funds, the fee was extended in revisions to the MUSTFA legislation, which also changed the name of the fund to the *Refined Petroleum Fund*. Although decisions about the final form of a Refined Petroleum Cleanup Program have yet to be made through the

The gasoline additive methyl tertiary-butyl ether (MTBE) has been mandated in western and northeastern states to meet the reformulated gasoline requirements to help reduce carbon monoxide emissions and ozone formation. Since Michigan did not have as serious a problem as other states, it was never mandated by the USEPA to use reformulated gasoline. Concern about the potential health risk from ground water being contaminated by this additive has led to reexamination of its use by the USEPA.

Within Michigan, there exist residual amounts of MTBE in some gasoline supplied by pipelines that transfer fuel to Michigan from other states. For over 10 years, the MDEQ has required monitoring for MTBE at underground storage tank release sites. At sites where levels exceed safe concentrations, the MDEQ has taken action to address the contamination. Michigan instituted a ban on MTBE in June 2003. The acceptable level of MTBE in ground water at sites of contamination is 40 parts per billion (ppb), based on aesthetic criteria of taste and odor. The aesthetic criterion is significantly lower than the health-based criterion of 240 ppb. Consequently, an individual would taste or smell the MTBE before it posed a health risk.

Abandoned Oil and Gas Wells

Since commercial oil and gas production began in Michigan in 1925, over 56,000 oil and gas wells have been drilled. Approximately 18,000 of these wells are in use today producing 28 percent of the natural gas and four percent of the oil used within the state. Nine hundred twenty-one new wells were drilled during 2003 and 2004.

The MDEQ regulates oil and gas drilling and production to conserve natural resources and to protect the environment, public health and safety, and property. Part of that effort is directed toward establishing optimal spacing of wells. During 2003 and 2004, the MDEQ issued 57 rulings increasing the size of the tract assigned to a well. This allows fewer wells to drain an oil and gas reservoir and provides more flexibility for locating a well to protect the environment. The MDEQ also issued three orders establishing secondary recovery projects, where gas or fluids are injected into a partially depleted oil or gas reservoir, to increase the ultimate production from existing wells. Two of those orders provided for injection of carbon dioxide, a beneficial use of this waste greenhouse gas.

When an oil and gas well is depleted, Michigan law requires the well owner to plug the well and restore the site. Abandoned wells that are not properly plugged can pose serious threats to the environment and public health and safety because they can serve as conduits for oil, gas, or brine to leak to the surface or into underground water supplies. Occasionally a well owner dies or



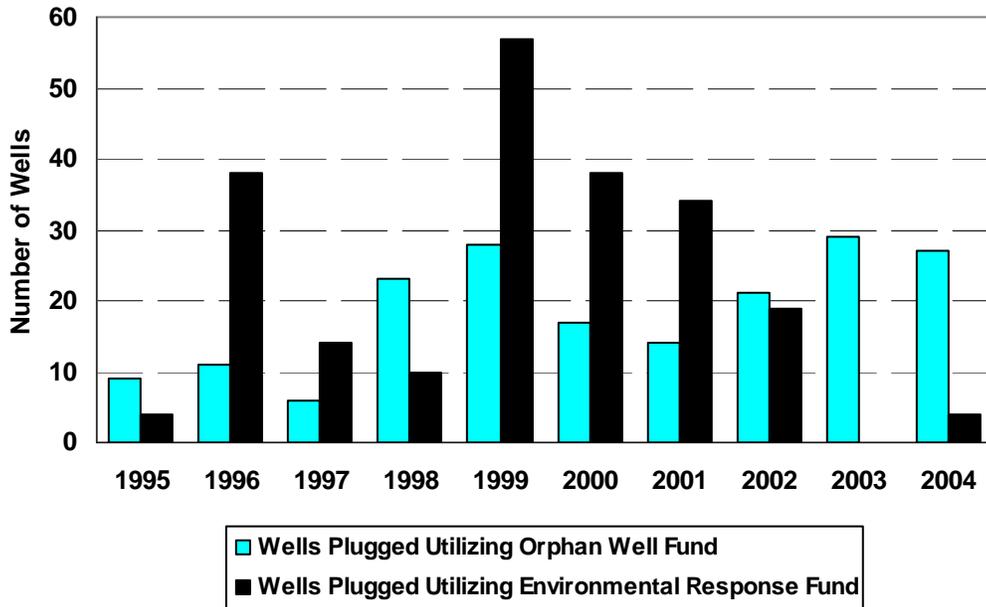
becomes insolvent and leaves an inactive well unplugged. The MDEQ plugs these *orphan* wells with funds provided from the state's Orphan Well Fund. The Orphan Well Fund was established in 1994 and is supported by taxes levied on oil and gas producers. In the case of an abandoned well that has a viable owner, the MDEQ may plug the well and clean up the site with money from the state's Environmental Response Fund or other sources, and pursue recovery of costs from the owner. The MDEQ has plugged 403 abandoned wells since 1995 (Exhibit 88).

Solid Waste Imports

During the period 1995 - 2004, solid waste imports have ranged between 12.2 and 28.0 percent of the total amount of solid waste disposed of into Michigan landfills. During Fiscal Year 2004, the bulk of these imports, approximately 64 percent, came from Canada. Most of the remaining out-of-state waste comes into Michigan from nearby



**Exhibit 88. Number of Oil and Gas Wells Plugged
1995 - 2004**



industrial waste and PCB waste.

During the last five years, the quantity of hazardous waste exported by Michigan has remained relatively constant (averaging about 242,000 tons/year) (Exhibit 91).

Comparing the import amounts to the export amounts, it can be seen that since 2000, the amount of hazardous waste imported has declined (583,000 tons per year in 2000 to 326,000 tons per year in 2004), while the average amount of waste exported during that 2000 to 2004 period remained relatively

states (e.g., Indiana, Illinois, Ohio, and Wisconsin). Solid waste imports show a continuing trend to increase (Exhibit 89). The increase in imports is likely due to the relatively close proximity of Michigan landfills to other states and Canada, and the continuing inability of the state, due to federal interstate commerce rules, to restrict the import of waste from outside the state. Federal legislation is currently being considered that could drastically reduce the amount of Canadian waste entering into Michigan.

constant. In 2004, Michigan remained a net importer of hazardous waste, by 98,585 tons per year.

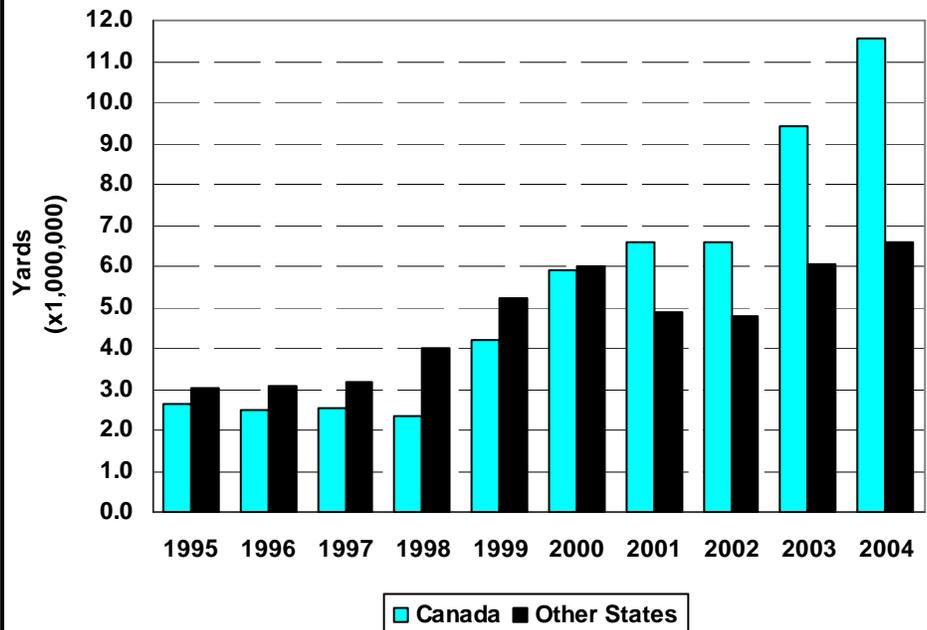
Hazardous Waste Imports and Exports

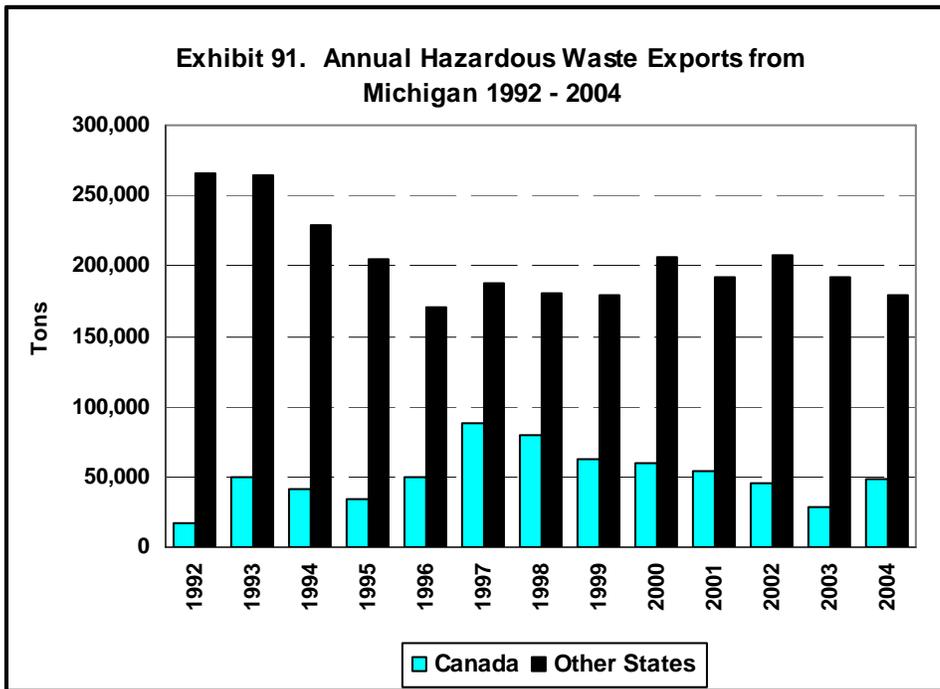
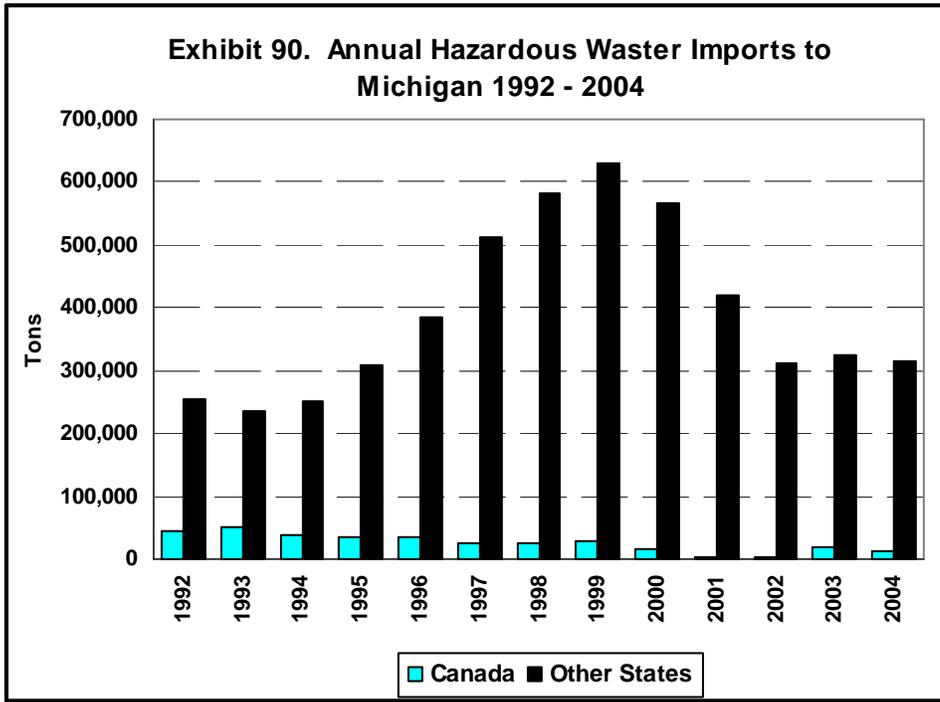
During the period from 1992 to 1999, the importation of hazardous waste to Michigan for disposal rose from 301,000 tons per year to 630,000 tons per year. Since then, it has declined to 326,482 tons per year in 2004 (Exhibit 90). A portion of the observed reduction in waste importation between 2001 and 2002 is due in part to MDEQ's improved data collection procedures, which filters out extraneous data on liquid

Scrap Tires

Over 290 million scrap tires are generated each year in the United States. Michigan contributes

**Exhibit 89. Annual Solid Waste Imports to Michigan
1995 - 2004**





illegal scrap tire accumulations and the public health and environmental concerns associated with these scrap tire waste piles. In 1991, it was estimated that more than 30 million scrap tires were stockpiled and more than 7.5 million additional scrap tires were being generated annually. Each year, the MDEQ discovers additional collection sites that are regulated by law and develops more accurate figures on scrap tire stockpile inventories. Most of the newly identified sites are not active and often not in a visible location. Consequently, the documented number of scrap tires stockpiled in identified noncompliant sites has increased since 1991. The number of tires reported as being removed also may change over time due to improved tracking and data quality methods.

In 2004, 127 collection sites containing 11.9 million scrap tires were found by the MDEQ to be in noncompliance. Of these, approximately 6 million are pre-1991 tires. State law requires the MDEQ to make every effort to ensure that all abandoned scrap tires accumulated at collection sites prior to January 1, 1991, are cleaned up or collected by September 30, 2009.

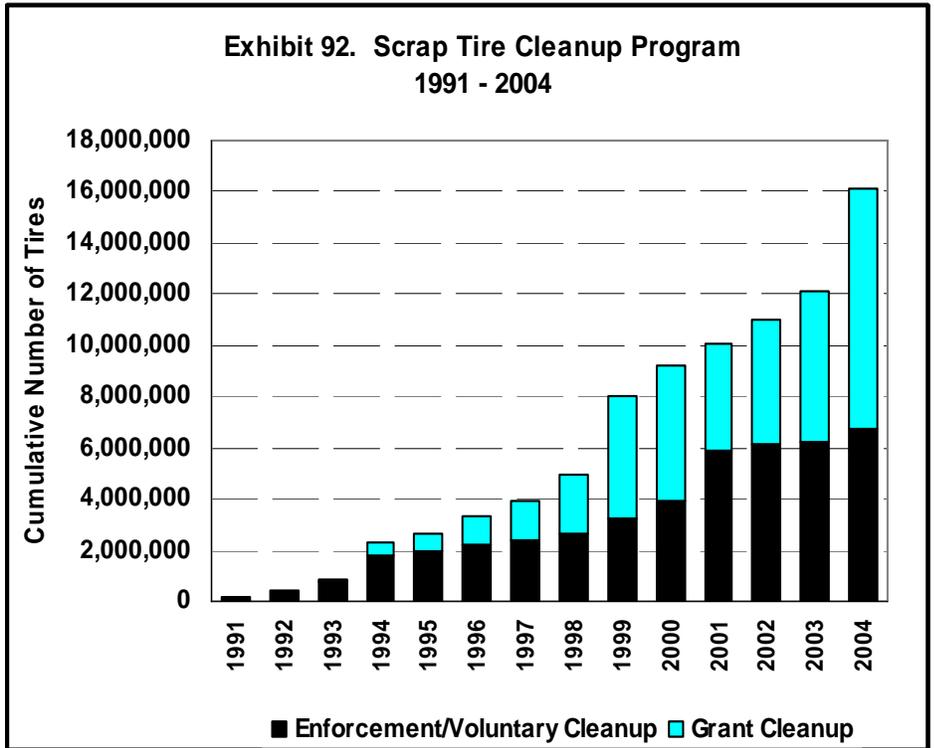
Since 1991, more than 16 million tires have been removed from the Michigan landscape through

ten million scrap tires annually to that waste stream. In the past, millions of these scrap tires were abandoned or illegally stockpiled each year on vacant lands and inner-city back alleys. The illegal accumulations resulted in public health, environmental, and aesthetic problems for many communities.

In 1990, Michigan enacted legislation, which went into effect in 1991, to address the concern of scrap tires. The purpose of the law was to help reduce



MDEQ grant funded cleanups and compliance and enforcement efforts. The cleanup of these public and privately owned properties has helped toward restoring the environmental quality and economic value of more than 1,000 sites across the state. Exhibit 92 shows the cumulative totals of tires removed by the MDEQ grant program and those removed voluntarily or through enforcement actions. A consistent enforcement and cleanup program.



Emergent Contaminants of Concern

Emergent Contaminants of Concern

Introduction

Recent decades have seen innumerable improvements in the United States in terms of new industrial processes and products, better agricultural and animal production, more effective medical treatments, and an increased availability and types of everyday household cleaning products. At the same time, there have been increasing concerns regarding the potential for contamination of the country's air, water, and land resources resulting from the production, use, and disposal of the many new products and byproduct contaminants needed in the production of these products. For many of the newly recognized contaminants, environmental and public health experts often do not have a complete understanding of the toxicological significance to the environment and human health (particularly, effects of long-term exposures at low-levels).

Currently, six contaminants have been identified as emergent contaminants of concern in Michigan: polybrominated diphenyl ethers, pharmaceuticals, perfluorooctane sulfonate, polychlorinated naphthalenes, tetrahydrofurans, and alkylphenol ethoxylates.

Identified Contaminants

Polybrominated Diphenyl Ethers

Polybrominated diphenyl ethers (PBDEs) are a family of chemicals used as flame-retardants that are added to plastics and textile coatings. They may be found in a variety of consumer products such as computer monitors, televisions, textiles,



and cushion and upholstery foams. Commercial production of PBDEs began in the 1970s. Three commercial PBDE mixtures have been produced: decabromodiphenyl ether (Deca-BDE),



octadecabromodiphenyl ether (Octa-BDE), and pentabromodiphenyl ether (Penta-BDE). While Deca-BDE has accounted for more than 80 percent of the PBDE production, Penta-BDE (Congeners 47, 99, and 100) and Octa-BDE (Congeners 153, 154, and 183) appear to be the two formulations of greatest concern to human health and the environment.

PBDEs can enter the air, water, and soil during their manufacture and use in consumer products. In an Indiana University study, air samples were analyzed from the mid-1997s to mid-1999s from urban, rural, and remote sites near the Great Lakes to investigate the occurrence, concentrations, and spatial and temporal differences of PBDEs. PBDEs were found in the air in both the particulate and gas phases. The levels of PBDEs encountered ranged from a low of five picograms per cubic meter (pg/m^3) near Lake Superior to about $52 \text{ pg}/\text{m}^3$ in Chicago. The observed levels remained relatively constant during the sampling period.

It is not possible yet to determine how long PBDEs remain in the air; however, PBDEs eventually do return to land or water by settling and being washed out by snow and rainwater. PBDEs do not



eggs collected from Lakes Erie, Huron, Michigan, Ontario, and Superior herring gull colonies in Canada and the United States (Exhibit 93).

Exhibit 94 shows PBDE concentrations found in herring gull eggs from nine colonies located within the Great Lakes waters of Michigan. The largest concentrations of PBDEs occurred in the Lake Michigan colonies (Big Sister Island and Gull Island). The Canadian government also analyzed PBDE concentrations from archived herring gull eggs collected from two Michigan colonies (Channel-Shelter Island in Lake Huron and Gull Island in Lake Michigan) between 1981 and 2000. These data show a general and, at times, exponential increase in PBDE concentrations in herring gull eggs in both colonies over the 19-year period (Exhibits 95 and 96). The Canadian Wildlife Service and Environment Canada have indicated that the collection of this information will continue in the coming years.

dissolve easily in water and, therefore, high levels of PBDEs are not found in water. The small amounts of PBDEs that do occur in water adhere to particles and eventually settle to the bottom. Sediments at the bottom of lakes and rivers generally act as reservoirs for PBDEs, and the PBDEs can remain there for years. In general, the breakdown of PBDEs in soils is very slow. PBDEs bind strongly to soil and do not normally leach deeply into soil with rainwater.

PBDEs have been found in a variety of Scandinavian, Japanese, and North Atlantic mollusk, fish, and bird species since 1979. Among fish from the Great Lakes, PBDEs have been found in varying concentrations in smelt from Lake Ontario, lake trout from Lakes Erie, Huron, Ontario, and Superior, and salmon from Lake Michigan tributaries. PBDEs were recently added to the list of contaminants monitored as part of the state/federal Chinook and Coho Salmon Trend Monitoring Program, the USEPA Whole Fish Trend Monitoring Program, and the USEPA's National Inland Lake Fish Contaminant Monitoring Study. In addition, the Michigan Great Lakes Protection Fund provided a grant to the USGS to analyze PBDEs in archived fish tissue.

In 2000, the Canadian Wildlife Service and Environment Canada analyzed PBDEs from

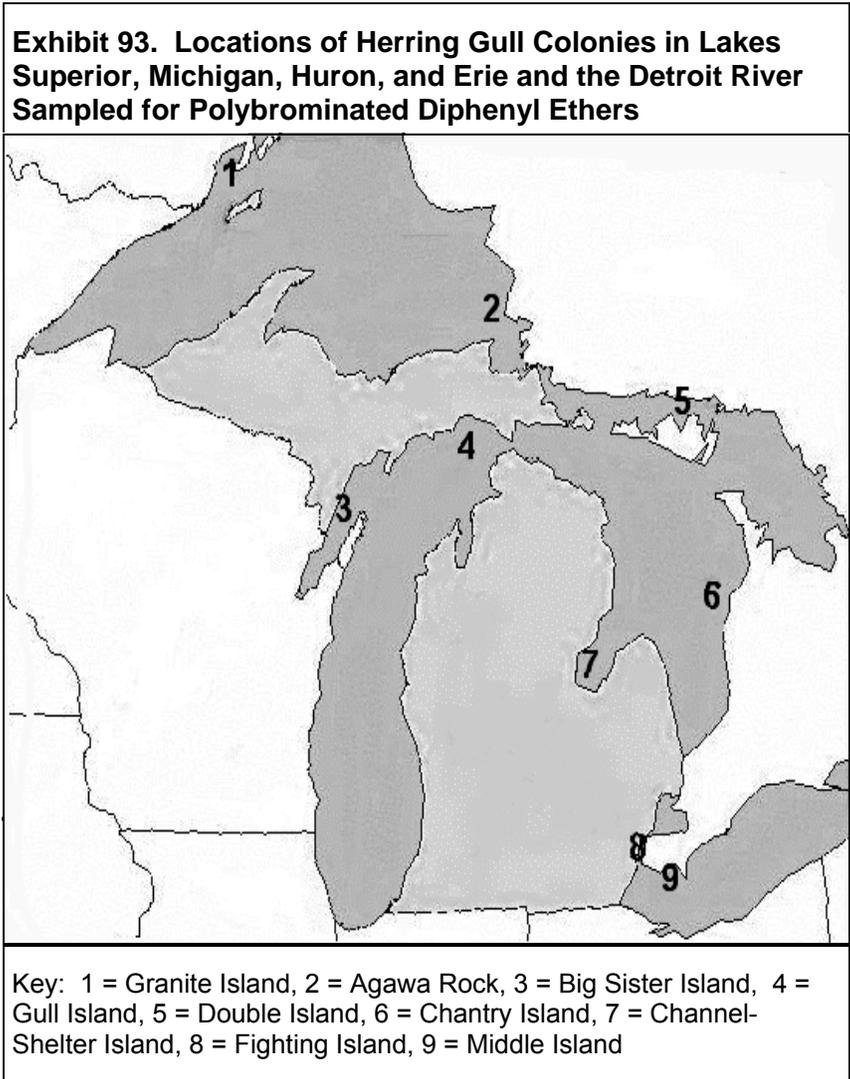
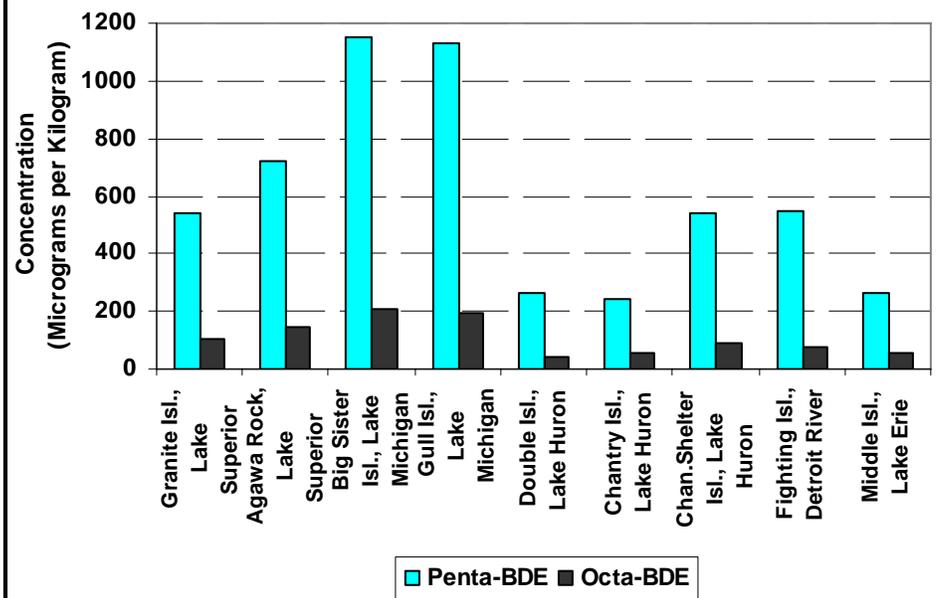


Exhibit 94. Polybrominated Diphenyl Ether Concentrations in Herring Gull Eggs from Great Lakes Colonies 2000



decisions regarding the addition of PBDEs to the state's *Critical Materials Register* (CMR) and to proposed Michigan legislation restricting the manufacture and distribution of certain PBDEs.

A preliminary recommendation emanating from the technical workgroup is that PBDEs should be added to the state's CMR. The CMR is a list of chemicals located in the Waste Water Reporting Rules of Part 31, Water Resources Protection, of 1994 Public Act 451. All facilities having a non-sanitary wastewater discharge are required to report annually on their use, discharge, and disposal offsite of chemicals listed on the CMR. The addition of PBDEs to the CMR also would trigger their consideration for placement on the

Although PBDEs have been detected in air samples, indicating that inhalation may be one exposure route for the general population, the main source of human exposure to PBDEs is considered to be consumption of foods with high fat content (e.g., such as fatty fish). PBDE concentrations have been found in human breast milk, blood plasma, and whole blood samples. In one Swedish study, PBDEs were found to have increased 50-fold between 1972 and 1997 in human breast milk. The toxicity of PBDEs to humans has not been fully investigated.

List of Polluting Materials located in the Part 5 Rules, Spillage of Oil and Polluting Materials, of 1994 Public Act 451. Chemicals on the Polluting Materials List are regulated with respect to their storage and accidental release. Currently, all chemicals on the CMR also are on the List of Polluting Materials.

A technical workgroup was formed at the request of the MDEQ to summarize available information on PBDEs. The technical workgroup, consisting of toxicologists from the MDEQ and a toxicologist from the Michigan Department of Community Health, drafted a document summarizing the available data on PBDEs. The report is currently being revised based on comments received on the first draft. The data collection was requested in order that state officials can make informed

Exhibit 95. Polybrominated Diphenyl Ether Concentrations in Herring Gull Eggs from Channel-Shelter Island, Saginaw Bay, Lake Huron 1981 - 2000

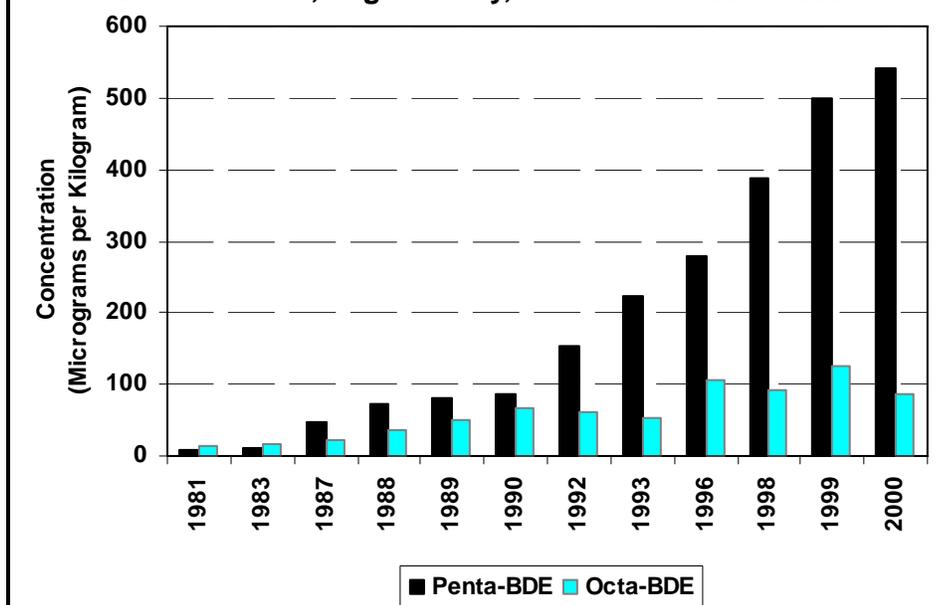
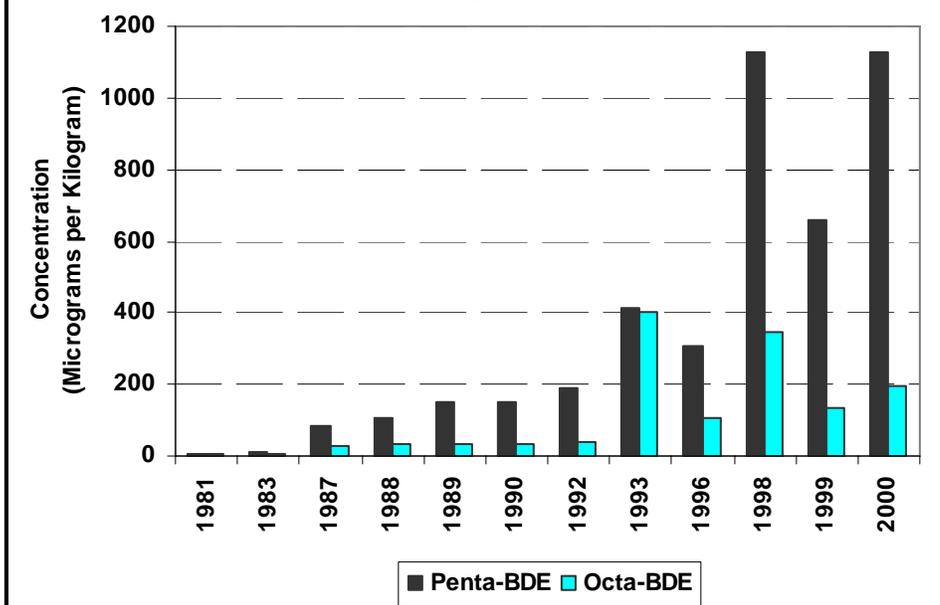


Exhibit 96. Polybrominated Diphenyl Ether Concentrations in Herring Gull Eggs from Gull Island in Lake Michigan 1981 - 2000



is often applied as a soil amendment.

According to the USEPA, certain pharmaceuticals, such as caffeine, nicotine, and aspirin, have been known for over 20 years to enter the environment through municipal sewage. Only more recently, however, has a larger picture



In 2005, legislation was passed in Michigan that placed restrictions on Octa-BDE and Penta-BDE due to their persistence, bioaccumulation, and toxicity. The legislation prohibits the manufacture, processing, and distribution of products containing more than one tenth of one percent of Octa-BDE or Penta-BDE beginning on June 1, 2006. The legislation does not apply to “original equipment manufacturer replacement service parts or the processing of recyclables” containing Octa-BDE or Penta-BDE. The sole United States manufacturer of Penta-BDE and Octa-BDE has agreed to cease production of these two substances. Given the impact of the recent legislation affecting Octa-BDE and Penta-BDE, the technical workgroup is currently researching available human and environmental health information on Deca-BDE for inclusion in its final report.

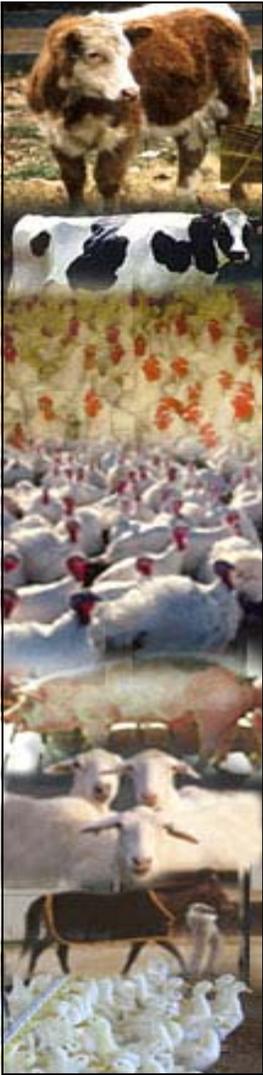
emerged where it has become evident that numerous other drugs and personal care products also are being released to the environment. The scope of the issue is poorly defined because the numbers and types of pharmaceuticals being released.

The routes of release of pharmaceuticals to the environment include treated and untreated sewage effluent from municipal waste water treatment plants, runoff from the land (e.g., from confined animal feeding operations and facilities caring for medicated pets), and by wind-borne drift of agriculturally applied antimicrobials to crops.

Pharmaceuticals

The existence of pharmaceuticals as environmental pollutants is a multifaceted issue. Pharmaceuticals typically occur as trace environmental pollutants (primarily at ppb to ppt levels in surface waters and ground waters) as a result of their widespread, continuous, and combined usage in a broad range of human and veterinary therapeutic activities and practices; and their occurrence in treated sewage sludge, which

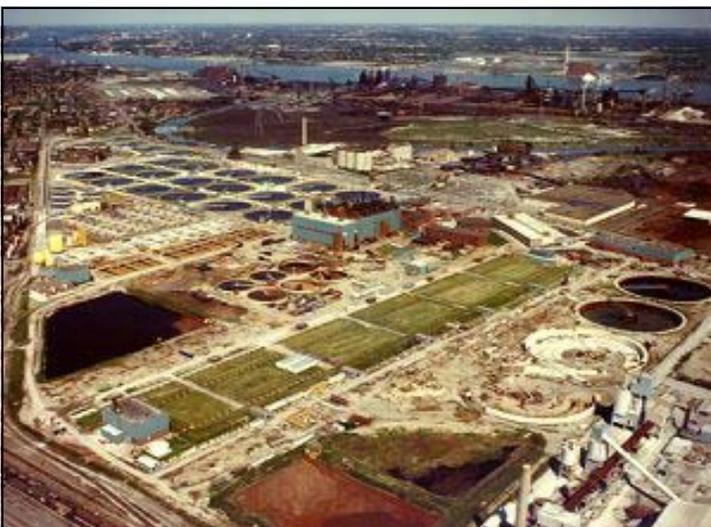




The growing body of published work regarding risk assessment has focused primarily on the origin, sources, and occurrence of pharmaceuticals in the environment. Comparatively less is known about human and ecological exposure, and much less yet is known about the potential health hazards associated with exposure to pharmaceuticals.

During 1999 and 2000, the USGS measured concentrations of 95 pharmaceuticals, hormones, and other organic wastewater contaminants (contaminants) in water samples from a network of 139 streams across 30 states – including Michigan. Contaminants were found in 80 percent of the streams sampled. The compounds detected represent a wide range of residential, industrial, and agricultural origins and uses with 82 of the 95 contaminants being found during the study.

The most frequently detected compounds in the study were coprostanol (fecal steroid), cholesterol (plant and animal steroid), N,N-diethyltoluamide (insect repellent), caffeine (stimulant), triclosan

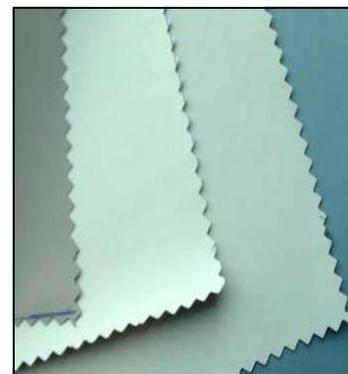


(antimicrobial disinfectant), tri(2-chloroethyl) phosphate (fire retardant), and 4-nonylphenol (nonionic detergent metabolite). Measured concentrations for this study were generally low and rarely exceeded drinking-water guidelines, drinking-water health advisories, or aquatic-life criteria. Many compounds, however, do not have such guidelines established. Little is known about the potential interactive effects (such as synergistic or antagonistic toxicity) that may occur from complex mixtures of contaminants in the environment.

Additional information regarding the many issues surrounding pharmaceuticals as environmental pollutants may be found on the USEPA Internet site (www.epa.gov/nerlesd1/chemistry/pharma/).

Perfluorooctane Sulfonate

Perfluorooctane sulfonate (PFOS) is a breakdown product of surface protectors used in carpets, leather, paper, fabric, and upholstery. PFOS can be persistent in the environment and bioaccumulative in various food chains. Based on tissue and blood plasma analysis from



14 mammal, 13 bird, 7 fish, 2 reptile, and 1 amphibian species, PFOS has been found to be widely distributed among wildlife on a global scale. Concentrations of PFOS in animals from relatively more populated and

industrialized regions have been found to be greater than those in animals from more remote locations.

Within Michigan, PFOS has been documented in double-crested cormorants, herring gulls, ring-billed gulls, lake whitefish, brown trout, Chinook

salmon, green frogs, and snapping turtles. In 2001, the MDEQ collected 41 water samples from 23 surface water locations and analyzed them for PFOS. Sample concentrations ranged from <0.5 to 29 nanograms per liter, with a median PFOS concentration of 3.1 nanograms per liter. The MDEQ is evaluating the significance of these results to determine what follow-up measures may be warranted.

Although little information is available on possible toxic effects of PFOS to wildlife, PFOS and related perfluorinated compounds have been shown to affect cell-to-cell communication and membrane transport and process of energy generation in animals. Currently available data indicate that concentrations of PFOS in wildlife are less than those required to cause significant adverse effects in laboratory animals. PFOS was recently added to the list of parameters monitored as part of the state/federal Chinook and Coho Salmon Trend Monitoring Program, and the USEPA's Whole Fish Trend Monitoring Program. As more information becomes available, a more refined assessment of the risk to wildlife may be possible.

Polychlorinated Naphthalenes

Polychlorinated naphthalenes (PCNs) are a group



of compounds that are used as cutting oils, engine oil additives, insulation, water repellents, and some wood, paper, and fabric preservatives. PCNs are persistent and tend to bioaccumulate in the environment. PCNs have been found in the Arctic, urban air, wildlife, and human tissues including breast milk.

Consumption of contaminated fish is considered to

be an important route of exposure of humans to PCNs. In a 2000 study, PCNs were measured in fish whole body and fillets collected from Michigan waters, including the Great Lakes, during 1996 – 1997. PCNs were found in all the fish analyzed. Concentrations of total PCNs in fish ranged from 19 picograms per gram to 31,400 picograms per gram (wet weight). In addition, in a joint study involving the MDEQ, Yokohama (Japan) National University, and MSU, sediment from the upper Detroit and lower Rouge Rivers in southeast Michigan and sediments from a nonpoint source location in Lake Michigan were analyzed, PCNs were found in all sediments from all locations with their concentrations ranging from 0.08 nanograms per gram to 190 nanograms per gram. PCNs were recently added to the list of parameters monitored as part of the state/federal Chinook and Coho Salmon Trend Monitoring Program, and the USEPA's Whole Fish Trend Monitoring Program. Additional information on this substance will be provided in the next Biennial Report.

Tetrahydrofurans

Tetrahydrofurans are substances that have been steadily increasing in production since the 1980s. Tetrahydrofurans are utilized in the production of elastomers, fibers, cements, coatings, and various other products. They also may appear in environmental emissions from various chemical production facilities. In 1998, the National



Toxicology Program concluded that under inhalation exposures, tetrahydrofurans demonstrated clear evidence of carcinogenicity in female mice and some evidence of carcinogenicity in male rats. The USEPA has not regulated

tetrahydrofurans as a carcinogen yet, In order for that to take place, the substance will need to have a draft toxicological profile completed for the USEPA's Integrated Risk Information System database and then be subject to an external peer review.

Alkylphenol Ethoxylates

Alkylphenol ethoxylates are used in various industrial processes. Alkylphenol ethoxylates degrade into more toxic chemicals in the aquatic environment. The breakdown compounds are moderately bioaccumulative and, in particular one, nonylphenol, is considered a possible endocrine disrupter. In a joint study involving the MDEQ, Yokohama (Japan) National University, and MSU, the alkylphenolic breakdown compounds were found in the sediments from upper and lower segments of the Detroit and Rouge Rivers. Nonylphenol was the most predominant among the breakdown compounds analyzed with its concentration ranging from less than 10 nanograms per gram to 60,000 nanograms per gram (dry weight). The MDEQ is not aware of any routine monitoring programs for alkylphenol ethoxylates in Michigan. It is anticipated that additional information on the contaminant will be available for presentation in the 2007 Biennial Report.



PHOTOGRAPH AND EXHIBIT CREDITS

- Animals:** *Bear, Frog* - MDNR; *Toad, Chickadee* – Linda Albro Sparks; ; *Bald Eagle* - USEPA Great Lakes National Program Office; *Juvenile Bald Eagle, Canadian Lynx, Asian Carp* - USFWS; *Kirtland's Warbler* – Ron Austing; *Emerald Ash Borer* – Michigan Technological University; *Zebra Mussel* - Dave Brenner; *Herring Gulls* - Chris Gregerson.
- Plants:** *Lichen* - MDNR; *Trillium in Woods* - Corey Sparks; *Frogbit, Purple Loosestrife* - Dave Brenner.
- Air:** *Air Monitors, Factory* - MDEQ; *Traffic* – Linda Albro Sparks; *Satellite Image of Michigan* - NOAA/NASA, *Three Stacks with Smoke* – William Taft; *Fermi Nuclear Plant* - www.NukeWork.com, *Factory across River and Three Smoke Stacks* – Corey Sparks.
- Water:** *Ice Breaker* - US Coast Guard; *Wetland, Road Construction, Angler on Shore, Sewer Overflow, Stream Assessment, Sediment Collection Boat and Sampler; Waste Water Treatment Plant* - MDEQ; *Invasive Species 2005 Poster* - Rachel Clark *Grand River Forest, Boys on Beach, Ambassador Bridge, Detroit River Beach* - Corey Sparks; *Angler in Boat, Au Sable River, Boys at Fountain, Beach with Kids* - Linda Albro Sparks; *Freighter "Irma", Little Girl on Beach* – Jesse Harrold; *Freighter Releasing Ballast* – MIT Sea Grant for Coastal Resources; *Freighter and Tugboat* - USEPA; *Great Lakes Map, Lake Michigan High and Low Water, Annex Partners Map* - NOAA; *Cook Nuclear Plant* - www.NukeWork.com.
- Land:** *Conservation Filter Strip* - USEPA; *Road Construction, Truck at Landfill, Labeled Hazardous Waste, Hazardous Waste Treatment Facility, Before and After of Bay City Double Tree Hotel and Convention Center, Oil Well, Old Tires* - MDEQ; *Underground Storage Tank Removal* – Michael Charbonneau; *Confined Animal Feedlot Operation* – USEPA; *Monitor, Pills, Pharmacy; Fabric, Foam Cushion, Insulation* - Unknown.
- Collages:** *Title Page, Ecological Measures, Programmatic Measures and Emergent Contaminants* - Linda Albro Sparks, Corey Sparks, David Kenyon, Keith Harrison, USEPA, USFWS, MDNR, MDEQ, and Various Others.
- Exhibits:** *Exhibit 1* - Michigan Environmental Science Board; *Exhibits 32 and 33* – Michigan Natural Features Inventory; *Exhibit 5* – Public Sector Consultants; *Exhibit 6* – Michigan Land Use Leadership Council; *Exhibits 2, 3, 4, 8 - 18, 21 - 28, and 59* - MDNR; *Exhibits 7, 19, 20, 28, 29 - 31, 38 – 58, and 64 – 92* – MDEQ; *Exhibit 34* – National Oceanic and Atmospheric Administration and Michigan Technological University's Center for Exotic Species; *Exhibit 35* - MDA; *Exhibit 36* – Anthony Ricciardi; *Exhibit 37* – Edward Mills; *Exhibit 51* - Gregg Ferris, Environment Canada; *Exhibit 60* - US Army Corps of Engineers; *Exhibit 61* - SOLEC; *Exhibits 62 and 63* - Air Improvement Resource, Inc; and *Exhibits 93 – 96* – Ross Norstrom, Mary Simon, John Moisey, Bryan Wakeford, D.V. Chip Weseloh, and Environment Canada..

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