# II. Technological Hazards
# B. Infrastructure Problems

The following list summarizes the broad types of infrastructure problems covered in this section:

1. Infrastructure Failures
2. Energy Emergencies
3. Transportation Accidents (air, rail, highway, marine)

A specific chapter is dedicated to infrastructure failures. Although various industrial hazards involve certain types of infrastructure (e.g. pipelines), and their breakdown, and this entire section of the hazard analysis relates to other types of infrastructure, the chapter specifically called infrastructure failures focuses upon interruptions in the provision of critical life-sustaining infrastructure, such as electricity and water supplies. As reported in a 2009 study by the National Academy of Sciences, an electrical blackout "has the potential to affect virtually all sectors of society: communications, transportation, banking and finance, commerce, manufacturing, energy, government, education, health care, public safety, emergency services, the food and water supply, and sanitation." Moreover, modern technological systems tend to be vulnerable to two trends that have been called "dependency creep" and "risk migration." These can be summarized as follows: "As systems become more complex, and as they grow in size, understanding and oversight become more difficult. Subsystems and dependencies may evolve that escape the close scrutiny of organization operators. Dependencies allow risk present in one part [of the] overall system to 'migrate' to others, with potentially damaging results. GPS and electric power systems have clearly accelerated dependency creep, and consequent risk migration. New technologies, such as nanoscale components, may not be adequately understood in the context of" existing risks to electric power systems.

One of the overarching patterns to be found within technical systems is the tradeoff between efficiency and vulnerability. Reserve capacity within a system can serve as a means for dealing with uncertainties and contingencies. In a competitive market environment, systems operate close to their full capacity and maximum efficiency during times when everything is functioning smoothly and predictably. Under such ideal conditions, "buffers shrink, costs fall, and profits rise," but when something in the operating environment breaks down, as in the case of a disaster or system failure, "unexpected developments perturb the system, finely tuned technical systems become brittle and have trouble operating outside relatively narrow parameters. Vulnerability can be the consequence of increased efficiency." Within this framework, solutions may involve the use of systems designed to include "excess capacity: costs are passed on to users and the society" as part of this operational design, rather than in the form of disaster response efforts after a failure has already occurred. Extra security may come at the expense of decreased efficiency, but the costs can be more fairly spread across the users of the technology, rather than concentrated in disastrous events. This problem of system management operates in an environment of "interdependencies, lack of knowledge, lack of slack, lack of trust, and lack of ways to overcome coordination problems." However, they key to the mitigation of problems in such complex systems can probably be found through addressing each of those conditions, point for point, and together as a whole.

> "Systems can quickly become dependent upon new technologies in ways that are unknown and unexpected by both developers and users… vulnerabilities in one part of the broader system have a tendency to spread to other parts of the svstem."

(The information and quotations in the preceding two paragraphs and text box were primarily obtained from "Severe Space Weather Events—Understanding Societal and Economic Impacts: A Workshop Report – Extended Summary," the National Academies Press, Washington DC, 2009.)

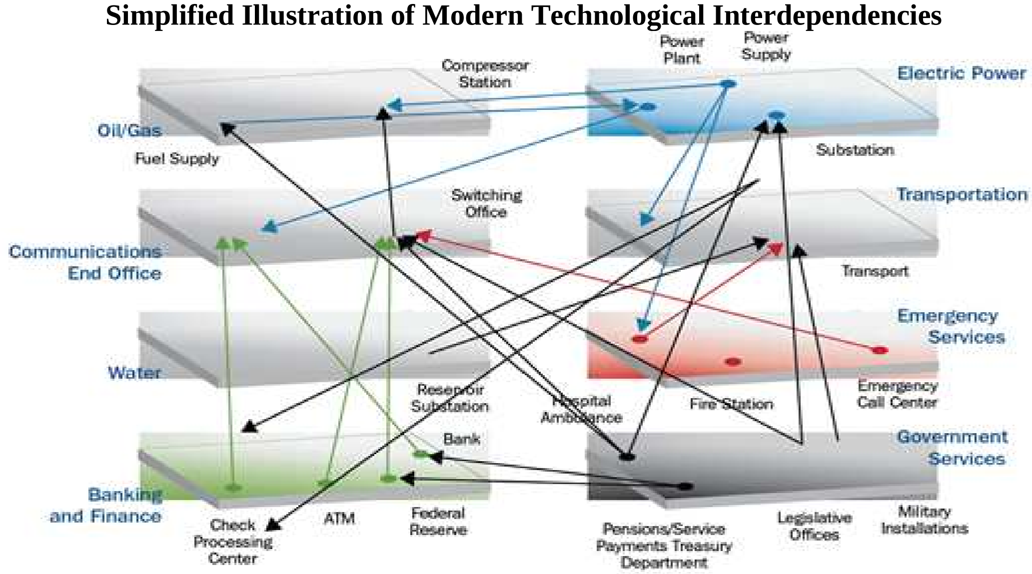
For the 2012 update of the MHA, new consideration has been given to aspects involving the safety and integrity of the built environment—bridges and structures—in addition to the traditional problems that had been covered in previous editions: broken water mains, sewage system breakdowns, and widespread and extended power failures. Energy emergencies are then discussed in a separate section, describing potential vulnerabilities involving breakdowns in the availability of key energy sources that power most of our modern activities—especially gasoline, electricity, natural gas. Finally, the last section deals with major transportation accidents that might involve any of the major modes of our transportation system.

Overlap Between Infrastructure Problems and Other Sections of the Hazard Analysis

Some specialized forms of infrastructure are addressed in other sections of this document—dam failures appear in the Hydrological Hazards section because they can be a direct cause of flooding. Urban flooding is closely related to failures in the drainage infrastructure, and is included in the Hydrological Hazards section, as part of the Riverine Flooding chapter. Many of the ordinary means that enable weather hazards to be regularly endured (winds, storms, and extreme temperatures) involve the provision of adequate means of safely sheltering and transporting people, goods, and services in spite of such weather events. Storm events are a major cause of infrastructure failures, which then expose people more directly to the severe weather extremes that occur in Michigan's climate. Hail, ice, lightning, and strong winds have all caused breakdowns in electrical supply, for example, which in turn may expose persons to extreme cold or heat. Floods are often prevented through the use of drains and pumps and structures, and a breakdown in the functions of such infrastructure can lead to extensive flood damages.

There are cases in which various industrial accidents and technological hazards might arise from failures in the electrical or water supply system, which may be needed for the maintenance and cooling of complicated processes, and without which some disastrous fire, explosion, or release of hazardous materials might occur. Infrastructure failures may lead to energy shortages, a breakdown in vital health care, transportation, and communication services, thus having not only a costly economic impact but also putting lives at stake. Public health emergencies, in particular, may arise from the effects of a breakdown in sanitation infrastructure, or power failures that cause breakdowns in food supply and preservation chains (refrigeration, processing, and storage conditions). In addition to being able to hinder emergency response capabilities, infrastructure failures can also make it more difficult to maintain the effectiveness of law enforcement services, and thus enable criminal activities (e.g. looting) to increase. Certain types of civil disturbance or terrorism might be more likely to arise in circumstances involving lengthy power failures. Many types of catastrophic incidents would be expected to disrupt energy supplies or infrastructure in some way. Some types of hazards (e.g. earthquakes, space weather) are most likely to cause damage through their effects on Michigan's infrastructure, rather than in direct harm to humans. The space weather hazard in particular (addressed in the chapter on Celestial Impacts) needs to gain new recognition, because satellites have now become a type of critical infrastructure.

**Simplified Illustration of Modern Technological Interdependencies**




Source: Department of Homeland Security, through the National Academies Press

# INFRASTRUCTURE FAILURES

*The failure of critical public or private utility infrastructure that results in a temporary loss of essential functions and/or services.*

***Hazard Description***

Michigan's citizens are dependent on public and private utility infrastructure to provide essential life-supporting services such as electric power, heating and air conditioning, water, sewage disposal and treatment, storm drainage, communications, and transportation. When one or more of these independent, yet interrelated systems fail due to disaster or other cause – even for a short period of time – it can have devastating consequences. For example, when power is lost during periods of extreme heat or cold, people can literally die in their homes if immediate mitigation actions are not taken. When the water or wastewater treatment systems in a community are inoperable, serious public health problems can arise that must be addressed immediately to prevent outbreaks of disease. When storm drainage systems fail, due to damage or an overload of capacity, serious flooding can occur.

These are just some examples of the types of infrastructure failures that can occur, and all of these situations can lead to disastrous public health and safety consequences if immediate actions are not taken. Typically, it is the most vulnerable members of society (i.e., the elderly, children, impoverished individuals, and people in poor health) who are the most heavily impacted by an infrastructure failure. If the failure involves more than one system, or is large enough in scope and magnitude, whole communities and possibly even regions can be severely impacted. (Note: Refer to the Dam Failures and Petroleum and Natural Gas Pipeline Accidents sections for more information on those particular types of infrastructure failures.)

***Hazard Analysis***

Infrastructure failures can affect hundreds of thousands of Michiganders when the conditions are "right" for a loss of critical systems. Melted transformers, ruptured pipes, crumbled bridges, and exploded transformers can cause inconvenience or havoc around the nation and the state, depending on the severity of the problem. The risk of infrastructure failure grows each year, as physical and technological infrastructure gets steadily more complex, and the interdependency between various facets of infrastructure (like pipelines, telecommunications lines, and roads) becomes more intertwined. Additionally, more vulnerable and aging infrastructure (rail lines, electrical components, bridges, roads, sewers, etc.) is in need of repair. Because of these reasons, large-scale disruptions in various components of infrastructure are likely. Major disruptions could lead to widespread economic losses, limit security, and altered ways of life.

Infrastructure failures can occur at any time and in any place in the state of Michigan. The metropolitan areas may be the most susceptible to interruptions in infrastructure, due to the additional volume of critical components of transportation, power, water, and telecommunication networks. Residents of these areas are also less likely to have adequate measures to "get through" infrastructure failures with generators, wood, and fireplaces. Economic losses from incapacitated business and industry are great in these areas. In northern regions of the state, there are fewer networks of infrastructure, but greater geographic areas are affected during infrastructure failures. Downed lines or blocked roads affect many more square miles than a similar occurrence around Detroit, but there are far fewer individuals and businesses at risk.

Although Michigan has in place many codes and standards that govern the design, construction and operation of public and private utility infrastructure, these codes and standards are often inadequate to protect the infrastructure from disaster-related damage. In many cases, the codes and standards call for the minimum level of structural integrity and operational performance recommended in accepted engineering practice, when a higher level would result in less disaster damage. Obviously, a balance must be reached between structural integrity, operational reliability, and short- and long-term costs associated with upgrading facility codes and standards.

It is possible to design and operate facilities that are virtually "disaster-proof." However, in many cases it is not economically feasible to do so. Too extensive of increases in integrity and reliability can result in prohibitive increases in cost. It is often too expensive to upgrade infrastructure codes and standards much beyond their current levels. However, in those cases where recurring, severe damage and system down-time occur due to natural or technological hazard events, it makes sense to explore the possibility of enhancing infrastructure design, construction, and operational codes and standards. The State of Michigan, in concert with public and private utility providers, is in the beginning phases of doing so through its statewide hazard mitigation efforts.

As Michigan's public and private utility infrastructure systems continue to age, infrastructure disasters will undoubtedly become more common. Because many of these systems were developed decades ago, the costs of repairing and replacing aging sections and/or components have greatly increased. As a result, many communities cannot afford to do the maintenance work necessary to keep the system in ideal operational mode. Increasing demands on the systems also lead to increased deterioration, and many components have far exceeded their useful service life. This creates a situation of increasing risk from infrastructure-related disasters, either as a primary event, or as a secondary event from floods, windstorms, snow and ice storms, or other natural or technological hazards. When those disasters do occur, they cause great inconvenience to the affected population and they can also create severe public health and safety concerns. Some urban deterioration includes missing manhole covers, sewer grates, chain link fences, and the occasional disappearance of signs from city streets. This type of issue is found more often in blighted neighborhoods. Cities already lacking in funds are forced to spend time and resources to mark the exposed manholes and sewers with construction barriers before they cause harm to vehicles and pedestrians. Workers also are forced to bolt down the covers and grates of cities' metal coverings.

The national economic downturn that began in 2007 has affected Michigan as much as any other state in the country, having the highest unemployment rate in the nation for many consecutive quarters. There will be less tax revenue, due to people leaving the state, the loss of jobs (particularly within the auto industry), and declines in property values, risking a loss of funding for construction/repairs. Michigan roads also suffer because of the fixed per-gallon gas tax (used to match federal funding and pay for road work) which stays constant, even when the costs of fuel and materials increase. Gas tax, diesel fuel tax, and vehicle registration fees collected in 2008 were the same as the amount collected in 1998. The effects of inflation contribute to a substantial reduction in the amount of (real) funds available for repairs. The 1946 to 1964 baby boom age cohort (defined by the United States Census) is currently approaching retirement age, or has already retired, and many may move to the southern United States for warmer weather, newer infrastructure, etc. which further threatens state tax revenue levels.

According to the Michigan Asset Management Council, the condition of 10,000 miles of Michigan's federal aid eligible roads went from either "good" or "fair" to "poor" between 2004 and 2007. According to the US Census Bureau, Michigan has been ranked in the bottom ten of all states for over 40 years in its level of funding. After a decade of stagnant revenues in road funding, the Michigan Department of Transportation (MDOT) showed an additional 15 percent decline in funding between 2008 and 2011. Another challenge for Michigan's roads and bridges is the annual winter freeze and thaw cycle that causes a continual breakdown of road and bridge surfaces. According to the July 2008 report by the Citizens Advisory Committee on Transportation Funding, Michigan's roads and bridges will require an estimated annual investment of $6.1 billion, which is nearly two times the current funding level, for basic improvements to its road and bridge system.

### Transportation Funding Task Force (TF2)

The Transportation Funding Task Force was created in response to Public Act 221 of 2007 (P.A. 221 or Act 221), legislation which passed both the Michigan Senate and House of Representatives with a bipartisan majority and was signed into law in December 2007. The purpose of the Task Force, as defined by P.A. 221, is to "review the adequacy of surface transportation and aeronautics service provision and finance" in Michigan, review strategies for maximizing the returns on transportation investment, and evaluate the potential of alternative strategies to replace or supplement transportation taxes and fees. A major and consistent focus of the group has been the need to stimulate economic activity and enhance personal mobility.

What the Task Force ultimately determined was that Michigan is approaching a crisis of infrastructure funding caused by the steady erosion of purchasing power, continued inflation in materials costs, and a decline in fuel-tax revenues due to spikes in gas prices, reduced travel, and a slowed economy. The decline in revenues, and a corresponding increase in demand for travel alternatives, has exposed the structural problems within the current mechanisms for transportation finance. For the past several years, the transportation revenue stream has been enhanced with bond revenues to provide a more robust level of investment. As a result, Michigan has made progress, particularly in improving the condition of the most highly used highways and bridges, but that bonding cannot continue without additional revenue.

Based on the information at their disposal, the Task Force could only conclude that much more investment in transportation is absolutely necessary. The Task Force learned that transportation agencies have been relentlessly vigilant in stretching their shrinking revenue. Their efforts may go unnoticed, because cost-cutting measures are designed not to disrupt service or impose on customers. Given the current state of the national economy, there is no guarantee that the federal government will come to Michigan's transportation rescue. Even if they did, Michigan is not in a position to take advantage of new federal funding. 2008 was the last year Michigan had enough state and local matching funds to claim all the federal transportation funding made available to the state. Some local agencies are already unable to make use of all federal transportation funding. In 2010 this became true across all transportation modes. Michigan must increase investment in transportation or past investment will be put at risk, and necessary infrastructure and transportation services will deteriorate.

The National Surface Transportation Policy and Revenue Study Committee recommended that investment in transportation by all levels of government should be at least $225 billion per year, an increase of 161 percent compared to national capital investment today of $86 billion. Michigan may lose up to $1 billion in federal funds each year, if transportation agencies do not have enough revenue to provide the required matching funds. The condition of Michigan's infrastructure would deteriorate, with 30 percent of Michigan roads predicted to decline into poor or fair condition during the next decade. The condition of airport pavement will also decline, with the average airport pavement already needing rehabilitation as of 2012, and crucial aviation safety programs threatened with termination or reduction in scope. Existing local transit services and intercity passenger rail services will be reduced, and intercity bus service to rural areas might be eliminated.

Restoring Michigan's investment in transportation has the potential to accomplish valuable and much needed changes. According the referenced study, the "good" level of investment was predicted to sustain 126,000 Michigan jobs, attract new businesses, and open new global markets for Michigan products and services. It will yield roughly $41 billion in other economic benefits for all sectors of the Michigan economy. For highways, roads and bridges, "good" investment will ensure that the most frequently used roads and bridges remain largely in good condition. For passenger transportation, a "good" investment level will allow transit agencies to begin replacing aging buses with greener, more fuel-efficient vehicles. It is estimated that congestion, poor pavement conditions, and crashes cost Michigan drivers and truckers $7 billion annually in wasted fuel, lost time, vehicle maintenance costs, medical costs, lost productivity, and property damage. Based on economic analysis conducted by the University of Michigan, the Task Force estimates that investment at the "good" level would provide an average Michigan household with an additional $2,000 per year in increased personal income and savings through reduced travel time and vehicle maintenance, and increased safety.

Two recent major engineering studies provide a glimpse of the extent of the infrastructure repair and rebuilding effort required just for Michigan to keep up with current and anticipated demand. The first study, completed by the American Society of Civil Engineers (ASCE) in 2009, found the results listed below.

**Michigan's Top Three Infrastructure Concerns as of September 2008**

1) Roads
2) Wastewater Infrastructure
3) Bridges

**Key Infrastructure Facts**

- 38% of Michigan's roads are in poor or mediocre condition, rated the 3rd worst state in the United States.
- In 2005, 39% of Michigan's urban highways were congested, compared to 23% in 2000.
- Michigan Department of Transportation will have a 15% decline in funding between 2008 and 2011.
- Michigan has the 8th worst road system in the nation, based on overall performance.
- Michigan is 6th in the nation in the total cost of road miles needed.
- A total of 23,000 road lane miles will need to be repaired or replaced by 2015, while expected funding will pay for only 876 lane miles, just 4% of what is needed.
- 25% of Michigan's bridges are structurally deficient or functionally obsolete.
- By 2030, unless additional roadway capacity is added, rush hour travel in major urban areas will take up to 50% longer to complete in Michigan.
- Driving on crumbling roads costs Michigan motorists a total of $2.6 billion per year.
- An additional 30% of Michigan roads will decline to fair or poor condition over the next decade.
- Under current funding mechanisms, Michigan stands to lose nearly $1 billion in federal funds each year, because its transportation agencies will not have enough revenue to provide the required matching funds.
- Michigan's drinking water infrastructure needs $11.3 billion over the next 20 years.
- Michigan's wastewater infrastructure needs $6 billion over the next 20 years.
- Michigan Department of Environmental Quality estimates that less than 40% of the State's stormwater infrastructure has even been reviewed for its impact on water quality.
- 52% of Michigan's schools have at least one inadequate building feature.
- There are 84 high hazard dams in Michigan. A high hazard dam is defined as a dam whose failure would cause a loss of life or significant property damage.
- A significant portion of the state's primary water distribution system is nearly 100 years old, with 80% of the city of Detroit's piping system having been installed before 1940.
- In 2007 alone, 26 billion gallons of raw or partially treated sewage spilled into surface waters in the state of Michigan, and 23 billion gallons, or 88% of the state total of sewage spilled into surface waters, were located in Detroit.

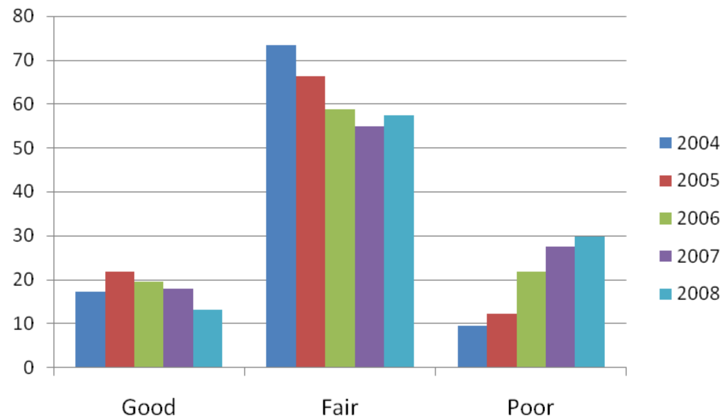
The ASCE study found a common thread nationwide of an increase in demands on public infrastructure without a corresponding increase in funding to perform the necessary maintenance and repairs on facilities, and to rebuild aging or dilapidated facilities.

Another study by the Southeast Michigan Council of Governments (SEMCOG), in 2005, estimated that the costs of replacing aging infrastructure and accommodating new growth in Southeast Michigan will likely top $26 billion over the next three decades, and may go as high as $70 billion when inflation and interest rates are added in. The study estimated that 60-70% of the region's sewers are more than 30 years old and will need extensive repairs or replacement to remain functional. (Nationwide, studies have shown it will cost $1 trillion to fix just the sewer problems alone in the United States over the next two decades.)

The Southeast Michigan Council of Governments (SEMCOG) showed survey data from 2004-2008 that documented a steady decline in the overall pavement condition of the major roads in Southeast Michigan.

Approximately 4,000 miles (10,660 lane miles) of the region's major roads were visually evaluated in 2008. Results of this survey indicate that 13 percent of the road network is in good condition, 57 percent is in fair condition, and 30 percent is in poor condition. SEMCOG also determined that gas tax revenues are declining in both the Federal Highway Trust Fund (HTF) and the Michigan Transportation Fund (MTF) because of higher gas prices causing people to drive less, increases in motor vehicle fuel efficiency and hybrid vehicles, and economic recession.

**Road condition trends, 2004-2008, by percent of lane miles**

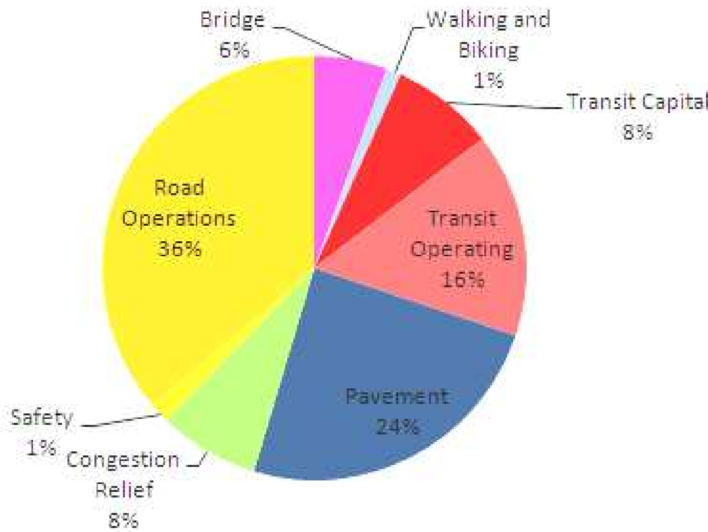



Southeast Michigan Council of Governments (SEMCOG): Direction2035

Direction2035 is the southeast Michigan region's long-range vision for transportation. It demonstrates how the transportation system can lend itself to improving the region overall by contributing to transportation goals, economic recovery, environmental health, community revitalization and stability, and quality of life. It consists of 1,850 transportation projects anticipated over the next 26 years, as well as policies and initiatives to be carried out by both SEMCOG and its partner agencies to keep moving the region in the right direction.

It is estimated that the region would need approximately $2.8 billion per year to address all identified transportation needs; but unfortunately, the region anticipates having only $1.3 billion per year available, a more than a 50 percent shortfall. Direction 2035 shows a need to make sure the region is using its limited funding wisely by addressing the highest priorities first, focusing on preservation of the existing system and implementation of the regional transit vision, and making transportation serve higher regional ideals. Direction 2035 has established the following transportation goals and objectives: enhance accessibility and mobility for all people; enhance accessibility and mobility for freight while maintaining community integrity; strategically improve the transportation infrastructure to enhance community and economic vitality; promote a safe and secure transportation system; and protect the environment, both natural and built.

The mixture of projects is designed to maximize regional goals and improve performance in those areas deemed most important for the region, including bridges, biking and walking facilities, transit, pavement, congestion, and safety. Also, Direction2035 calls for developing a regional transit authority to oversee an advanced transit system, helping local communities become safer and more walkable, coordinating transportation with water and sewer infrastructure needs, and maintaining a high level of security at our borders, ports, and airports. Projects are funded with a variety of federal, state, and local funds.




Michigan is a highly developed state. As such, it is highly dependent on public and private utility systems for the provision of essential life-supporting services, for the movement of people and goods, and for communications and the transmission of information. As a result, the possibility of infrastructure failure must be addressed in every Michigan community through wise system design and community development practices, and through prudent emergency preparedness that takes into account the issues and needs specific to infrastructure failures. In addition, the State of Michigan needs to continue to push for greater system reliability through its infrastructure-related hazard mitigation efforts. Although the problem of infrastructure failure will never be completely eliminated, it can certainly be greatly diminished through proper planning, design, construction, and maintenance practices.

Impact on the Public

Many forms of infrastructure are relied upon by the public, to provide the essential components of a productive modern lifestyle. The supply of fresh water (for drinking, cleaning, washing, cooking, and other uses) may sometimes be interrupted by pipe freezes, breaks, or water main failures. In addition to the need for citizens to find alternative sources of water, there is the potential for certain types of water system failures to allow contaminated water to be delivered and consumed, causing negative public health impacts. Pipe or water main failures may also cause localized damage, erosion, and flooding.

A failure of electric power systems may cause severe problems for persons who rely on medical equipment for their very survival, or for the maintenance of good health. A properly functioning power supply is also essential to maintain the safety of citizens who are working, traveling, attending to domestic matters, or involved in certain types of recreational activities. A sudden power failure may cause (1) traffic lights to stop functioning, (2) traffic patterns to slow dramatically (resulting in traffic jams and delays in emergency response capabilities), (3) interference with important communication networks and needed machinery (including other important infrastructure, such as sewer lift stations and hospital equipment), or (4) sudden darkness when vital operations are taking place or dangerous activities are being performed as a part of people's ordinary occupations and activities. Food storage and safety relies heavily on an ongoing supply of electrical power. A great many community events, business operations, and tourist attractions are similarly reliant upon electrical infrastructure.

Communication systems are vital for emergency response and operations, as well as a great many business functions and personal matters. Failure of communication systems may include (1) an area's mass media (conveying important emergency, health, public awareness, educational, recreational, and economic information), (2) its emergency 9-1-1 systems (allowing residents to quickly call for emergency assistance or to report hazardous conditions), (3) its land-based and/or cellular telephone systems (inhibiting a great number of valuable communications), (4) the internet (an increasingly important means of communicating and running business operations), or (5) specialized radio communication systems (such as those used by police, EMS, and other vital service networks). The impacts include great inconvenience, lost personal and business opportunities, and various degrees of added risk throughout citizens' lives.

Drainage infrastructure failures may cause normally safe areas to become flood-prone, causing all the impacts of that hazard (described previously), but in locations beyond those that are recognized as floodplain and wetland areas. Often, "urban flooding" is the result, in which the drainage capacities of a built-up area are exceeded, and polluted waters back up into streets, basements, yards, parking areas, etc. This causes transportation and access problems, property damages, potential injuries and ill-health, cleaning costs and inconvenience, and the loss of irreplaceable records, artwork, photos and historic documents, and other personal articles. Another type of potential impact is environmental, when sewage processing capabilities cannot be adequately maintained and result in the deposition of untreated sewage into some part of the local environment, such as an area river.

The impacts of transportation infrastructure failures are dealt with in separate subsections elsewhere in this document, under categories such as transportation accidents, pipeline accidents, and hazardous material releases.

Impact on Public Confidence in State Governance

The failure of water systems, including "boil water" advisories or reports of actual or potential contamination, may have a disgruntling effect on some residents' confidence in government, although this would not necessarily be connected with Michigan state government unless it involves inadequate regulations or oversight of local utility providers. (Many water sources are private rather than public.) Some communities have decided to include water contamination issues as a hazard, in their local hazard mitigation plans.

Failure of the electrical power system would likely be similar to that of a water system in its effect, with some citizens being disgruntled and blaming "government," while others are served by private utilities that may be held responsible instead. So long as a power failure is very short and infrequent, most citizens probably have no problem overlooking it.

Failure of transportation systems, on the other hand, is generally considered to be an area of clear governmental responsibility, although the blame for failures will depend upon what kind of failure had taken place. Road maintenance can have local, state, and federal components. Transportation planning tends to involve both local and regional decisions, overseen by state and federal guidelines and regulations. When the safety of major bridges, highways, airports, and railroads comes into question, significantly more weight tends to be placed upon the role of higher-level (e.g. state and federal) agencies than local ones. A bridge collapse like the one that occurred in Minnesota would be expected to result in substantial amounts of dissatisfaction with government, and that event may have increased general concerns about the adequacy of bridges, nationwide. Otherwise, the public is probably more focused upon road conditions and individual driving behavior, rather than larger-scale transportation-related systems and regulatory issues (e.g. airlines, trains, ferries). Please refer to the Transportation Accidents subsection that follows.

Failure of communication systems is not likely to be extensively connected with confidence in government, due to the number of private firms involved, except where these systems are necessary for efficient emergency response and public warning functions during a hazardous situation.

Drainage and sewage infrastructure is most associated with local/county governments, and any dissatisfaction with the capacity of those systems is likely to be directed toward the appropriate agencies at that level, rather than toward the state and federal government. (Also see the subsections on dam failure and flooding, elsewhere in this document.)

Impact on Responders
Many forms of infrastructure are used by responders before, during, and after an emergency event. A good supply of water is needed for firefighting, and for certain types of hazardous materials response operations. Clean water is also used in the provision of emergency medical care, but special reserves of such water may have to be transported to the response sites (or special staging areas, in larger events), if the local water supply has been damaged or found to be insufficient. Water infrastructure failure may severely impede the normal operation of medical facilities, and may also lead to water contamination that poses the risk of public health emergencies.

Electrical power systems are used in most modern activities, and their failure may severely affect responders' notification, warning, and communications systems during an emergency event. Power failures that affect traffic signals can cause traffic jams that interfere with emergency response. Important equipment may need to be run by generator (or other alternative power sources) and thus cause certain types of operations to become more complicated to stage, and less effective. During nighttime events, extra difficulties may be created by the need to find alternative sources of artificial light, and the difficulties of dealing with looters may also be compounded.

Communication systems are vital for emergency operations and response, but are often very difficult to effectively sustain in an organized fashion during emergency events. An inability to convey messages between responders, officials, and the general public may cause preparedness, response, and recovery operations to be severely handicapped. Alternative means of communication are usually less effective and efficient, involving extra time and effort to be expended by responders who could otherwise be engaged in other productive activities.

Failures in drainage infrastructure may cause normally safe areas to become flood-prone, thus potentially causing flood hazards (described earlier) to interfere with responders' effectiveness, safety, and efficiency. The impacts of transportation failures are dealt with in separate subsections in this document (fog, transportation accidents, etc.)

Impact on the Environment
Public and private utility infrastructure failures can negatively impact the environment, as with wastewater collection and treatment facilities discharging various pollutants, contaminants, and raw sewage into the natural environment. Surface water and groundwater discharge facilities can negatively harm the environment with suspended soil sediments, dissolved chemical substances, or biological material, for example. Sewage disposal systems can back up or overflow, causing basement flooding. When sewage processing capabilities cannot be adequately maintained, it may result in the deposition of untreated sewage into some part of the local environment, such as an area river. Pollutants can lead to the poisoning of aquatic wildlife or the creation of vast dead zones, in receiving lakes and waters where there isn't enough oxygen for marine life to survive.

County and watershed drainage systems, and water conveyance and treatment systems, range from small agricultural drains to massive urban storm and sanitary sewer systems. These can contaminate the environment in the event of an infrastructure failure. Detention and retention basins, dams, flood pumps, irrigation diversions, and erosion control structures are also part of the infrastructure. These facilities vary from rural open channels, with drainage areas of several hundred acres, to large river systems with drainage areas of several hundred square miles.

Electric power and telecommunication facilities and systems can have environmental impacts stemming from tree trimming and clearance, the installation and maintenance of overhead lines, or when placing new distribution systems underground.

***Significant Infrastructure Failures in Michigan***
Unfortunately, Michigan has had its share of infrastructure failures, mostly due to the effects of natural disasters such as snow and ice storms, severe cold, windstorms, tornadoes, and floods. Michigan has had numerous widespread and severe electrical power outages, caused mostly by severe weather such as windstorms or ice and

sleet storms. (Note: Refer to those sections for more information on specific events.) Michigan has had several power outages in recent years that left upwards of 500,000 people (roughly 5% of the State's population) without power for periods lasting from several hours to several days at a time. Fortunately, most of those occurred during months when severe cold temperatures were not a problem. If they had occurred during the cold winter months, there certainly would have been a potential for loss of life – especially among the elderly and other more vulnerable members of society.

### 1978, 1980 — Macomb Co., Oakland Co. — Sewer Main Collapse

In 1978, and again in 1980, a large sewer main that served nearly 300,000 residential and business users in northern Macomb and Oakland Counties partially collapsed. The collapses were of such magnitude that continued sewer service to 300,000 users was in peril. Fortunately, officials were able to install temporary sleeves within the damaged main until it could be properly repaired. However, in order to relieve the back-pressure and keep basements from filling with sewage, officials were forced to divert millions of gallons of raw sewage into the Clinton River, fouling miles of Lake St. Clair beaches. Eventually, the damaged sections of sewer main were repaired, but this unfortunate incident caused tremendous disruption and environmental damage to the area. It showed how serious a large-scale sewer infrastructure failure in a densely populated area could be.

### December 1989 — Monroe County — Water Supply Infrastructure Failure

The December 15, 1989 water emergency in Monroe was the result of a water intake in Lake Erie being blocked by ice build-up and Zebra Mussel crustaceans. Officials issued water conservation and boil-water advisories, and schools and most large businesses were closed. Local hospitals limited their activity to emergencies only and referred new patients to out-county hospitals. The hospitals operated on bottled water for the duration of the incident. The fire service was also adversely impacted, invoking mutual aid and stationing tankers throughout the city in case a fire occurred. The city eventually completed an emergency hookup with the Toledo, Ohio water system, which helped alleviate most of the water supply problems. The city also had three pumps drawing water from the River Raisin and pumping it to the water treatment facility. Emergency measures continued for three days. By December 18, the flow of water was back to normal. This incident showed how a vast public infrastructure system can be made inoperable – and thousands of people inconvenienced or even imperiled – by something as small as an aquatic mollusk.

### July 7, 1991 — Electric Power Infrastructure Failure

One of the major electrical blackout events due to storms was on July 7, 1991 when a powerful wind storm affected a large portion of central North America and knocked out power to over 1 million customers from Iowa to Ontario. Almost the entire lower half of the lower penisula of Michigan was affected by the derecho, with wind gusts of 65 to 85 mph. Electrical power was cut off to around 850,000 customers in Michigan alone, which was the largest number of customers to lose power from a single storm up to that time.

### November 1992 — Lansing — Water Supply Infrastructure Failure

A Lansing water emergency occurred on November 15, 1992 when a transformer exploded, causing a power outage to portions of the city. Because a water pumping station was affected, officials were concerned about the loss of pressure and possibility of contamination within the water distribution system (which served Lansing and Delhi Township). Officials issued a boil-water advisory, and bottled water was distributed at four locations in the city. Local hospitals also had to be supplied with bulk supplies of fresh water to meet their normal operational needs. The water emergency was terminated the next day when tests indicated no contamination in the water supply.

### Winter of 1993/94 — Northern Michigan — Water Supply and Sewer Infrastructure Failures

The underground freeze disaster in northern Michigan in 1994 provided an indication of how vulnerable our public water and sewer infrastructure can be to the adverse effects of natural phenomena. Due to a prolonged period of severe cold weather that caused ground frost to greatly increase beyond normal depths, municipal water and sewer systems in ten counties partially failed, disrupting service to over 18,000 homes and businesses and causing over $7 million in infrastructure damage. Some of the homes and businesses were without normal water and sewer service for several weeks. At final count, over 3,200 water and sewer lines had been frozen and/or broken, making this infrastructure failure not only unusual but also unprecedented in U.S. history in terms of scope and magnitude. This disaster showed how vulnerable our underground infrastructure can be when the "right" set of natural conditions occurs. Furthermore, these types of disasters may occur with greater frequency in the future, as our public infrastructure ages and thus becomes more fragile (and since most systems are not built to be "disaster resistant/disaster proof" in the first place).

### June 1996 — Thumb Area — Drainage Infrastructure Failure

The June 1996 flood in the Thumb area, which resulted in a Presidential Disaster Declaration for seven counties, also can be considered an infrastructure disaster due to the severe impact on the drainage system in the region. Because the region's topography is relatively flat, there is extensive use of sub-surface tile and open drainage channels to make the land productive and usable. These drains are critical to the development of the region. Without them, much of the area would become economically useless swampland. The 1996 floods proved just how critical these drainage channels are to the local economy (both agricultural and non-agricultural) and to the citizens of the area. When the drains overflowed, surrounding farm fields were flooded—many for days—killing the crops that had just been planted and preventing further planting and cultivation. In addition, hundreds of culverts were damaged or destroyed and many roads and bridges were washed out, resulting in numerous road closures. The cumulative effects of these events included severe economic losses to both agricultural enterprises and supporting businesses and services. In addition, essential services and daily travel were disrupted, and physical damage to drains, culverts, roads, bridges and other essential facilities resulted in tremendous repair and replacement costs for the affected local jurisdictions.

### December 1998 — Detroit — Natural Gas Infrastructure Failure

Sometimes, failure of one type of utility infrastructure is directly caused by a failure in another type of utility infrastructure. That was the case in Detroit on December 12, 1998, when a 30-inch water main in the downtown area burst, crushing a nearby 12-inch gas main and flooding it with water. Approximately 200,000 gallons of water flooded nearly 20 miles of gas line, shutting down gas service to hundreds of downtown Detroit businesses and residents on both sides of I-375. Officials estimated that 600 buildings (including hotels, offices, restaurants, shops, and residences) were affected by the gas service shutdown. Crews from Michigan Consolidated Gas worked around the clock for the next four days to drain water from the gas lines and hundreds of gas meters, to get gas service restored. Even after restoration was complete, problems and service interruptions continued to plague some structures for several days until more permanent repairs could be made. Michigan Consolidated Gas called the water contamination incident the worst in the company's 150-year history. Economic losses for the affected hotels, restaurants, and other businesses were substantial because the incident occurred during the normally profitable pre-Christmas holiday period.

### May 31, 1998 — Southern Michigan — Electric Power Infrastructure Failure

On May 31, 1998 a derecho with winds averaging 60 to 90 mph (the highest being 130 mph) raced across lower Michigan, causing about 860,000 customers in Michigan to lose electrical power, and around 2 million across the United States. The 860,000 customers became a new historical record in Michigan, slightly exceeding the number of customers that lost power during the Southern Great Lakes Derecho of 1991. Some would not get power back for 10 days. For Consumers Energy utility company, which serves much of western and middle Lower Michigan, this derecho event was considered to be the most destructive weather event in its history.

### June 1999 — Oakland County — Water Supply Infrastructure Failure

On June 7, 1999 a drilling company, hired to relocate fiber optic cable for a new highway interchange, accidentally broke a water main in the city of Auburn Hills, setting off a week-long water emergency that closed hundreds of businesses and schools and forced thousands of residents to boil water, or drink bottled water, until repairs could be made. Local officials estimated that 118,000 residents in over 44,000 households in Auburn Hills, Orion Township, Lake Orion, and Rochester Hills were affected by the water emergency. The crisis forced the closure of several major business enterprises, including the DaimlerChrysler headquarters and technology center, the Palace of Auburn Hills sports arena, and the 200-store Great Lakes Crossing Mall, idling thousands of workers. Businesses outside Oakland County were also affected because of a shortage of parts from suppliers with plants in Auburn Hills and Rochester Hills. Economic losses associated with the water emergency were so extensive that local officials gave up trying to calculate the costs. However, officials estimated that the weeklong ordeal likely caused losses in the tens of millions of dollars.

### January 1, 2000 — Statewide — Y2K – Electric Power Infrastructure Failure

The most anticipated electric power failure in the history of humankind never actually occurred. The much-celebrated year 2000 (commonly known as Y2K) computer conversion crisis was considered by many to be the biggest “non-event” ever. Actually, several years of mitigation and preparedness efforts had paid off on the morning of January 1, 2000, when the electric power grid and other critical public utility systems remained operational – stemming fears that there would be widespread power outages, resource shortages, and economic and social chaos. The electrical grid in Michigan and across the country continued to operate on January 1 and beyond, without so much as a hiccup – a testament to the proactive efforts of the electric power industry.

### June and August 2000 — Detroit — Electric Power Infrastructure Failure

Detroit fell victim to two significant power outages in 2000—one that began on June 13 and lasted for 4 days, and another that occurred from August 31-September 1. The two outages—the third and fourth major power failures in the city since 1991—caused significant disruptions in commerce and city services and (in the midst of impacts from other wind, storm, and flood events) again put the city in a negative national spotlight during a time of crisis.

The June 13-16 outage actually began on June 12, when one of three main lines connecting Detroit Edison to the Detroit Public Lighting Department failed. During the process of repairing the line on June 13, a cable connection failed, setting off a chain reaction that completely disabled the two remaining connections. The resulting outage cut power to 1,250 traffic lights, 42,000 street lights, Detroit Receiving Hospital, four senior housing complexes, all public housing, Detroit City Airport, the Renaissance Center, Wayne State University, Wayne County Community College, the Detroit Institute of Arts, the U. S. District Courthouse, the City-County Building, and most city buildings and schools. Businesses and homes that received electricity directly from Detroit Edison were not affected. The outage affected a total of 4,500 buildings, idled over 167,000 school children, caused significant business and parking revenue losses, and forced the city to pay out millions in overtime costs for city workers. The power outage also left some public schools without their electronic alarm systems, which resulted in four being broken into and vandalized.

The August 31 outage occurred when the Detroit Public Lighting Department cut electrical service to parts of the city (to avoid a widespread outage like the June 13-16 incident) after two generators failed due to high demand caused by hot weather. Power to municipal buildings and services was lost on much of the city’s west side, and large portions of the east side, including schools, police stations, street and traffic lights, government offices, hospitals, and Wayne State University. Power was restored the next day. Follow up investigation revealed that a squirrel jumping on an electrical conductor may have caused an explosion at a substation that eventually led to the power failure.

### July 2000 — Mackinac Island — Electric Power Infrastructure Failure

Beginning on July 22, 2000, Mackinac Island began to experience intermittent power outages that escalated into a complete power blackout two days later. The outage continued until July 28, when several large generators were brought to the island by Edison Sault Electric Company to provide temporary power until the island’s electrical infrastructure could be repaired. The cause of the outage was later determined to be the overheating of five of the seven underwater cables that provided power to the island from the mainland. The damaged cables were subsequently replaced.

The outage came at the worst possible time for the residents, visitors, and businesses on Mackinac Island—at the height of the tourist season (with more than 35,000 tourists on the island) and during the week of the popular Chicago to Mackinac yacht race. Somehow, the island’s businesses and visitors managed to cope, but not without significant inconvenience, additional operating costs, and some loss of revenues.

### September 2000 — Genesee County — Drainage Infrastructure Failure

Heavy rainfall in Genesee County on September 22-23, 2000 caused the Thread Creek to flood and inundated the city of Grand Blanc’s storm and sanitary sewer systems, as well as Genesee County’s secondary sewer system. The city of Grand Blanc received 4.5 inches of rain in eleven hours, and the resulting flooding damaged nearly 50 homes and businesses. The Governor requested, and received, an SBA Disaster Declaration for this event, making available low-interest disaster loans to affected residents in Genesee County and the contiguous counties of Lapeer, Livingston, Oakland, Saginaw, Shiawassee, and Tuscola.

### September 2000 — Oakland and Wayne Counties — Drainage Infrastructure Failure

On September 10 and 11, 2000, unusually heavy rainfall occurred in southeast Michigan, overwhelming municipal storm drainage systems and causing damage to 130,000 homes and businesses in Wayne and Oakland Counties. The majority of the flooding was due to sewer backups into homes and businesses, caused by short-term power failures at pumping stations, and by the capacity of the stormwater collection system being exceeded. As a result, raw sewage backed up into basements in at least 15 Wayne County communities, creating serious public health and safety concerns and causing widespread property losses. Due to the extensive damage and public health and safety threats, a Governor’s Disaster Declaration was granted to Wayne County on September 20. On October 17, a Presidential Major Disaster Declaration was granted to Wayne County, making available disaster assistance to individuals and businesses that had incurred flood damage. On October 27, Oakland County was added to that Major Disaster Declaration.

### February 2001 — Genesee County — Pump Station Failure

On February 14, 2001 a pump station in Genesee County went down for 34 hours, causing 2.5 millions gallons of raw sewage per hour to go into the Swartz Creek and Flint River. A health advisory was issued for high bacterial counts in the water. Power was lost, homes were evacuated, and nearly 1,000 reports were received regarding flooding. About 60 to 100 roads and bridges were temporarily closed and impassible due to the flood waters. There was nearly $2,000,000 in damage from pump station failures.

A total of over $213 million in disaster relief assistance was provided to individuals to pay for temporary housing, to repair flood related damages and replace essential household items, and for other necessary disaster related expenses. An additional $30 million in hazard mitigation assistance was also made available to the state, bringing the total public cost of this disaster to nearly $250 million.

### March 2002 — Wayne County — Emergency Dispatch Failure

A small construction vehicle operated by a waterproofing worker accidentally ruptured a water line in the garage of police headquarters in Detroit. The water drained down into the basement, where it shorted out electricity and the telephone system in the dispatch center and on two other floors. Callers could not get help through the city's 911 police-and-fire dispatch center for more than two hours until a back-up call-in system was activated at Detroit City Airport.

### September 2002 — Oakland County — Water Main Failure

A five foot diameter water main ruptured, lowering pressure to several thousand homes in southern Oakland County. A 20-by-20-foot section of pavement collapsed on 12 Mile Road, in Farmington Hills, as the water washed away the supporting soil. The pavement fell on top of a gas main, forcing the evacuation of a dozen nearby homes. Nearby trees were washed away and several utility poles were destabilized by the rushing water.

### February 2003 — Western Lower Peninsula — Electrical Blackout

A break in a major transmission line caused a 60-mile electrical blackout that stretched over parts of six counties. The break cut electricity to tens of thousands of customers in the counties of Montcalm, Mecosta, Oceana, Newaygo, Muskegon, and northern Kent. The customers included hospitals, retirement homes, and schools. The power outage apparently started in the Croton-Hardy Dam area in Newaygo County. The power line that was cut normally supplies electricity to about 70 substations in the affected counties.

### May 5, 2003 — Wayne County — Underground Explosions

In the City of Detroit, a massive explosion occurred just before noon, sending a couple of heavy manhole covers flying up above the ground in the area of Michigan and Griswold. It was believed that methane gas had leaked from a sewer line and accumulated, until ignited by a spark. Underground line insulation burned under the streets at Shelby and Lafayette. A firefighter who had been parked in a nearby fire truck was injured when the blast shattered the truck's windshield and side window and caused punctured eardrums. The explosions were at least four in number, and some electrical power had to be turned off in the area, in order to extinguish the fire.

### August 2003 — Northeastern United States — Electrical Blackout

On Aug. 14, 2003, most residents of the northeast United States and Ontario were hit by the largest blackout in North America's history. Electricity was cut to 50 million people, bringing darkness to customers from New York to Michigan. Some essential services remained in operation in most of these areas, although backup generation in some cities was not up to the task. The phone systems remained operational in most areas; however, the increased demand by people phoning home left many circuits overloaded. Water systems in several cities lost pressure, forcing boil-water advisories.

Cellular telephones experienced significant service disruptions as their transmission towers were overloaded with a sudden increase in the volume of calls. Television and radio stations mostly remained on the air, with the help of backup generators, or by relaying their broadcasts through the Grimsby transmission towers, which were online throughout the blackout. Most interstate rail transportation in the United States was shut down, and the power outage's impact on international air transportation and financial markets was widespread. Meanwhile, the reliability and vulnerability of all electrical power grids were called into question. Total costs of the blackout have been estimated at between 4 and 10 billion dollars.

### May 2004 — Macomb County — Water Main Failure

On May 18, 2004, a 36-inch water main broke in Macomb Township, leaving thousands of customers without water. It was the fourth time that this same water main had broken in the past four years. The break forced 20 schools to close, and shut down restaurants and other businesses. A boil-water advisory was put into in effect for several days.

### July 2004 — Marquette County — Water Main Failure

One of two pipes, 16 inches in diameter, ruptured lengthwise just inches from the footing of the city's water treatment center. Water gushed out of the city's grid at a rate of 9,000 gallons per minute, drained both of the 500,000 gallon water towers, and eliminated pressure in all 85 miles of city pipeline. Electric service was not interrupted, although the city briefly shut down its power units, which are cooled with water, and reverted to a backup generator. A boil-water advisory was put into effect for several days.

### January 2005 — Muskegon County — Water Main Failure

In January of 2005, most of the residents of the city of Muskegon Heights lost water service for a brief time. The cause of the failure was determined to be a broken water main.

### August 2005 — Crawford County — Water Main Failure

A contractor working in the City of Grayling broke a 10 inch water main, causing a total disruption of water to the city as all well sites had to be shut down. Residents were told to boil water for several days, and water was restored to the city after repairs the next day.

### May 3, 2006 — Macomb County — Underground Explosions

The downtown area was disrupted by underground power line explosions, when an excessive load was placed upon an old power cable. One blast sent a heavy manhole cover shooting through the air, but no injuries were reported from the incident. Persons were evacuated from the downtown area, amidst smoke from the blast. Electricity was restored by the next day, after maintenance crews worked on the problem overnight.

### March 2007 — Muskegon County — Sewer Main Break

On Friday March 2, 2007 a break occurred in a 66 inch underground sewer main in Muskegon Township, resulting in flood damage to several homes and sending 25 million gallons of raw sewage into Muskegon Lake. The county hired crews to repair the ruptured pipe as soon as possible. Around 30 homes had to be evacuated. The county spent $38 million to replace eight and a half miles of underground sewer main.

### September 2008 — Genesee County — Sewage Flooding

A September 13-14, 2008 weekend of pounding rain in Genesee County sent water and sewage flooding into hundreds of area homes and caused large-scale discharges into area rivers. There were over 400 calls of flooding, and water and sewage back ups in basements. There were also concerns about E. Coli bacteria in the water.

### December 2008 — Genesee County — Sewage Spill

Over the weekend of December 27-28, 2008, an estimated 61 million gallons overflowed from a Flint retention pond into the Flint River. This was the county's biggest sewage spill in 2008. The spill was the result of melting snow and heavy rains over the weekend.

### January 2009 — Gogebic County — Water Main Failure

On January 8, 2009, a 16 inch water pipe (a main that supplied the city) cracked due to pipe degradation. All schools in Ironwood were closed. Local health officials issued an advisory to conserve and boil drinking water, due to the water main break. Potable and non-potable water was available through Ironwood

Public Safety for delivery and pickup, and Gogebic Community College was open for assistance as well. Eventually, in the afternoon of January 12, 2009, all water was returned to normal.

December 31, 2010 – January 3, 2011 Wayne County Water Main Failure

Seventeen thousand residents of Highland Park lost running water over the 2011 New Year's weekend. In the early afternoon of December 31, 2010 a key water pump failed in the Highland Park treatment system, and that triggered the backup system, which draws from nearby Lake St. Clair. The inundation of water in the Highland Park system caused a massive rupture, leading to the loss of water pressure throughout the city. Residents were left without water for cooking, cleaning or flushing toilets. Those with water boiler systems lost their heat during the frigid temperatures. Spontaneous protests erupted in front of the city hall that afternoon, as residents became aware of the lack of water. A "boil water alert" was issued, warning residents that the water could be contaminated, and a state of emergency was declared in the city. The public schools were closed on the following Monday to avoid health concerns from the boil water advisory. The crumbling infrastructure throughout the Detroit area is becoming increasingly dangerous to the population, and upgrades or replacements to the system are needed.

February 23, 2011 Kalamazoo County Water Main Failure

A water main leak sent an estimated one million gallons of water flowing into a residential area on the west side of Kalamazoo, causing damage to homes and prompting police to close parts of West Main Street for about four hours. An estimated 40 homes had flooding damage to varying degrees.

June 9-10, 2011 Wayne County Electrical Blackout

Aging power transmission lines failed under the stress of high demand for electricity, due to multiple days of at least 90 degree heat. Some of Detroit's public buildings (including the municipal and court offices, a convention center, and Wayne State University) were blacked out on June 9-10th, 2011. Traffic signals were also blacked out, causing traffic issues, especially during the evening rush hour. The blackout provided a stark reminder of deteriorating infrastructure in a city already struggling to provide basic services.

December 2013 Statewide Electrical Power Infrastructure Failure

A massive ice storm hit Michigan shortly before Christmas, knocking out power to approximately 380,700 homes and businesses, some of whom were then without power for up to a week and a half. The outages came in waves, with the first hitting on the night of the storm and others following later on as ice weighed down tree branches and power lines which then broke. Consumers Energy, DTE Energy, and the Lansing Board of Water and Light were the hardest hit power companies. Consumers Energy said that the storm was the largest Christmas-week storm in the company's 126-year history and the worst ice storm in 10 years. Utility crews had a difficult time restoring power as more ice, snow, and frigid temperatures arrived after the initial event. The Michigan Public Service Commission began an assessment of the event, its aftermath, and the quality of response procedures used.

### *Bridge Failures*

As Michigan's bridge infrastructure systems continue to age, infrastructure disasters will undoubtedly become more common. Because many of these systems were developed decades ago, the costs of repairing and replacing aging sections and components of bridges have greatly increased. As a result, many communities cannot afford to do the maintenance work necessary to keep the system in an ideal operational mode. Michigan is fortunate not to have suffered a major bridge collapse, but many areas in the United States have suffered such catastrophic failures, with casualties. A quarter of Michigan's bridges have been determined to be structurally deficient or functionally obsolete. Preparation for and awareness of a potential failure is important for mitigation purposes, so the following list covers the most significant bridge disasters in the United States (that might similarly occur at some point in Michigan).

### *Significant Bridge Failures in the United States*

December 1967 Point Pleasant, West Virginia Bridge Failure

On December 15, 1967, the Silver Bridge collapsed while it was full of rush-hour traffic, resulting in the death of 46 people. The bridge, constructed in 1928, connected Point Pleasant, West Virginia and Kanauga, Ohio, over the Ohio River. Investigation of the wreckage identified the cause as the failure of a single eye-bar in a suspension chain, due to a small defect 0.1 inch deep. Analysis showed that the bridge was carrying much heavier loads than it had originally been designed for, and that it was poorly maintained.

May 1980 Tampa, Florida Bridge Failure

On May 9, 1980 in Tampa, Florida, during a blinding spring squall, the freighter Summit Venture rammed into the Sunshine Skyway and knocked out a 1,200-foot length of the bridge across the mouth of Tampa Bay. Thirty-five people, most of them in a Greyhound Bus, died as a result of the accident.

October 1989 Oakland, California Bridge Failure

On the afternoon of October 17, 1989, the Cypress Street (Viaduct) Freeway bridge in Oakland, California collapsed as a result of the Loma Prieta earthquake. The braces that held the upper-level to the lower-level broke in two and then fell outward, dropping the upper-level down on top of the lower-level with a force of approximately two million tons. Autos, trucks, and buses were crushed, along with their occupants. The collapse started in the northern sections of the freeway, and like a domino effect, each adjacent section began to collapse in turn. The collapse resulted in 42 fatalities.

September 2001 South Padre Island, Texas Bridge Failure

In the early morning hours of September 15, 2001, four loaded barges crashed into one of the Queen Isabella Causeway's support columns in South Padre Island, Texas, resulting in three 80-foot sections of the bridge falling into the water and leaving a large gap in the roadway. The collapsed sections were near the highest point of the causeway, making it difficult for approaching drivers to notice. Eight people were killed as their cars fell 85 feet into the water. Five vehicles were recovered from the water, along with thirteen survivors.

August 2007 Minneapolis, Minnesota Bridge Failure

On August 1, 2007 the I-35W Mississippi River bridge, a steel truss arch bridge that carried Interstate 35W across the Mississippi River in Minneapolis, collapsed during the evening rush hour. It collapsed into the river and onto the riverbanks beneath, killing 13 people and injuring another 145. The bridge was Minnesota's fifth busiest, carrying 140,000 vehicles daily. The NTSB cited a design flaw as the likely cause of the collapse, and asserted that additional weight on the bridge at the time of the collapse contributed to the failure.

Immediately after the collapse, help came from emergency response mutual aid within the seven-county Minneapolis-Saint Paul metropolitan area, and from charities and volunteers. City and county employees managed the rescue, using post-9/11 techniques and technology that may have saved additional lives. This failure stemmed from a major recent flaw and showed how this could happen in any location in the United States, including Michigan, with its significant number of "structurally deficient" bridges.

### *Structural Collapse (not terrorist or criminally motivated)*

The collapse of part or all of any public or private structure or building is considered a structural failure. The level of damage and severity of the impacts is dependent on factors such as the size of the building, the number of occupants of the building, the time of day, day of week, the type of building use, on-site chemical storage, weather conditions, and the quantity of products stored in the structure. Along with misuse, accidents, and weather-related loads, the causes of failure may be found in deficiencies of design, detailing, material, workmanship, or inspection. Detroit is home to some of the oldest skyscrapers in the nation, with a total of 13 buildings over 300 feet tall that were constructed before 1930. The age of the structure is sometimes not related to the cause of the failure. With the aging of buildings, crumbling, deterioration, and collapse can occur at any height, either in the building's interior or its exterior. Funding is needed to repair several of the older structures. Enforcement of building codes can better guarantee that structures are designed to hold-up under normal conditions. Routine inspection of older structures may alert inspectors to "weak" points and will lessen the probability of a failure.

Physical hazards from electrical equipment, downed electrical lines, fire, explosion, noise, vehicles and heavy equipment, sharp objects, falling objects, hazardous materials, and uneven or unsteady working surfaces are a major cause of fatalities involving building collapses. Chemical and biological hazards can occur as well. The primary biological hazards include blood-borne pathogens and water-borne pathogens that present risks only in the event of direct contact with bodily fluids. Pathogens include bacteria, viruses, or fungi. Water-borne pathogens are organisms transmitted through direct contact with water sources that are most often contaminated with sewage. Blood-borne pathogens are transmissible only when blood or other body fluids from an infected person (living or dead) enter another person.

Fortunately, there has not yet been a major mass-casualty event in Michigan due to a building collapse, or even a partial collapse, but there have been incidents in other parts of the United States that resulted in numerous fatalities, some of which include criminal and terrorist attacks. Below is a list of structural collapses resulting in multiple fatalities from non-criminal and non-terrorist causes.

July 1981 Kansas City, Missouri Walkway Collapse

The Hyatt Regency hotel walkway collapse was a major disaster that occurred on July 17, 1981 in Kansas City, Missouri, killing 114 people and injuring more than 200 others during a tea dance. Approximately 2,000 people had gathered in the atrium to participate in and watch a dance contest. At 7:05 PM, the walkways on the second, third, and fourth floor were packed with visitors as they watched over the active lobby, which was also full of people. The fourth floor bridge was suspended directly over the second floor bridge, with the third floor walkway set off to the side, several meters away from the other two. The connection failed and both walkways crashed—one on top of the other, and then into the lobby below.

The cause of the accident was a flawed design change that doubled the load on the connection between the fourth floor walkway support beams and the tie rods carrying the weight of both walkways. This new design could barely handle the dead load weight of the structure itself, much less the weight of the spectators standing on it. The serious flaws of the revised design were further compounded by the fact that both designs placed the bolts directly in a welded joint between two facing C-channels, the weakest structural point in the box beams. Investigators concluded that the basic problem was a lack of proper communication between stakeholders. In particular, drawings that were only preliminary sketches had been interpreted as finalized drawings. The initial design had been accepted without performing basic calculations that would have revealed its serious flaws.

April 1987 Bridgeport, Connecticut. Building Collapse

On April 23, 1987, 28 construction workers were killed when a 16 story residential project under construction in Bridgeport, Connecticut, collapsed. Its partially erected frame completely collapsed, probably as a result of high concrete stresses on the floor slabs which resulted in cracking and a kind of punch-through failure. It was believed that this accident highlighted the deficiencies of the lift slab construction techniques used at that time.

June 2003 Chicago, Illinois Balcony Collapse

On June 29, 2003 in Chicago, Illinois, the deadliest balcony collapse in United States history occurred. Thirteen people were killed and another 57 were injured when an overcrowded balcony at a party collapsed. The second floor balcony collapsed onto the first floor, which itself collapsed into the basement below (30 foot total drop), carrying a total of around 100 persons between them.

Initial inquiries suggested that the collapse was probably due to overcrowding, but it was ultimately determined that poor construction was to blame. The balcony was one foot wider than codes had permitted, giving it too large an area. The balcony also had inadequate supports, was floored with undersized lengths of wood, and was attached to the walls with screws that were too short. The effects of age on the structure also played a role.

***Programs and Initiatives***

Following are brief synopses of some of the laws, programs and special initiatives aimed at preventing or greatly reducing the impacts of utility infrastructure failure in Michigan:

State and Federally-Assisted Infrastructure Mitigation Projects

The State of Michigan has been very proactive in its mitigation efforts for public infrastructure. Since 1994 the State has allocated over 32 million in federal Hazard Mitigation Grant Program (HMGP) funds for about 100 projects designed to address vulnerabilities in water, sewer, storm drainage, telecommunications, radio communications, and highway transportation infrastructure. For details, please refer to Attachment C in the 2011 Michigan Hazard Mitigation Plan.

Water Distribution Systems

Michigan's public water supplies are regulated under the Federal Safe Drinking Water Act. The Michigan Department of Environmental Quality, as a primary agency for the Federal government, provides supervision and control of Michigan's public water supplies (including their operation and physical improvements) under the Michigan Safe Drinking Water Act (1976 PA 399).

The Drinking Water and Radiological Protection Division of the MDEQ regulates, through a permit process, the design, construction, and alteration of public water supply systems. Water supply construction must be conducted within the framework of the Michigan Safe Drinking Water Act, as well as the Architecture, Professional Engineering and Land Surveying Act (1937 PA 240, which requires professional engineers to prepare construction documents for water works construction that costs over $15,000). Most communities in Michigan have, in conjunction with the MDEQ, developed water system master plans that conform to the requirements of the Michigan Safe Drinking Water Act. From a hazard mitigation standpoint, this is important because it helps ensure that all new water system construction, and alterations to existing systems, will conform to the minimum standards set in the Act. While not making water infrastructure "disaster-proof," the standards provide at least a basic level of design, structural, and operational integrity to new or renovated portions of a community's water supply system.

Wastewater Collection and Treatment Systems

The Federal Clean Water Act regulates discharge from community wastewater collection and treatment systems. The regulatory aspects of the Act that pertain to municipalities have been delegated to the MDEQ Surface Water Quality Division, for surface water discharge facilities, and the MDEQ Waste Management Division, for groundwater discharge facilities. Authority for the oversight of planning, facility design review, and construction permitting of sewerage systems collection, transportation, and treatment facilities is derived from Part 41 of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451), and Administrative Rules promulgated under the authority of Part 41. The two MDEQ divisions assist local communities with the development and maintenance of their wastewater collection and treatment systems. In addition, they monitor and regulate these systems to ensure that pollution abatement and health conditions are met. Although the regulatory authority vested in the MDEQ is primarily aimed at preventing the pollution of the waters of the state, there are requirements in place under 1994 PA 451 regarding the design, construction, operational integrity, and reliability of wastewater collection and treatment systems.

The U.S. Environmental Protection Agency's (EPA) Technology Transfer Program, the "Recommended Standards for Sewage Works" developed by the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, and other technical references all provide important technical information to MDEQ personnel about the design and operation of wastewater collection and treatment system components. This information is used extensively by the MDEQ to review designs and operational procedures for the municipal wastewater program. Included within this guidance are basic minimum standards that help ensure an adequate level of structural and operational integrity for wastewater systems.

## Surface Drainage Systems

Michigan's first drain laws appeared on the books as Territorial laws, years before Michigan had achieved statehood. After attaining statehood in 1837, the State passed its first drain law in 1839. Since that time, there have been 45 separate acts passed regarding drainage, up to the most recent recodification of drain law in 1956. Since 1956, the present drain code has been amended over 200 times—an indication of how important and dynamic the issue of drainage continues to be in Michigan.

The Michigan Drain Code provides for the maintenance and improvement of the vast system of intra-county (county) and inter-county drainage facilities. Each drain has a corresponding special assessment district (watershed), a defined route and course, an established length, and is conferred the status of a public corporation with powers of taxation, condemnation, ability to contract, hold, manage and dispose of property, and to sue and be sued. Drainage districts and drains are established by a petition of the affected landowners and/or municipalities. County drains, with a special assessment district entirely within the county, are administered by the locally elected County Drain Commissioner. Inter-county drains, with a special assessment district in more than one county, are administered by a drainage board that consists of the drain commissioners of the affected counties, and is chaired by the Director of the Michigan Department of Agriculture and Rural Development (MDARD) or an MDARD Deputy Director.

The intra-county and inter-county drainage program, administered by county drain commissioners and the MDARD, operates, maintains, and improves water conveyance and treatment systems—ranging from small agricultural drains to large urban storm and sanitary drains. (Note: Some drains are constructed of pipes that range in size from 12 inches in diameter to over 16 feet in diameter, with massive pumping stations that carry storm and/or sanitary sewage and serve thousands of residents. Other drains are open channels or ditches that vary from several feet in width, and being dry during part of the year, to large river channels in excess of 100 feet in width. Floodwater-retarding dams, flood pumps, erosion control structures, storage basins, and wastewater treatment structures are also part of the infrastructure constructed under the Michigan Drain Code.) Statewide, there are over 18,000 established drainage districts with an estimated combined length of over 40,000 miles of channel. These facilities vary from rural agricultural open channels, with drainage areas of several hundred acres, to large river systems with drainage areas of several hundred square miles.

As Michigan's villages, towns, and cities have grown, the drains that were primarily designed to serve agricultural needs have also been used to carry stormwater from municipalities and subdivisions, as well as to serve as outlets for sanitary treatment plants and a variety of other permitted discharges. The operation, maintenance, and improvement of drains in suburban and urban areas now provides for the management of stormwater, combined sanitary overflows, and sanitary sewage collection and treatment. Increasing demands on the drainage system in many areas of the State require that continuous improvements be made to enhance drain capacity and flow characteristics, reduce sedimentation, and improve structural integrity.

The Michigan Drain Code allows for landowners and/or municipalities to petition for the maintenance or improvement of drainage systems. Drain commissioners or drainage boards, in the absence of a petition, are allowed to maintain the drainage systems but are limited by law in the amount of money they are allowed to expend. The maintenance limit is equal to $2,500 per mile of established drain. This amount is generally sufficient for ordinary operations and maintenance, but is inadequate during times of widespread damage such as that which happens during a disaster. Because drainage districts stand on their own, money (or the maintenance limit) cannot be shared between districts. This greatly limits flexibility and can severely constrict drain reconstruction, improvement, and damage mitigation efforts in a post-disaster setting. Efforts are underway to amend the Michigan Drain Code to more adequately address current and anticipated future problems and concerns, and to make it more applicable to modern land development circumstances.

## Electrical Systems

Disaster-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. DTE, Consumers Energy and other major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by wind, snow and ice, and other hazards. Typically, these programs focus on trimming trees to prevent their encroachment on overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution systems underground. The Michigan Public Service Commission (MPSC) monitors the reliability of power systems to help minimize the scope and duration of power outages.

### Telecommunications Systems

Like electric utility companies, telecommunications companies are concerned with the issue of protecting facilities and systems from disaster-related damage. Major telecommunications companies have programs to improve system reliability and physically protect facilities and system components from wind, snow and ice, and other hazards, using many of the same techniques as the electric utility companies.

### Sewage System Overflows/Backups

Public Act 222 of 2001, Government Liability for Sewage Disposal Systems Backup, provides that under certain circumstances, governmental agencies that own or operate sewage disposal systems may be held liable for the overflow or backup of the system (e.g. basement flooding). The Act requires that persons seeking compensation for personal injury or property damage must show that all of the following existed at the time of the event:

- The municipality (at the time of the event) had owned or operated, or directly or indirectly discharged into, the portion of the sewage disposal system that allegedly caused damage or injury.
- The sewage disposal system of the municipality had a construction, design, maintenance, operation, or repair defect.
- The municipality knew, or in the exercise of reasonable diligence should have known, about the defect and failed to take reasonable steps in a reasonable amount of time to repair, correct or remedy the defect.
- The defect must be 50% or more of the cause of the event and the damage or injury.

### Michigan Public Service Commission

The goal of the Michigan Public Service Commission is to assure safe and reliable energy, telecommunications, and transportation services at reasonable prices. In January of 2004, the Michigan Public Service Commission adopted new rules that require electricity providers to restore power to customers within 16 hours of a catastrophic event. Under the new guidelines, utility companies also must restore power within eight hours to customers who have lost it, if there is no catastrophic event. If the guidelines are not met, the utilities could face up to $20,000 for the first offense, up to $40,000 for the second violation, and up to $50,000 for a third offense. If companies do not restore power within 16 hours, homeowners will get a $25 credit, paid by the utilities, unless there is a catastrophe. A catastrophe is defined by the commission as severe weather conditions that knock out power to more than 10 percent of a utility company’s customers; or when a state of emergency is declared by a local, state or federal government.

On September 1, 2009, the Michigan Public Service Commission completed a document called the Report on Status of Power Quality, to review performance measurements for evaluating the service, quality, reliability, and power plant generating cost efficiency of the electric utilities operating in Michigan.

### Protection of Critical Michigan Infrastructure

The EMHSD/MSP spearheaded a statewide effort to identify and compile information on critical infrastructures in Michigan. Partners in this multi-faceted initiative include state agencies, local governments, federal agencies, and key private sector utilities, such as the electric power and communications industries. This multiyear effort is resulting in the development of a comprehensive list of critical public and private sector infrastructures that will provide the basis for subsequent actions designed to reduce the likelihood or potential impacts of a terrorist attack or other homeland security threats.

National Association of Regulatory Utility Commissioners (NARUC)

NARUC is an association representing the State public service commissioners who regulate essential utility services, such as electricity, gas, telecommunications, water, and transportation, throughout the country. As regulators, the members are charged with protecting the public and ensuring that the rates charged by regulated utilities are fair, just, and reasonable.

U.S. Army Engineer Research and Development Center (ERDC)

The Mission of the Engineer Research and Development Center (ERDC) is to provide scientific knowledge, technology, and expertise in engineering and environmental sciences to support the Armed Forces in their missions. ERDC has a featured service section specifically dealing with infrastructure-related issues, including programs such as the Concrete Technology Information Analysis Center (CTIAC), High-Performance Materials and Systems Selection, Materials Testing Center (MTC); and the Soil Mechanics Information Analysis Center (SMIAC).

***Hazard Mitigation Alternatives for Infrastructure Failures***

- Proper location, design, and maintenance of water and sewer systems (to include insulation of critical components to prevent damage from ground freeze).
- Burying electrical and phone lines, where beneficial and appropriate, to resist damage from severe winds, lightning, ice, and other hazards.
- Redundancies in utility and communications systems, especially "lifeline" systems; to increase resilience (even if at the cost of some efficiency).
- Separation and/or expansion of sewer system to handle anticipated stormwater volumes.
- Use of generators for backup power at critical facilities.
- "Rolling blackouts" in electrical systems that will otherwise fail completely due to overloading.
- Replacement or renovation of aging structures and equipment (to be made as hazard-resistant as economically possible).
- Physical protection of electrical and communications systems from lightning strikes.
- Tree-trimming programs to protect utility wires from falling branches. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Increasing public awareness and widespread use of the "MISS DIG" utility damage prevention service (800-482-7171).

***Tie-in with Local Hazard Mitigation Planning***

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the “Local Hazard Mitigation Planning Workbook” (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that infrastructure failures were identified as some of the most significant hazards (often in connection with severe weather events) in local hazard mitigation plans for the following counties: Alger, Chippewa, Clinton, Gogebic, Ionia, Iosco, Isabella, Jackson, Kent, Keweenaw, Lake, Lenawee, Luce, Mackinac, Marquette, Mason, Newaygo, Oakland, Oceana, Ontonagon, Ottawa, Presque Isle, Roscommon, St. Clair, Sanilac, Shiawassee, Van Buren, Washtenaw, Wayne, and Wexford.

Infrastructure Failure Guidance for Local Hazard Mitigation Planning

Whether the failure of electrical power, telephone, natural gas, water, sewage disposal, or transportation systems occurs as a primary stand-alone incident, or if the hazard occurs as a secondary result of extreme temperatures, snowfall, flooding, or winds—the risk of infrastructure failures is large. Infrastructure failures can affect hundreds of thousands of Michigan residents when the conditions are "right" for a loss of critical systems. Melted transformers, ruptured pipes, crumbled bridges, and exploded transformers can inconvenience or wreak havoc around the nation and the state, depending on the severity of the problem.

The risk of infrastructure failure grows each year, as physical and technological infrastructure gets steadily more complex, and the interdependency between various facets of infrastructure (like pipelines, telecommunications lines, and roads) becomes more intertwined. Additionally, essential repairs to vulnerable and aging infrastructure do not keep up with the growing volume of rail lines, electrical components, bridges, roads, sewers, etc. in need of repair. Because of these reasons, large-scale disruptions in various components of infrastructure are much more possible today than ten or twenty years ago. The risk of failure will continue to grow, and such major disruptions could lead to widespread economic losses, limit security, and altered ways of life.

Infrastructure failures can occur at any time and in any place in the state of Michigan. The metropolitan areas and the greater Detroit area are the most susceptible to interruptions in infrastructure, due to the additional volume of critical components of transportation, power, water, and telecommunication networks. Residents of these areas are also less likely to have adequate measures to "get through" infrastructure failures, with a lack of generators, wood, and fireplaces. Economic losses with incapacitated business and industry are much greater in these areas as well. In northern regions of the state, there are fewer networks of infrastructure, but greater geographic areas are affected during infrastructure failures. Downed lines or blocked roads affect many more square miles than a similar occurrence around Detroit, but there are far fewer individuals and businesses at risk.

To assess the risks of infrastructure failure in your locale, an examination of past infrastructure failures is very important. Have there been numerous power outages whenever there are severe winds? Do extremely cold or extremely cold temperatures strain or cause failures of water, gas, and electric resources? How often have various sewer, water, and electric lines been renovated? Is there a tree management program in place to limit structural damage during thunderstorms and winter storms? What are local regulations for new infrastructure? Questions such as these can be answered by contacting utility companies and municipal public services (city water and sewage). These companies/departments should have records of power and water failure incidents and can provide some answers on the age of infrastructure components. Information on service providers, service areas, and infrastructure details can be found through the Michigan Public Service Corporation, at www.michigan.gov/mpsc.

Transportation infrastructure concerns can be discovered through city and county road commissions, and through MDOT. Traffic volumes of major roads and information on recent and future projects can be found through the MDOT website, at www.michigan.gov/mdot. Contact of local engineering firms may be of interest to determine if there are any recent publications or studies of various infrastructure components in your community, as well.

# ENERGY EMERGENCIES

*An actual or potential shortage of gasoline, electrical power, natural gas, fuel oil, or propane—of sufficient magnitude and duration to potentially threaten public health and safety, and/or economic and social stability.*

***Hazard Description***

An adequate energy supply is critical to Michigan's (and the nation's) economic and social well-being. The American economy and lifestyle are dependent on an uninterrupted, reliable, and relatively inexpensive supply of energy that includes gasoline to fuel vehicles, and electricity, natural gas, fuel oil, and propane to operate homes, businesses, and public buildings. Energy emergencies became a serious national issue in the 1970s, when two major "energy crises" exposed America's increasing vulnerability to long term energy disruptions. Americans have always dealt with short term energy disruptions caused by severe weather damage (i.e., downed power lines and poles), broken natural gas and fuel pipelines, and shortages caused by the inability of the energy market to adequately respond to consumer demand and meet needed production levels. However, the Oil Embargo of 1973-74, the natural gas shortage of 1976-77, the 1979 major price increases in oil resulting from the Iranian Revolution, the Gulf War in 1991 (after Iraq invaded Kuwait and destroyed many of its oil fields), and the aftermath of the September 11, 2001 terrorist attacks all forced the country to recognize its vulnerability to energy disruptions. That vulnerability was again exposed during the Great Blackout of 2003, when about 50 million electric customers in the northeast United States lost power due to a power grid malfunction. The oil price increases during 2007 and 2008 pushed American gasoline prices to over $4 a gallon and caused major economic and energy related issues as well.

There are three types of energy emergencies. The first and most frequent type of energy emergency involves physical damages to energy production or distribution facilities, caused by severe storms, tornadoes, floods, earthquakes, or sabotage. Michigan has experienced a number of these short-term energy disruptions in recent history, mostly due to high winds associated with severe thunderstorms, or damage caused by ice storms. While there have been only a few incidents of sabotaged energy systems in this country, networks supporting terrorist activity exist throughout the world and the possibility of more frequent incidents in the United States is always present. This category of energy emergency also covers short-term disruptions caused by human error, accidents or equipment failure, such as the power outages that occurred in Detroit in December 1998 and the Summer of 2000, the Wolverine Pipeline Company pipeline rupture in Jackson County in June 2000, the Mackinac Island power failure in July 2000, and the Great Blackout of 2003 that affected over 50 million energy customers. (Refer to the Infrastructure Failures, Pipeline Accidents, Severe Winds, and Ice/Sleet Storms sections of this document for additional information on short-term energy emergencies caused by weather, accidents, and equipment failure.)

The second type of energy emergency involves a sharp, sudden escalation in energy prices, usually resulting from a curtailment of oil supplies. Michigan experienced this type of energy emergency in the 1970s, due to events in the world oil market, and in 1990, following Iraq's invasion of Kuwait. The winter of 2000/2001 saw a sharp spike in natural gas costs, due to reduced availability. However, many Michigan customers were unaffected, due to a price freeze on Michigan's major gas utilities. When oil reserves in Louisiana were blocked during Hurricane Katrina (August 2005), the effects were felt in Michigan and the Governor issued a State of Energy Emergency due to a gasoline shortage. Since 2001, energy costs for the average U.S. household have more than doubled, and sharply escalating gasoline prices have again strained the budgets of lower and middle class families. The summer of 2008 had the highest oil prices on record, following a dramatic rise in prices from 2007 to 2008, and gasoline prices peaked at more than $4 per gallon. This contributed to the economic downtown beginning in 2007, as well as a move toward more fuel-efficient vehicles.

The third type of energy emergency is a sudden surge in energy demand caused by a national security emergency involving mobilization of U.S. defense forces. National defense, in a time of crisis, will demand an increase in energy. Although the regulated natural gas and electric utilities have approved state and federal priority allocation systems that are in place, regulatory changes to introduce competition into natural gas and electric markets have not fully addressed how such shortages might be managed once these markets are fully opened.

Michigan uses coal, nuclear power, natural gas, renewable power, petroleum, and hydroelectric power for energy. The following table describes the usage of each type in Michigan, and compared to the rest of the United States.

## Types of Energy Used: Michigan vs. U.S

| Type | Michigan | U.S. |
|---|---|---|
| Coal | 62.6% | 51.0% |
| Nuclear | 23.3% | 20.1% |
| Natural Gas | 10.2% | 17.2% |
| Renewable Power | 2.5% | 2.1% |
| Petroleum | 0.8% | 2.8% |
| Hydro | 0.6% | 6.8% |

Source: Michigan Public Service Commission

***Hazard Analysis***

America's early 21st Century energy situation is at a crossroads. Although energy issues came to the forefront in the aftermath of the 1970s "energy crisis," many energy issues still remain to be addressed. There have been tremendous strides in energy efficiency in homes and home appliances, and with automobile fuel efficiency, saving billions of dollars in energy costs, and our dependence on foreign oil imports has been decreasing, now roughly 45% of total oil consumption. World demand for oil is projected to increase 37% over 2006 levels by 2030, according to the 2007 U.S. Energy Information Administration's (EIA) annual report. Cars and trucks are predicted to cause almost 75% of the increase in oil consumption by India and China between 2001 and 2025. Auto sales in China have continued to grow and now match U.S. levels, resulting in part from economic growth rates around 10 percent for many years in a row. Although the Strategic Petroleum Reserve and other mechanisms have been put in place to reduce the negative consequences of another oil embargo or similar supply disruption, the possibility always remains for an event of near-equal magnitude and impact.

Total U.S. energy consumption has increased by more than 28% since the early 1970s – due mostly to relatively healthy economic growth, changes in commuter patterns, and an increase in the use of home and office computers and other electronic devices. In addition, a commuter-oriented lifestyle has also increased in Michigan. However, during that same period, the U.S. share of world energy consumption actually decreased from 31% in the early 1970s to approximately 25% in the late 1990s. In the 1990s, Michigan's total energy consumption grew over 14%. While this growth was slower than overall economic growth in Michigan due to increasing energy efficiency, growing economies have usually required increasing amounts of energy.

On the electric energy front, electric power system restructuring efforts, currently ongoing in Michigan and across the country, may be considered experiments involving increased competition, lower electrical rates, and increased production and reliability. According to the MPSC's Semi-Annual Appraisal of Energy Markets, issued in September 2008, Michigan's peak electrical demand will grow by 1.2% per year for the next 20 years, but this calculation was made before the 2007-2009 recession, which reduced electrical demand. As economic recovery continues, the demand for electricity should rise. This growth requires at least one new power plant by 2015, and at least three more plants built at a similar frequency, if renewable energy mandates and energy conservation measures are not employed. On the natural gas front, increases in the price of natural gas in Michigan and elsewhere, coupled with spot shortages of natural gas, are likely to renew the emphasis on home, commercial, and industrial energy conservation measures for that energy source.

Despite all these efforts, Michigan still remains vulnerable to short-term energy shortages, as was evidenced by the sharp price increases and decreased supply of gasoline caused by the June 2000 pipeline break in Jackson County and Hurricane Katrina in September 2005. Although other factors contributed to the shortages and price increases, the pipeline break again demonstrated our dependence on an uninterrupted energy supply to sustain our economy. The frequent short-term utility outages caused by severe weather, accidents, or equipment failure are another reminder of our dependence on energy in our daily lives. Although we eventually recover from these short-term energy shortages, it often involves considerable inconvenience and expense. The energy shortages faced by California in 2000/2001, in the wake of its electrical deregulation plan, proved that the country is vulnerable to power deficiencies. While California made many mistakes that have not been duplicated in Michigan and elsewhere, its situation again proves how critically important energy is to our national and economic security. In 2003, the Great Northeast Power Blackout provided another example of the vulnerability of our energy supply system in the United States. The late 2000s oil price increases have played a major role in the worst economic recession since the Great Depression, as well as the move for the automakers to build more fuel efficient and electric/hybrid vehicles.

Michigan has an excellent energy emergency planning program through the Michigan Public Service Commission. Many mechanisms have been put in place to reduce the impacts caused by short- and long-term energy disruptions. Indeed, Michigan's position as a major business, agriculture, educational, tourism, and industrial center requires that we continue to do so. However, even with those efforts, the threat of both short and long-term energy emergencies still exists in Michigan, due to our dependence on large-scale energy distribution systems to provide us with power.

Impact on the Public

Energy emergencies could cause the public, including small business owners and self-employed persons, to experience significant financial impacts from higher prices or limited/curtailed energy supplies. Business and commuting costs would be likely to increase temporarily. Persons with special medical needs may have difficulty traveling or otherwise having those needs met.

Impact on Public Confidence in State Governance

Portions of the public tend to infer government control and efficacy over market-related economic aspects of the situation. That is, many persons are unclear in their knowledge about limitations in the government's authority, responsibility, and effectiveness in situations that are substantially defined and shaped by a competitive private sector.

Impact on Responders

Energy emergencies may potentially affect response capabilities, through limitations or shortfalls in resources, and in the amount of expense associated with the use of such resources. A good example could be a shortage of fuel that is needed to operate fire trucks. The budgets of involved agencies may become overburdened. Resources may need to be carefully shared between agencies, or supplemented with special state or federal assistance.

Impact on the Environment

Principal air emissions involve substances that could cause a negative impact on the environment, such as particulate matter, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. Each of these pollutants varies in its emission rate and potential opportunities for reduction. Fossil fuel consumption is closely linked to greenhouse gas emissions and therefore climate change. The burning of fossil fuels results in the conversion of carbon to carbon dioxide, which contributes to the atmospheric greenhouse effect and global warming. Nuclear power plants generate radioactive by-products that can be harmful to the environment and must therefore be carefully stored in selected locations. The use of hydroelectric dams can also create negative consequences for aquatic wildlife, such as preventing fish from traveling upstream.

### *Energy Emergencies Affecting Michigan and Other States*

Following are some energy emergencies that occurred in or affected Michigan and other states. Although the term "emergency" is used, it is important to note that not all of these events were officially declared as "emergencies" (e.g., "State of Emergency" or "State of Energy Emergency") under the applicable federal or state statute. However, each event fits one of the classifications outlined above.

November 9, 1965 | Northeast United States | "Great Northeast Blackout."

On November 9, 1965, the largest electrical blackout in U.S. history to that time occurred in the Northeastern United States when a single transmission line tripped near Niagara Falls, New York, setting off a series of failures that ultimately left 30 million people without power for as long as 13 hours. The outages occurred throughout New York, Ontario (Canada), most of New England, and parts of New Jersey and Pennsylvania. The lessons learned from this single event changed the way electric utility systems are designed and operated today. In addition, the National Electric Reliability Council – now called the North American Electric Reliability Council (NERC) – was formed in the wake of the 1965 Northeast Blackout to promote the reliability of the electricity supply for North America. (Refer to the Programs and Initiatives section below for more information on the NERC.)

October 1973-March 1974 | Entire United States | Middle East (OPEC) Oil Embargo

In October 1973 the Organization of Petroleum Exporting Countries (OPEC) – a Middle East oil cartel composed of most of the world's major oil producing countries – halted the flow of oil to the United States in retaliation for U.S. support of Israel in the 1973 Arab-Israeli War. From October 1973 to March 1974, OPEC maintained an embargo on oil imports to the United States and other Western nations that supported Israel, causing gasoline shortages and inflated oil prices. The embargo had a particularly negative effect on the U.S. economy and was one of the primary causative factors of the economic recession that plagued the country from 1973 to 1975. The OPEC embargo put the term "energy crisis" in the forefront of the news for months and forced the United States to seriously reevaluate its reliance on foreign oil imports and overall use of energy.

Winter of 1976-77 | Entire United States | National Energy Emergency (declared)

A natural gas shortage during the bitter winter of 1976-77 forced President Carter to proclaim a national energy emergency on February 2, 1977. President Carter did not mince words in his address to the nation on April 18, 1977 when he declared that combating the energy shortage was the "moral equivalent to war." Carter went on to urge the country to learn to prudently manage its shrinking energy supplies or be faced with potential future disaster. Carter proposed a plan that included strict conservation of fuel supplies, higher prices for oil and natural gas to reduce consumption, penalties for wasteful use of energy, and tax credits for the installation of solar energy devices. Carter also suggested that expansion of nuclear power should be the nation's last resort in seeking solutions to its energy problems. (Fortunately, Michigan was not as seriously affected by this emergency as many other states.)

July 13, 1977 | New York City | Electrical Blackout

On the night of July 13, 1977, New York City and parts of Westchester County to the north were plunged into darkness by an electric power blackout caused when four lightning strikes knocked out vital power lines feeding the city's power grid. Neighboring electric utility companies in New Jersey, New England and Long Island were automatically disconnected from the Con Edison power grid serving the city to prevent damage to their own systems, leaving the city's power grid as an "island" of electricity, separated from all outside sources of generation. (Con Edison is the utility that provides electric service to New York City.) The blackout, which lasted in some neighborhoods for 25 hours, came at a troubled time for New York City, and the reaction of the city's residents to the situation was marked with both resilience and violence. In many areas, neighbors helped neighbors and strangers helped strangers. However, other neighborhoods exploded into violence. Dubbed by some in the media as the "night of terror," the blackout brought out the worst in many of the city's residents as stores were ransacked, looted and destroyed, buildings were set on fire, and cars were stolen. The police, for the most part, could not stop the mayhem. Although they made over 3,700 arrests, most accounts indicate that thousands of perpetrators escaped before being caught. At the height of the blackout, over 1,000 fires burned throughout the city – six times the average rate – while at the same time the fire department was responding to 1,700 false alarms. Ironically, Con Edison had (and still has) one of the most reliable, least interrupted electric power systems in the United States.

March 28, 1979 | Harrisburg, Pennsylvania | Three Mile Island Nuclear Plant Accident

On March 28, 1979 the most serious nuclear reactor accident ever to occur at a commercial power plant in the United States occurred at the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania. This incident resulted from a plant malfunction, combined with operator override of automatic safety systems. These errors resulted in a partial meltdown of the reactor core. Utility, state, and local personnel implemented response plans to protect the public in the area around the plant, while onsite efforts were undertaken to cool the reactor and eliminate any possible release of radioactive material. While this accident resulted in no off-site health consequences, it had a major negative impact on the continued development of the nuclear power industry in the United States.

Coincidentally, the Three Mile Island accident occurred two weeks after the release of the movie "The China Syndrome," which portrayed a nuclear reactor disaster. The combination of the movie, the accident, and a jury verdict later that spring against a Kerr-McGee nuclear facility in Oklahoma regarding plant safety raised new doubts in the mind of the public about official assurances of nuclear safety. As a result, support for nuclear power took a severe nosedive. In Michigan, plans by Consumers Power Company (now Consumers Energy Company) to complete a nuclear power plant in Midland were curtailed due to the public perceptions and constantly escalating development costs. Instead, the plant was converted to a natural gas fired facility.

1979-80 | Entire United States | Oil Price Increases

In 1979, the revolt in Iran against the rule of the Shah (dubbed the "Iranian Revolution") reduced world oil production and the OPEC nations announced a 14.5% increase in oil prices. By June 1979, OPEC again raised the average price of a barrel of oil by more than 50%, forcing the price of gasoline and fuel oil for American consumers to skyrocket, creating panic conditions in many parts of the country and causing a nationwide strike by independent truckers. The energy price increases resulted in long lines at gasoline stations, higher inflation, and signaled a reaffirmation of America's energy vulnerability.

During this time, federal price and allocation controls moderated the price increases and caused oil companies to allocate supply. For a period of several months, customers were only able to purchase 70 to 80% of their historical amounts. Under the federal allocation program, states had the authority to direct up to 3% of the monthly gasoline supply to meet the needs of priority users such as police, fire and emergency medical services, in addition to other emergency hardship needs. The State of Michigan redirected over 100 million gallons of gasoline, heating oil, and diesel fuel. The peak of the supply shortfall occurred in May 1979. Longer lasting, and ultimately more serious, was its role in the "double dip" economic recession of 1980 and 1981-1982, in which many lost jobs and manufacturing output was seriously depressed.

In response to the situation, President Carter proposed a plan, delayed by Congress for almost a year, which included conservation of existing fuel supplies, a long-range decrease in foreign oil imports, and the development of new sources of energy. Carter further proposed the deregulation of domestic oil prices in order to stimulate domestic oil production. However, Carter's deregulation plan didn't work as planned and instead resulted in American oil companies significantly raising gasoline prices. The combination of the higher price levels set by OPEC and the American oil companies caused gasoline and fuel oil prices to nearly double. The start of war between Iran and Iraq in 1980 further boosted oil prices. By the end of 1980, the price of crude oil stood at 19 times what it had been just ten years earlier.

### December 1998 | Detroit | Natural Gas Main Failure

On December 12, 1998 in Detroit, a 30-inch water main burst in the downtown area, crushing a nearby 12-inch gas main and flooding it with water. Approximately 200,000 gallons of water flooded nearly 20 miles of gas line, shutting down gas service to hundreds of downtown Detroit businesses and residents on both sides of I-375. Officials estimated that 600 buildings (including hotels, offices, restaurants, shops, and residences) were affected by the gas service shutdown. Crews from Michigan Consolidated Gas worked around the clock for the next four days to drain water from the gas lines and hundreds of gas meters and restore gas service. Even after restoration was complete, problems and service interruptions continued to plague some structures for several days, until more permanent repairs could be made. Michigan Consolidated Gas called the water contamination incident the worst in the company's 150-year history. Economic losses were substantial for the affected hotels, restaurants, and other businesses, because the incident occurred during the normally profitable pre-Christmas holiday period.

### 1999-2000 | Northeastern United States | Home Heating Oil Shortage

In mid-January 2000, a combination of adverse weather conditions, low heating oil inventories, natural gas capacity and delivery constraints, and production problems created rapid price increases in fuel oil and natural gas markets in the Northeast United States. When colder weather hit, consumers increased their demand for home heating oil and natural gas, and prices rose significantly. The temperature change increased weekly heating requirements by about 40%. Because fuel oil stocks were below normal levels, available supplies were limited and prices responded sharply to the increase in demand. The surge in home heating oil prices lasted for approximately four weeks and then subsided. However, the level and duration of the price increase prompted the President to ask the Secretary of Energy to examine opportunities for converting factories and major users from oil to other fuels, helping to free up oil supplies for use in heating homes. (Michigan also saw increased prices as supply was pulled from the Midwest in response to the higher prices in the Northeast.)

The federal government also took other actions to address the surge in heating fuel prices, including releasing funds from the Low Income Home Energy Assistance Program (LIHEAP) to relieve some of the financial burden to low income households. (Michigan was also a recipient of emergency funding from the LIHEAP.) The most significant action, however, occurred on July 10, 2000 when the Department of Energy established the Northeast Heating Oil Reserve. The reserve is intended to reduce future risks presented by home heating oil shortages from events such as this one. The maximum inventory of heating oil in the reserve will be two million barrels, which should provide relief from weather-related shortages for approximately ten days—the time it takes ships to bring heating oil from the Gulf of Mexico to New York Harbor.

### June 2000 | Jackson County | Petroleum Product Pipeline Rupture

On the morning of June 7, 2000 a Wolverine Pipeline Company pipeline ruptured in Jackson County's Blackman Township, releasing 75,000 gallons of gasoline into the environment and forcing the evacuation of more than 500 homes in a one square mile area around the spill. The leak was detected when a drop in pressure was recorded at a metering station along the 80-mile pipeline that runs through Blackman Township from Joliet, Illinois to Detroit.

In addition to causing significant environmental and public safety problems, the spill shut down 30% of the state's gasoline transportation capability for nine days. The ruptured pipeline was capable of carrying approximately seven million gallons of gasoline per day. (This is equivalent to having 467 tanker trucks with a capacity of 9,000 gallons each making daily round trips from Jackson to Detroit.) While the pipeline was being repaired, tanker trucks from several surrounding states were brought in to help make up for the loss of the pipeline. As truck deliveries could not fully replace the pipeline transportation capacity, drivers began falling behind on deliveries and a growing number of gas stations were without one or more grades of gasoline for periods of time. The pipeline was not returned to service until June 17, and then at only 80% of capacity.

The pipeline rupture caused short-term supply problems in Southeast Michigan and, along with other factors, contributed to an increase in gasoline prices from an average of $1.68 per gallon, when the pipeline broke, to over $2.00 per gallon in the ensuing weeks of June. One of the major contributing factors to the shortages and price increases was that Michigan had very low gasoline inventories going into that summer. In some areas of the Midwest, inventories were 13.5% below average in May 2000—their lowest levels since 1981. The closing of the Total Refinery in Alma in December 1999 also contributed to the supply problem. The Alma refinery's capacity of just under one million gallons per day had satisfied approximately 8% of Michigan's average daily gasoline demand. The closing of the refinery increased Michigan's reliance on the Chicago area gasoline markets, thereby increasing the dependence on the Wolverine pipeline. A final contributing factor was a reduction in transportation capacity caused when one of the two barges supplying petroleum products to marine terminals in Traverse City, Cheboygan, and Bay City was in dry dock for repairs. Supply problems in northern Michigan and Bay City were eased once the barge returned to service in early June 2000. All of these factors combined to make gasoline supplies very tight even before the Wolverine pipeline ruptured.

### June and August, 2000 | Detroit | Electrical Blackouts

Detroit fell victim to two significant power outages in 2000 – one that began on June 13 and lasted for 4 days, and another that occurred from August 31-September 1. The two outages (the third and fourth major power failures in the city since 1991) caused significant disruptions in commerce and city services and put the city in a negative national spotlight during a time of crisis (winds, storms, and flooding).

The June 13-16 outage actually began on June 12, when one of three main lines connecting Detroit Edison to the Detroit Public Lighting Department failed. During the process of repairing the line on June 13, a cable connection failed, setting off a chain reaction that completely disabled the two remaining connections. The resulting outage cut power to 1,250 traffic lights, 42,000 street lights, Detroit Receiving Hospital, four senior housing complexes, all public housing, Detroit City Airport, the Renaissance Center, Wayne State University, Wayne County Community College, the Detroit Institute of Arts, the U. S. District Courthouse, the City-County Building, and most city buildings and schools. Businesses and homes that received electricity directly from Detroit Edison were not affected. The outage affected a total of 4,500 buildings, idled over 167,000 school children, caused significant business and parking revenue losses, and forced the city to pay out millions in overtime costs for city workers. The power outage also left some public schools without their electronic alarm systems, resulting in four being broken into and vandalized.

The August 31 outage occurred when the Detroit Public Lighting Department cut electrical service to parts of the city (to avoid a widespread outage like the June 13-16 incident) after two generators failed due to high demand caused by hot weather. Power to municipal buildings and services was lost on much of the city's west side and large portions of its east side, including schools, police stations, street and traffic lights, government offices, hospitals, and Wayne State University. Power was restored the next day. Follow up investigation of the cause of the outage revealed that a squirrel jumping on an electrical conductor may have caused an explosion at a substation that eventually led to the power failure.

### July 2000 | Mackinac Island | Electrical Blackouts

Beginning on July 22, 2000 Mackinac Island began to experience intermittent power outages that escalated two days later into a complete power blackout. The outage continued until July 28, when several large generators were brought to the island by Edison Sault Electric Company to provide temporary power until the island's electrical infrastructure could be repaired. The cause of the outage was later determined to be overheating damage to five of the seven underwater cables that provide power to the island from the mainland. The damaged cables were subsequently replaced to mitigate future problems.

The outage came at the worst possible time for the residents, visitors, and businesses on Mackinac Island—at the height of the tourist season (with more than 35,000 tourists on the island) and during the week of the popular Chicago to Mackinac yacht race. Somehow, the island's businesses and visitors managed to cope, but not without significant inconvenience, additional operating costs, and some loss of revenues.

### 2000-2001 State of California Electrical Blackouts

The energy deregulation efforts in California which began in 1996 took a nasty turn in late 2000 and early 2001 when the state began to experience power shortages and blackouts caused by the state's inability to purchase sufficient electric power supplies to satisfy demand. The blackouts often affected hundreds of thousands of customers at a time and created havoc for homeowners, business and industry, schools, banks, television stations, traffic control systems, and other major electrical users. The root cause of the energy emergency was the way in which California had designed and administered its deregulation plan in the first place. Under the plan, private utilities in the state had to sell their power plants and buy electricity on the open market, an approach that supposedly would result in lower electrical rates. However, the state's two largest private utilities—Pacific Gas and Electric Company and Southern California Edison—had lost at least $10 billion because of soaring wholesale prices for electricity and because rate caps imposed under deregulation had prevented them from passing those costs on to customers. As a result, both utilities were consistently short on power, as well as cash to pay their bills, and teetered on bankruptcy.

California's rapid growth in the 1990s (13.8%), coupled with the fact that no new power plants had been built since the mid-1980s, also contributed to the energy emergency. Had there been a glut of electricity on the West Coast, California's plan might well have worked as planned. Since there wasn't, the state's utilities had to compete for scarce, expensive power on the open market and then were not able to pass the extra costs on to customers.

Recognizing the seriousness of the situation, California's Governor declared a "state of emergency" in January 2001 and ordered the state Water Resources Department to temporarily buy up to $1 billion in power from electric wholesalers and provide it to the two utilities, to prevent continued blackouts. The Governor also signed a bill to amend the requirement that utilities sell their power plants under the state's deregulation plan.

California's energy deregulation experience provides an example of how problematic deregulation efforts can be if not properly designed and implemented. This has ramifications for states that have energy deregulation plans. In 2000, the Michigan Legislature passed the Michigan Customer Choice and Electricity Reliability Act and its companion Securitization Act (141 and 142 PA 2000). The two laws restructured Michigan's electric power supply system and gave the state's 3 million electrical customers the option of choosing their electricity supplier by January 1, 2002. Unlike California's plan, however, Michigan's deregulation plan does not impose strict rules on where the state's major utilities can purchase the power they sell. In addition, Michigan has a number of power plants that have been recently completed or are under construction.

### December 2000 State of Michigan Propane Supply Problems

Going into the Winter of 2000-2001, propane supplies were very tight and inventories were low. In the Midwest, propane inventories in mid-October 2000 were 44% below the levels of one year earlier. In December 2000, the state experienced record cold weather. Heating degree-days showed that temperatures were 27 degrees colder than normal—the second coldest December on record and the snowiest on record. The propane industry found it increasingly difficult to maintain deliveries in light of the high levels of demand. In response to industry requests and in view of the heavy snows and very cold weather, the Chair of the Michigan Public Service Commission, in consultation with the Emergency Management and Homeland Security Division of the Michigan State Police, requested a 10-day waiver of limits on driver hour restrictions from the Regional Administrator of the Federal Motor Carrier Safety Administration. Waivers were granted for Michigan (and also Indiana, at their request). The extremely tight supply, coupled with additional demand to use propane as a substitute for natural gas (which also had a sharp run-up in prices), caused residential propane prices to reach a record high in Michigan of $1.76 per gallon in January 2001 before declining to $1.00 per gallon by the end of the heating season. A significant warming trend in January allowed the industry time to replace seriously depleted supplies. Had this not occurred, the situation could have become much more serious.

### August 2003 Northeastern United States Electrical Blackout

On Aug. 14, 2003, much of the northeast United States and Ontario was hit by the largest blackout in North America's history, exceeding the Great Northeast Blackout of 1965. Electricity was lost by 50 million people, bringing darkness to customers from New York to Michigan. Some essential services remained in operation in most of these areas, although backup generation in some cities was not up to the task. The phone systems remained operational in most areas, but the increased demand by people phoning home left many circuits overloaded. Water systems in several cities lost pressure, forcing boil-water advisories. Cellular telephones experienced significant service disruptions as cellular transmission towers were overloaded with a sudden increase in the volume of calls. Television and radio stations mostly remained on the air with the help of backup generators, or by relaying their broadcasts through Grimsby transmission towers, which were online throughout the blackout. Most interstate rail transportation in the United States was shut down, and the power outage's impact on international air transportation and financial markets was widespread. Meanwhile, the reliability and vulnerability of all electrical power grids was called into question.

On November 19, 2003, the U.S.-Canada Power System Outage Task Force released an interim report placing the cause of the blackout on First Energy Corporation's failure to trim trees in part of its Ohio service area. The report said that a generating plant in the Cleveland, Ohio, area went off-line amid high electrical demand, and strained high-voltage power lines that later went out of service when they came in contact with overgrown trees. The report also found that First Energy did not take remedial action or warn other control centers until it was too late, because of a bug in the Unix-based General Electric Energy's XA/21 system that prevented alarms from showing on their control system, and they had inadequate staff to detect and correct the software bug. The cascading effect that resulted ultimately forced the shutdown of more than 100 power plants.

### August 2005 State of Michigan Petroleum Product Supply Problems

On August 31, 2005, Governor Granholm issued three executive orders to address the energy-related issues in Michigan caused by Hurricane Katrina. The massive hurricane had blocked off oil refineries stationed in Louisiana and affected the supply in Michigan. Executive Order 2005-16 declared a State of Energy Emergency in accordance with 1982 PA 191. Executive Order 2005-17 temporarily waived regulations relating to motor carriers and drivers transporting gasoline, diesel fuel, and jet fuel. Executive Order 2005-18 provided for a temporary suspension of rules for gasoline vapor pressure. The State of Energy Emergency was in effect until November 29, 2005.

### Winter of 2005-2006 United States Natural Gas Price Increases

During the winter of 2005-2006, Michigan saw record-high natural gas prices. Eighty percent of Michigan homes rely on natural gas as their primary heating source, and Michigan's average monthly residential heating bill from November to March increased from $128 a month the previous winter to $180 during 2005 and 2006. The reason for the high prices was largely due to both the lingering effects of Hurricane Ivan, in 2004, and 2005's Hurricanes Katrina and Rita. Substantial disruption of natural gas production in the Gulf of Mexico had reduced supply, driving up prices. There was further uncertainty about the prospect of even higher prices, depending on how long it might take to return natural gas production from the Gulf of Mexico to normal levels. Fortunately, prices did go down, averaging $152 a month for the 2006-2007 winter and the 2007-2008 winter. (Refer to the Natural Gas Prices Monthly Average Table from 2000-2009 for further details.)

2007-2008 United States Oil Price Increases

Crude oil prices reached an all-time high in Michigan in July-September 2008. During 2003, the price rose above $30 a barrel in the peak summer months, and reached $60 a barrel by August 2005 nationally. The dramatic rise in oil prices began in March of 2007, with a steady increase that included little break during the 2007-2008 winter's traditional low point. March of 2008 started a very large increase in oil prices, at just over $80 a barrel, then clearing $100 a barrel in May, and finally peaking at $147 a barrel in July 2008. Following the July peak, oil prices then took a dramatic dive, and by November 2008 returned to just under $40 a barrel, the lowest level since March 2005. (Refer to the Oil Price, January 2003-December 2008 table for further details.) The increase in prices led to gasoline prices of over $4 a gallon during the summer of 2008. Commentators attributed these price increases to many factors, including reports from the United States Department of Energy and others, the decline in petroleum reserves, concern about high demand for oil, Middle East tension, and oil price speculation. Also, deferred maintenance on refineries that escaped hurricane damage led to an increase in fires and accidents in 2007 and disrupted supplies. A reduction in routine refinery maintenance was made necessary by the need to operate near full capacity, to make up for a loss in refinery capacity from the 2005 Atlantic hurricane season. In 2008, Hurricane Ike played a role in the price spike. Rising demand from U.S. consumers had stretched refinery capacity to the limit and made the whole system more vulnerable to disruptions.

Winter of 2008-2009 United States Natural Gas Price Increases

During the winter of 2008 and 2009, Michigan saw nearly record high natural gas prices, similar to that of the 2005-2006 winter. State regulators attributed higher heating costs to the increased price of crude oil. Regulators said Michigan fared better than other states because Michigan stores some natural gas in underground tanks. The economic recession's higher unemployment rate, combined with higher heating costs, caused utility companies to shut off more power or natural gas because of unpaid bills. The number of gas shutoffs were up 39 percent in Michigan. (Refer to the Natural Gas Prices Monthly Average table at the end of this chapter for further details.)

Winter 2013-2014 Statewide Propane Shortages

Due to one of the harshest winters in Michigan in terms of extreme cold and higher than average snowfall amounts, Michigan residents struggled with propane shortages. The average cost of propane more than doubled from normal levels. The problem was exacerbated by (1) farmers' use of more propane to dry grain crops following a wet late harvest season during the fall, (2) pipeline disruptions and shutdowns, and (3) a rail closure in Canada. Heavy snowfall also made it difficult to deliver fuel by overland routes. Due to increased vehicle and equipment failures and hazardous road conditions, commercial drivers more easily hit their commercial driving limits, so on January 10th, Governor Rick Snyder declared an energy emergency, which suspended state and federal regulations on the number of hours and consecutive days that drivers can operate commercial vehicles. On January 19th, the U.S. Department of Transportation declared an emergency and relaxed transportation rules in Michigan and several other states until the emergency was over. The emergency declarations and transportation waivers in the Midwest were extended through March 1st. The Michigan Department of Natural Resources offered a program to issue firewood permits, which usually aren't sold during the winter. Some state-level efforts to address the shortage include $7 million in Michigan Energy Assistance Program funds devoted to "deliverable fuel heating assistance," and MDHS work to dedicate another $7 million to Low Income Heating and Energy Assistance Program (LIHEAP) assistance for residents who rely on propane or other deliverable fuels for heat.

### *Programs and Initiatives*

The federal government has put into place a significant legislative and programmatic infrastructure, with and through the state governments, to address energy emergencies. Following are some of the more important components of that infrastructure:

#### Department of Energy Organization Act of 1977

The energy crisis of the 1970s demonstrated the need for a unified energy organization at the federal level. The Department of Energy Organization Act of 1977 (P.L. 95-91) brought the federal government's various energy agencies and programs into a single agency. The Department of Energy, established on October 1, 1977, assumed the responsibilities of the Federal Energy Administration, the Energy Research and Development Administration, the Federal Power Commission, and parts and programs of several other agencies. The Department of Energy coordinates and administers the federal government's energy functions, including research and development of energy technology, federal power marketing, energy conservation, the nuclear weapons program, energy regulatory programs, and a central energy data collection and analysis program.

#### Strategic Petroleum Reserve

America's "first line of defense" against a cutoff in oil supplies is the Strategic Petroleum Reserve (SPR) – an emergency supply of crude oil stored in huge underground salt caverns along the Gulf of Mexico. As of November 2010, the Strategic Petroleum Reserve had an inventory of 726 million barrels. This equates to 34 days of oil, at current daily US consumption levels of 21 million barrels a day. This system currently has the capacity to hold 727 million barrels. It is the largest emergency oil stockpile in the world, representing a $20 billion national investment in product and facilities. The total value of the crude in the SPR is approximately $66 billion. The price paid for the oil is $20.1 billion (an average of $28.42 per barrel).

The need for a national oil storage reserve was first recognized in the early 1940s. However, it took the 1973-74 OPEC oil embargo and the economic shock waves that followed to finally get the SPR established. President Ford set the SPR into motion when he signed the Energy Policy and Conservation Act (P.L. 94-163) on December 22,

1975. The legislation set forth a U.S. policy to establish a reserve of up to one billion barrels of petroleum. In July of 1977, the first oil was delivered to the SPR.

The Strategic Petroleum Reserve reduces the nation's vulnerability to the economic, national security, and foreign policy consequences of petroleum supply interruptions, such as was experienced in 1973-74. Decisions to withdraw crude oil from the SPR during an energy emergency are made by the President under the authorization of the Energy Policy and Conservation Act. In the event of an energy emergency, SPR oil would be distributed by competitive sale. The value of the SPR was tested in 1991, when President Bush ordered the first ever emergency drawdown of the SPR to dampen oil price hikes during the Persian Gulf War. The U.S. government's stated policy to withdraw oil early in a potential energy supply emergency makes the SPR a significant deterrent to oil import cutoffs, and a key tool of foreign policy.

### National Energy Act of 1978

President Carter's goal of a comprehensive national energy program was achieved, at least in part, with the passage of the National Energy Act of 1978, which consisted of several separate pieces of legislation. The National Energy Conservation Policy Act (P.L. 95-619) set standards and provided financing for energy conservation in public and private buildings. The Power Plant and Industrial Fuel Use Act (P.L. 95-620) encouraged the transition from oil and gas to coal, in industrial and power plant boilers. The Public Utilities Regulatory Policies Act (P.L. 95-617) provided Congress with authority over the interstate transmission of electric power. The Natural Gas Policy Act (P.L. 95-621) unified the natural gas market and promoted the deregulation of the natural gas industry. The Energy Tax Act (P.L. 95-618) approved tax credits for the installation of solar, wind, and geothermal energy devices to promote energy conservation.

### State Energy Conservation Program Improvement Act of 1990

Under the State Energy Conservation Program Improvement Act of 1990 (P.L. 101-440), states are required to submit to the U.S. Department of Energy an energy supply emergency planning program, consistent with applicable federal and state laws. The contingency plan provided by this program must include an implementation strategy or strategies (including regional coordination) for dealing with energy emergencies. In Michigan, this energy emergency planning requirement falls under the purview of the Michigan Public Service Commission (MPSC), an agency within the Michigan Department of Licensing and Regulatory Affairs. (See "Michigan Public Service Commission Energy Emergency Program" below for additional information.)

### Michigan Public Service Commission Energy Emergency Program

The Michigan Public Service Commission (MPSC) is responsible for energy emergency planning and response in Michigan. The three MPSC divisions that are involved in energy emergency planning and response activities are the Management Services Division, the Regulated Energy Division, and the Operations and Wholesale Markets Division. The energy emergency responsibilities of these divisions can be grouped into four broad categories:

- Monitor Michigan's energy supply system for the purpose of detecting unusual imbalances that may indicate the potential for an energy emergency, and advise the appropriate state officials of such events.
- Develop, administer, and coordinate energy emergency contingency plans.
- Act as the communications focal point for federal, state, and local activities related to energy emergency planning and management.
- Maintain ongoing contact with the petroleum, natural gas, and electric industries concerning Michigan's energy situation.

In the event of an energy emergency, or in anticipation of such an emergency, the Chairman of the MPSC may consult with or convene and chair the MPSC Energy Emergency Management Team (EEMT), which consists of senior MPSC staff. The EEMT will monitor developments, prepare assessments, and develop responses. The MPSC Chairman will be responsible for consulting with or convening the EEMT, assigning tasks to its members, and providing information developed by the EEMT to the Governor. In general, the EEMT's responsibilities include the monitoring of developments, preparation of assessments, and implementation of responses on a day-to-day basis.

Pursuant to 1982 PA 191 (The Declaration of State of Energy Emergency Act), the Governor may declare a State of Energy Emergency and order mandatory energy conservation actions following such a declaration. (See below for more information on 1982 PA 191.) In addition to declaring a State of Energy Emergency, the Governor may also declare a State of Emergency or State of Disaster under 1976 PA 390, as amended (The Michigan Emergency Management Act), and direct necessary actions through the Emergency Management and Homeland Security Division, of the Michigan Department of State Police. In that scenario, the MPSC plays a supporting role with situation monitoring, communications, and other activities. If a national energy emergency occurs, the MPSC is the primary coordinating agency with the U.S. Department of Energy's Office of Emergency Operations—the federal agency responsible for national contingency planning and response in the event of a nationwide energy shortage.

Public Act 295 of 2008

The Act promotes the development of clean and renewable energy and energy optimization through the implementation of standards that will cost-effectively provide greater energy security and diversify the energy resources used to meet consumers' needs. The Act encourages private investment in renewable energy, energy efficiency, and the improvement of air quality. Michigan Public Service Commission Temporary Order U-15800 was approved to implement the Act. It outlined formats for renewable energy plans, provided guidelines for requests for proposals (for gas and electric suppliers covered by plans), and addressed energy optimization plan implementation issues.

State Emergency Relief (SER)

The State Emergency Relief (SER) program provides a wide range of energy-related emergency services. The cost for SER energy services is covered with state and other federal funds. The SER program is administered by the Department of Human Services (DHS). An application is needed to request assistance and an appointment is generally required. Eligibility for SER energy services is based on a household's demonstration of immediate need for assistance with home heating fuel, electricity, or energy-related home repairs. This may involve a declared need for a deliverable fuel (such as fuel oil, liquid propane, gas, wood, or coal), presentation of a shut-off notice for natural gas or electricity, or a verified need for an energy-related home repair. In addition to immediate need, SER energy services eligibility is based on income to be received in the 30-day period following application. All households will have their income compared to the SER Income Need Standard that estimates the costs of shelter, heat, utilities, personal and incidental needs.

Energy Emergency Plans / Procedures

The MPSC develops and maintains three emergency procedure manuals for responding to energy emergencies pertaining to electricity, natural gas, and petroleum. (It is important to note that these three plans do not fully cover the wide range of events that could create an energy emergency in Michigan. For example, events involving military mobilization are not covered, nor are plans for responding to shortages of propane or fuel oil for residential users. If emergencies were to occur in those areas, the MPSC and other relevant state agencies would develop additional response actions as needed.)

The Michigan Motor Fuels Shortage Response Plan outlines a series of options that could be considered if Michigan is faced with a serious gasoline shortage, including measures designed to manage limited supplies and to reduce the demand for gasoline.

The Michigan Emergency Electrical Procedures consists of three sets of procedures for dealing with electricity shortages, each appropriate to a particular situation. The first set addresses *sudden or unanticipated short-term capacity shortages*, such as those experienced in the aftermath of severe weather that damages electrical production or distribution facilities. The second set addresses *anticipated or predictable short-term capacity* *shortages,* such as those experienced during short-duration periods of hot weather when system demand is expected to exceed capacity. The third set addresses *long-term capacity shortages,* when it becomes necessary to live with a reduced supply for an extended period of time (more than a week).

The Michigan Natural Gas Procedures Manual outline procedures for addressing a long-term national gas shortage or an isolated disruption within the transmission or distribution systems.

State Energy Emergency Response

As indicated above, the Chairperson of the MPSC may convene the MPSC's internal Energy Emergency Management Team (EEMT) to coordinate response to an actual or anticipated energy emergency. Energy emergencies involving petroleum products, electricity, and natural gas supplies require specific actions unique to each. However, the MPSC has developed a series of response actions that are the same regardless of the energy source involved. The MPSC response to an energy emergency can be described in four phases, each phase specifying an appropriate level of mobilization to address a potential or developing emergency situation:

**MPSC Response Phases**

**Phase I – Monitor and Alert**

- Monitor/forecast supply, demand, and price.
- Alert of incipient problems.

**Phase II – Assess and Decide**

- Assess the magnitude and implications of an emergency.
- Increase monitoring of the affected system/region.
- Evaluate available programs to deal with the emergency in economic, technical, and social terms.
- Select an appropriate program of response.

**Phase III – Action and Feedback**

- Implement emergency programs.
- Continue monitoring.
- Evaluate output to determine if the contingency plan is successful.
- Initiate remedial action to plan, if required.

**Phase IV – Review and Lessons Learned**

- Phase-out of emergency operations.
- Prepare after-action reports and conduct special analyses.
- Revise plans, if necessary.
- Resume routine monitoring.

## Energy Supply Monitoring

Understanding and responding appropriately to an energy emergency depends on the availability of quantified information. For that reason, the MPSC monitors energy supplies and demand as a part of its emergency preparedness program. The MPSC tracks energy developments affecting Michigan, the region, and the nation through industry contacts, the DOE Energy Information Administration, the Internet, trade publications, and various statistical reports.

Historical and forecast data are published by the MPSC semi-annually in the *Michigan Energy Appraisal*, which provides an overview of the balance between energy supply and demand in Michigan and across the region. In the event of an actual or anticipated energy emergency, special updates to this basic publication can be issued to the EAC and MPSC EEMT as required to aid in decision-making during the response effort.

## Public Information and Crisis Communications

As part of its energy emergency planning program, the MPSC maintains a public information program designed to help prevent confusion and uncertainty as well as enlist the support and cooperation of the public during an actual or anticipated energy emergency. The public information program is implemented at the discretion of the Governor and Chairperson of the MPSC at such time as a government response (whether voluntary or mandatory) is required. The public information program will provide the public with two basic sets of information: 1) an educational campaign to inform citizens about ways to minimize their use of energy and the inconvenience resulting from a disruption; and 2) an informational campaign to provide clear and concise information on the problems, and the steps being taken in response. In accordance with the Michigan Emergency Management Plan (MEMP), public information activities will be coordinated through a state Joint Public Information Team (JPIT) and Joint Public Information Center (JPIC).

## Michigan Customer Choice and Electrical Reliability Act of 2000

Signed into law on June 3, 2000, the Michigan Customer Choice and Electrical Reliability Act (141 PA 2000) and its companion Securitization Act (2000 PA 142) heralded a new era of electrical energy restructuring in Michigan. The two laws cut electric rates for residential customers by 5%, imposed a 2 to 4 year rate cap for residential, commercial and industrial customers, created more competition among electrical suppliers, and increased electrical generation and reliability of the power supply. Acts 141 and 142 provided the foundation that allowed Michigan to restructure and deregulate its electric power supply system.

## The Declaration of a State of Energy Emergency Act of 1982

The Declaration of a State of Energy Emergency Act (1982 PA 191) provides the Governor with the authority to declare a State of Energy Emergency to formulate an appropriate state response to an actual or anticipated energy emergency. The Governor may declare a State of Energy Emergency which remains in effect for the duration of the emergency or for 90 days, whichever is shorter. The State of Energy Emergency may be extended upon the approval of the Michigan Legislature, and it may be terminated by a majority vote of both houses of the Legislature.

When a State of Energy Emergency declaration is in effect, the Governor is authorized to:

1. Order specific restrictions on the use and sale of energy resources, which may include:
    - Restrictions on the interior temperature of buildings.
    - Restrictions on the hours and days during which buildings may be open.
    - Restrictions on the conditions under which energy resources may be sold.
    - Restrictions on lighting levels and the use of display and decorative lighting.
    - Restrictions on the use of privately owned vehicles, or a reduction in speed limits.
    - Restrictions on the use of public transportation, including directions to close a public transportation facility.

- Restrictions on the use of pupil transportation programs operated by public schools.

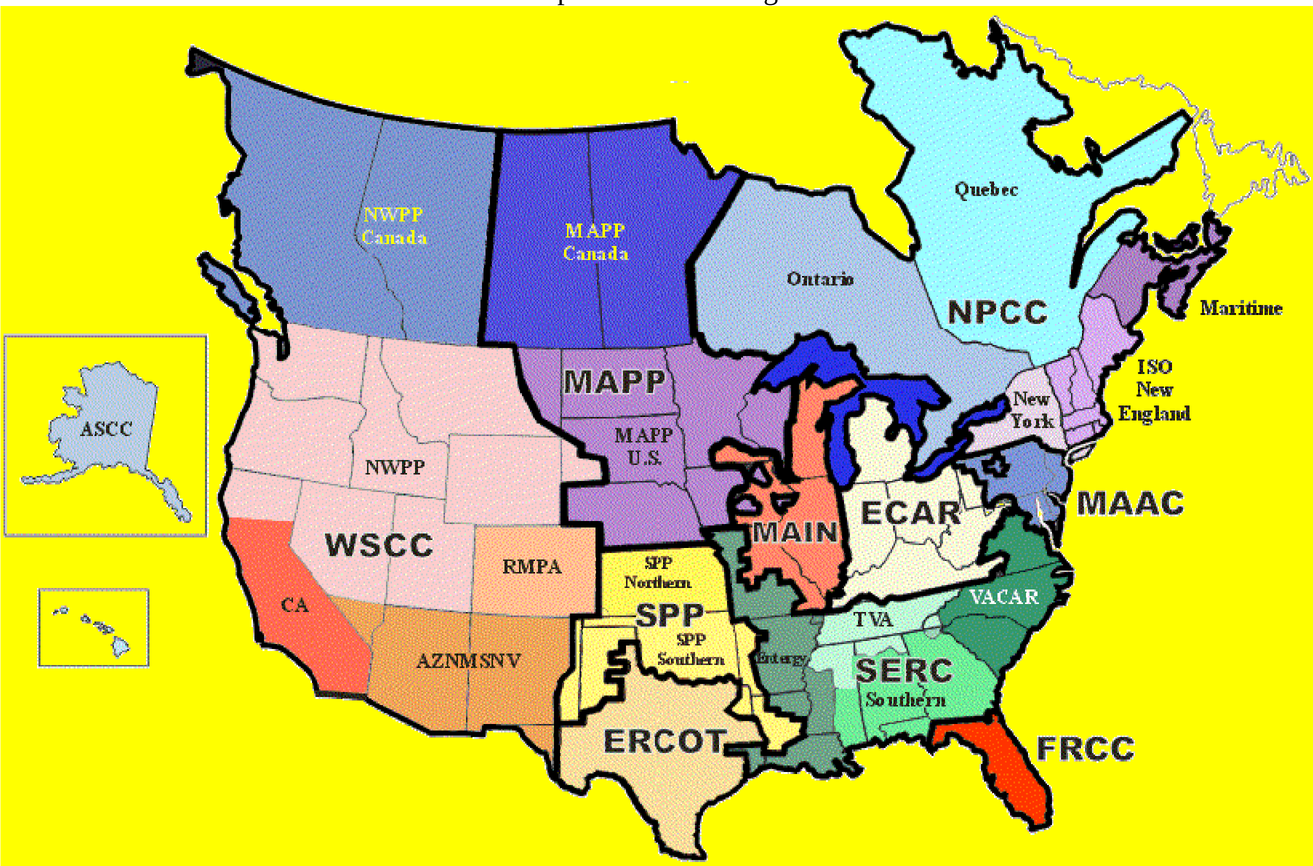
2. Direct an energy resource supplier to provide an energy resource to a health facility; school; public utility; public transit authority; fire or police station or vehicle; newspaper or television or radio station (for the purpose of relaying emergency instructions or other emergency message); food producer, processor, retailer or wholesaler; and to any other person or facility which provides essential services for the health, safety, and welfare of Michigan residents.

3. By Executive Order, suspend a statute or an order or rule of a state agency, or a specific provision of a statute, rule, or order, if strict compliance with the statute, rule, or order, or a specific provision of the statute, rule, or order will prevent, hinder, or delay necessary action in coping with the energy emergency.

North American Electric Reliability Council (NERC)

The NERC was originally created in 1968, in the aftermath of the Great Northeast Blackout of 1965, as the National Electric Reliability Council, and was renamed the North American Electric Reliability Council. The North American Electric Reliability Corporation (NERC), was formed on March 28, 2006 as the successor to the North American Electric Reliability Council (NERC). This association is composed of eight separate regional electric reliability councils. The purpose of the NERC is to ensure that electric utilities and other electricity suppliers work together to develop and maintain an adequate electric supply to meet the country's needs. NERC's primary responsibilities include working with stakeholders to develop standards for power system operation, monitoring and enforcing compliance with those standards, assessing resource adequacy, and providing educational and training resources as part of an accreditation program to ensure that power system operators remain qualified and proficient. The NERC and its regional reliability councils do this by reviewing past practices for lessons learned, monitoring present practices for compliance with applicable policies, criteria, standards, principles and guidelines, and assessing the future reliability of the nation's electric systems.

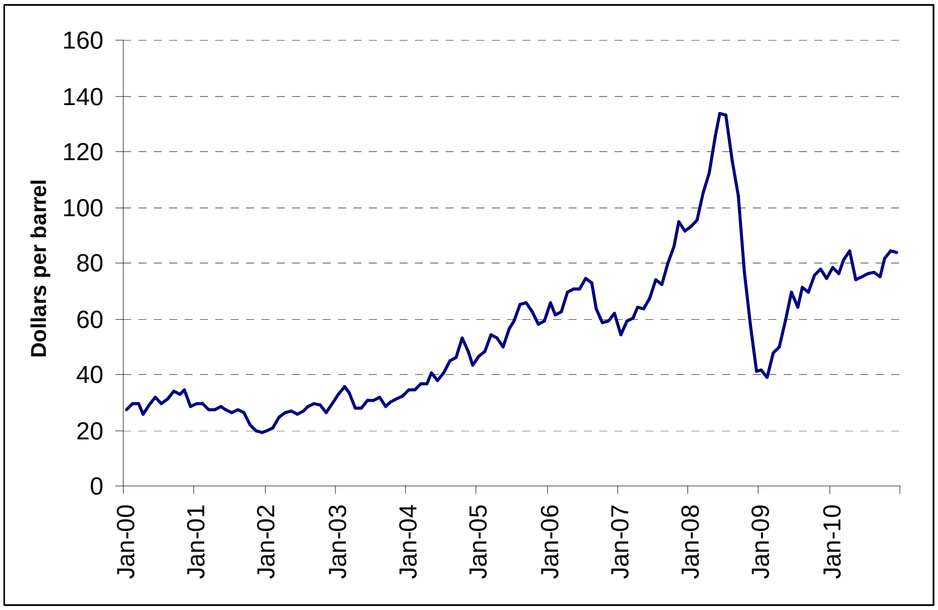
**North American Electric Reliability Council**
Map of Electrical Regions



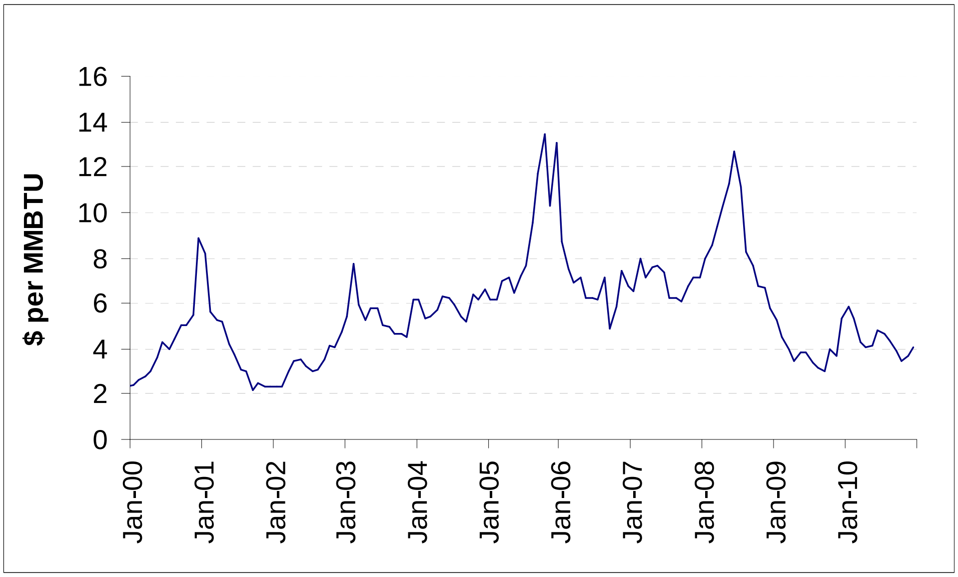

***Hazard Mitigation Alternatives for Energy Emergencies***

- Redundancies and alternatives in the energy supply system; provision of backup supply systems.
- The capacity to use more than one type of fuel to sustain necessary operations and functions.
- Use of alternative sources of energy (e.g. solar, wind sources) for key functions.
- Architectural designs that reduce the need for outside energy inputs.

**West Texas Intermediate Crude Oil Price**
**January 2000 – December 2010**
**(U.S. EIA Short Term Energy Outlook)**




**Natural Gas Prices (Monthly Average, 2000-2010)**
(Henry Hub pricing point)



## Midwest Energy Consumption Patterns

NOTE: Energy Market Maps, Energy Infrastructure Maps, and Renewable Energy Maps were no longer provided publicly on the Energy Information Administration (EIA) web site, for national security reasons, and thus are not included in this document.

# TRANSPORTATION ACCIDENTS

*A crash or accident involving an air, land, or water-based commercial passenger carrier.*

***Hazard Description***

Air Transportation Accidents

There are four circumstances that can result in an air transportation accident: 1) an airliner colliding with another aircraft in the air; 2) an airliner crashing while in the cruise phase of a flight due to mechanical problems, sabotage, or other cause; 3) an airliner crashing while in the takeoff or landing phases of a flight; or 4) two or more airliners colliding with one another on the ground during staging or taxi operations. When responding to any of these types of air transportation accidents, emergency personnel may be confronted with a number of problems, including: 1) suppressing fires; 2) rescuing and providing emergency first aid for survivors; 3) establishing mortuary facilities for victims; 4) detecting the presence of explosive, radioactive, or other hazardous materials; and 5) providing for crash site security, crowd and traffic control, and protection of evidence.

Major Land Transportation Accidents

A major land transportation accident in Michigan has the potential to create a local emergency event, or to seriously strain or overwhelm local response and medical services. It could involve a commercial intercity passenger bus, a local public transit bus, a school bus, or an intercity passenger train. Although these modes of land transportation have a good safety record, accidents do occur. Typically, bus accidents are caused by the bus slipping off a roadway in inclement weather or colliding with another vehicle. Intercity passenger train accidents usually involve a collision with a vehicle attempting to cross the railroad tracks before the train arrives at the crossing. Unless the train accident results in a major derailment, serious injuries are usually kept to a minimum. Bus accidents, on the other hand, can be quite serious—especially if the bus has tipped over. Numerous injuries are a very real possibility in those types of situations. Sometimes, "ordinary" highway crashes can be of unusual significance, when they either involve a large number of vehicles or in some manner cause the entire shut-down of a major highway for a significant period of time. (For example, on July 3, 2010, in the City of Flint, a tanker accident and fire caused I-475 to be closed down for many hours, in both directions.)

Michigan's High Speed Rail Program

In 1999, Michigan began the implementation of its High Speed Rail Program. As one of the first projects, train speeds will be increased from 79 miles per hour to over 100 miles per hour on a segment of Amtrak's passenger train route between Detroit and Chicago. The existing rail corridor between Kalamazoo and Grand Beach has been upgraded with improvements to the track, the signal and communication system, and the at-grade crossing warning devices. The state-of-the-art signal and communication system uses advanced technology to communicate between the at-grade crossings and the train, and also uses a Differential Global Positioning (DGP) train location system. These improvements will ensure the highest level of passenger safety. The goal of Michigan's High Speed Rail Program is to reduce travel time on the entire Detroit-to-Chicago rail corridor from approximately six hours to three and one-half hours. Future plans also include an increase in trip frequencies along the corridor, from the current four daily round trips up to eight or possibly even 10 daily round trips.

The fastest passenger trains now operating in the United States are on the Northeast Corridor, traveling between Washington D.C. and New York City at approximately 125 miles per hour. Although this high-speed passenger rail service is relatively new to the United States, similar systems have been in place for quite some time in Europe and Japan, with an outstanding safety record.

From a hazard perspective, the higher-speed train service will provide new challenges for communities on the Detroit-to-Chicago rail corridor to address in their emergency planning and preparedness efforts. To ensure that all communities are adequately prepared, the Federal Railroad Administration (FRA), the Michigan Department of State Police (MSP), the Michigan Department of Transportation (MDOT), and the affected communities' emergency managers have all been working with the Operation Respond Institute to install an emergency information system along the corridor. This system is designed to quickly provide detailed railroad equipment information to emergency responders.

<u>Water Transportation Accidents</u>

A water transportation accident involving one of the 20 commercial marine passenger ferries operating from Michigan’s Great Lakes shoreline communities could have significant life safety consequences. Most of these marine ferry services operate on a seasonal basis (typically May through November). Vessel sizes vary, but it is not uncommon for 100-200 passengers or more to be on board many of the ferries at the peak of tourist season. In a typical year, these ferries make thousands of trips across Great Lakes waters. Although the vessels have an excellent safety record and must pass rigorous Coast Guard inspections, the potential for an accident is always present. Accidents in other states or countries involving similar vessels validate the need for rigorous emergency preparedness actions to prevent loss of life in an open water setting such as the Great Lakes. For instance, the Ethan Allen tour boat that capsized in Lake George, New York, in 2005 took the lives of 20 senior citizens.

***Hazard Analysis***

The one commonality all transportation accidents share, whether air, land, or water-based, is that they can result in mass casualties. Air transportation accidents, in particular, can result in tremendous numbers of deaths and injuries, and major victim identification and crash scene management problems. Water transportation accidents, on the other hand, may require a significant underwater rescue and recovery effort that few local jurisdictions may be equipped or trained to handle. Michigan’s fourteen Regional Planning Offices may have already performed an analysis of transportation in a particular area, and should be consulted for more information.

<u>Air Transportation Accidents</u>

Statistics from the NTSB and the airline industry show that the majority (over 75%) of airplane crashes and accidents occur during the takeoff or landing phases of a flight. As a result, developed areas that are adjacent to major airports, and along airport flight paths, are particularly vulnerable to this hazard. Accordingly, the greater the number of landings and takeoffs, the greater the probability of a crash or accident. The challenge for jurisdictions with a passenger air carrier airport is to develop adequate procedures to handle a mass casualty incident that could result from an airplane crash or accident.

The map at the end of this section shows the locations of Michigan's airports. Those airports are classified as transport airports, which are the most highly developed facilities in the state and have paved runways capable of handling jet aircraft. According to MDOT statistics, in 2010 these airports collectively handled over 28.2 million passengers (24.4 million from Detroit Metro alone). Nineteen airports have a greater probability of experiencing a commercial passenger airplane crash or accident, either at the airport or in the immediate vicinity of the airport, since these are the main takeoff and landing spots for such commercial flights.

<u>Land Transportation Accidents</u>

More than 130 certified intercity carriers provide passenger, charter, commuter, and special bus service directly to 220 Michigan communities. Of these carriers, six offer regular route service. Michigan’s intercity rail passenger system consists of 568 route miles, along three corridors, serving 22 Michigan communities. (See the maps at the end of this section.)

Although these modes of land transportation have an excellent safety record, the combination of large numbers of passengers, unpredictable weather conditions, potential mechanical problems, and human error always leaves open the potential for a transportation accident involving mass casualties. Such an incident could occur with any of the aforementioned transportation modes, in any of the communities served by these systems. Nationally, an average of about six persons die each year in charter and commuter bus crashes, and 11 school children die in school bus accidents. About 8,500 children are injured each year in school bus crashes. Communities served by any of these systems should plan for a land transportation-related mass casualty incident in their emergency preparedness efforts.

## High Speed Rail: Future Challenges

The new high speed rail service between Detroit and Chicago will provide special challenges for communities located along that rail corridor. Although the rail infrastructure will be greatly enhanced and state-of-the-art safety improvements will be instituted, the possibility of a high speed collision between the train and an automobile or truck will still exist. Of special concern are the 360 public and private at-grade crossings in place along the 279 mile corridor. An at-grade crossing always involves the potential for a collision between the train and a vehicle attempting to drive across the tracks.

The U.S. Department of Transportation, through the Federal Railroad Administration, regulates the speed at which trains operate over highway/railroad at-grade crossings. These regulations allow trains to operate at up to 110 miles per hour over highway-railroad at-grade crossings with conventional warning devices only (cross buck signs, side of street and/or overhead flashing lights, and/or gates). At speeds between 110 and 125 miles per hour, positive barriers must be installed at highway-railroad crossings. At speeds above 125 miles per hour, all highways and railroads must be grade separated. These regulations were developed by evaluating the risk of accident damage, using the following philosophy:

- Up to 110 miles per hour: The highway vehicle occupant is most at-risk.
- 110 to 125 miles per hour: Possible injury to the train's occupants, due to rapid deceleration.
- Above 125 miles per hour: Greater likelihood of injury to train occupants, and the train may be derailed.

Amtrak, and high speed train manufacturers, have done computer simulations of accidents that could cause a significant rapid deceleration (similar to a highway vehicle-train accident). These simulations predict only minor injuries to the train's occupants. Based on the passenger train accident history in the state, the FRA regulations, and the computer simulations, the likelihood of a serious passenger rail transportation accident that results in significant casualties appears to be low. However, any collision between a train and a vehicle could result in casualties. Over a 10 year period from 2000 to 2009, there were 787 collisions in Michigan between trains and vehicles. It is only prudent that communities along the rail corridor be prepared to handle a mass casualty passenger rail accident as a worst-case scenario, and to plan for that contingency in their emergency preparedness efforts.

## Water Transportation Accidents

A map at the end of this section shows the locations of Michigan's 20 marine passenger ferry services. These services have a good safety record, having never suffered a serious accident that resulted in loss of life or property. Nonetheless, given the large number of trips that are made over Great Lakes waters every year, the possibility of a water transportation accident involving one of these vessels is still a possibility. Furthermore, should such an accident occur, the often-turbulent Great Lakes waters, coupled with the potentially large number of passengers on board, could pose tremendous obstacles to carrying out an effective water rescue and recovery operation.

The U.S. Coast Guard, local law enforcement marine safety units, and the ferry operator would provide primary rescue response to a Great Lakes marine passenger ferry accident. These agencies are highly trained and skilled in water rescue operations, but their resources may not be sufficient or their efforts timely enough to save everyone should a fully loaded ferry sink. Even with on-board life saving equipment, some loss of life might be inevitable—especially in inclement weather and/or rough lake waters. In addition, hypothermia is a real concern—even in balmy Great Lakes waters in the middle of summer.

Impact on the Public

Although automobile crashes tragically kill many hundreds of Michigan residents each year, this analysis necessarily focuses on the types of accidents that are large enough in scale to potentially cause an emergency or disaster-level situation. Airplane crashes and train derailments pose the largest problems, with the potential to cause mass casualties and significant local property destruction—especially since these modes of transportation pass through densely populated urban areas. On a smaller scale, but still potentially devastating to smaller or rural areas, would be major highway accidents involving passenger buses that result in heavy casualties, with the potential to overwhelm smaller emergency medical systems in those areas. An event that might go almost unnoticed in a large and wealthy metropolitan area might easily overwhelm the resources of a poor or rural community. In certain cases, power equipment or other infrastructure may be damaged by such accidents, causing additional impacts (please refer to the section on infrastructure failures). Marine accidents have the most direct impact on human life, but may also discourage water-related tourism, if they receive enough negative publicity. Certain types of marine accidents may also involve a release of hazardous or environmentally damaging industrial materials (see hazardous materials section).

Impact on Public Confidence in State Governance

There may be a sense that improper regulation, authorization, or oversight was maintained by the state, following an event of significant size or impact involving mass transit providers such as trains, airplanes, ships, buses, or trolley/monorail systems. In the case of major accidents involving the highway system, there is often a perception that roadway capacities are too limited—either by design, lack of sufficient funding, or the effects of annual construction projects. Some may perceive that greater enforcement of laws and regulations (e.g. motor carrier) might have prevented a major incident from taking place.

Impact on Responders

Routine "fender benders" or personal vehicle accidents are usually handled by law enforcement officers and are not considered to be community-level emergency events (although they may cause traffic jams and delays that impede emergency response). Only when large numbers of vehicles or persons are involved would motor vehicle accidents be considered large-scale events with the need to engage community-wide response efforts. In very small or rural communities, an overturned bus could be considered a major transportation accident, if such an incident caused enough injuries that local emergency medical capabilities could not adequately handle the situation. Thus, in many ways, this sort of incident is an example of a "mass casualty" event that local and state emergency management programs train to handle.

The impact on responders in highway events is usually limited to the risks of being in and around moving traffic streams, and the diversion of limited resources into the handling of a single large incident. Larger-scale and more unusual events involve the crashing or breakdown of large air, rail, or marine transportation vehicles. A bridge or tunnel collapse, or huge interstate pileup involving dozens of vehicles, may also cause an emergency-level event to occur. In the case of large plane crashes or train derailments, responders may be exposed to fires and hazardous materials, and may encounter problems with looters. In cases involving marine transportation accidents, special rescue operations may occur under perilous weather and lake conditions, in a time-sensitive effort to rescue persons stranded in (usually chilly or freezing) lake waters before they drown or suffer harmful effects from hypothermia or exposure. In all major transportation incidents, which take place in the outdoors, responders will be exposed to the elements and may be plagued by extreme temperatures, hail, winds, or lightning for extended periods of time, when managing these events. (Each of these hazards is described more fully in other subsections of this document.)

Impact on the Environment

Transportation accidents on land, in air, or in water may impact the environment if toxins or chemicals are released. The burning of petroleum, in an accident that involves an explosion, will quickly release sulfur dioxide, oxidized nitrates, and carbon monoxide into the air. These gases contribute to climate change, ozone depletion, and acid rain. Accidents involving watercraft may also cause a chemical release to occur. Similarly, an aircraft accident could spread petroleum and debris on land or in water.

***Significant Passenger Transportation Accidents***

As the following listings indicate, passenger transportation accidents occur with some regularity in Michigan. Fortunately, Michigan's recent transportation accidents have not been as deadly as accidents in many other parts of the country or around the world, but the possibility always exists for a major accident that results in multiple casualties.

October 28, 1942 Hamtramck (Wayne County) School Bus and Passenger Train Collision

During the morning of October 28, 1942, a major transportation accident occurred in Hamtramck when a school bus collided with a passenger train. The accident resulted in 16 fatalities and 27 injuries, and of the total of 45 bus passengers, only three were not injured. The driver of the bus claimed he did not see the approaching train because of an overcrowded doorway blocking clear visibility. The majority of the fatalities occurred near the back of the bus, and many of them were children headed for school.

January 14, 1950 Gaylord (Otsego County) Passenger Bus Accident

A bus collision during a severe snowstorm killed five persons and injured several others. A chartered bus returning 20 members of the Michigan Tech hockey squad from East Lansing to Houghton crashed head-on with a southbound Greyhound bus driving around an "S" curve. Both buses had bad damage, with the sides of each ripped open and some passengers thrown. All available ambulances and state police cruiser cars from the area and from neighboring cities were rushed to the scene. Some of the injured stayed in a hospital in Gaylord over the succeeding weeks.

August 19, 1951 Alpena (Alpena County) Passenger Bus Accident

A Greyhound bus, jam-packed with 40 vacationers bound from Mackinac City to Detroit, crashed head-on with a large beer truck in the outskirts of Alpena on highway US-23. The crash resulted in 10 fatalities and 27 injuries, and many of the bodies were reportedly so mangled that identifications were almost impossible.

Easter Sunday, 1958 Saginaw (Saginaw County) Passenger Airplane Crash

Prior to the August 1987 crash of Northwest Airlines Flight 255, Michigan's worst commercial passenger airplane crash had occurred on Easter Sunday, 1958, at Saginaw Tri-City International Airport. In that incident, which resulted in 47 fatalities, ice had built up on the plane's directional systems and the pilot was unable to reach the runway on the landing approach.

September 1976 Alpena (Alpena County) Military Airplane Crash

During one morning in September 1976, a military airplane tanker on a routine training mission crashed in a densely wooded swampy area. The violent crash had an expolsion described as a large ball of fire, followed by several more explosions which pulverized the plane into hundreds of pieces ranging from mere inches to ten feet in length. The accident resulted in 15 fatalities, but despite the severity of damage, there were five survivors.

March 4, 1987 Detroit (Wayne County) Passenger Airplane Crash

On March 4, 1987, a plane bound from Cleveland to Detroit crashed and skidded into three ground vehicles and caught fire. The cause of the accident was the captain's inability to control the airplane while descending on the final approach for landing. Nine of the 22 passengers died from a post-crash fire, lack of fire-blocking material, and poorly designed aircraft components.

August 16, 1987 Romulus (Wayne County) Passenger Airplane Crash

Michigan's worst commercial passenger airplane crash, and the seventh worst in U.S. aviation history (see the table below), occurred on August 16, 1987, at Detroit Metropolitan Airport. In that incident, Northwest Airlines Flight 255 was unable to gain sufficient altitude at takeoff and crashed onto nearby highway I-94, killing 156 passengers and crew. A small child was the lone survivor. A Governor's Disaster Declaration was granted to the City of Romulus and numerous state resources were mobilized to assist in the recovery.

December 3, 1990 Romulus (Wayne County) Passenger Airplane Crash

An unfortunate example of an airliner ground collision occurred on December 3, 1990, when two Northwest Airlines aircraft (Flight 299 and Flight 1482) collided with one another in heavy fog on a runway at Detroit Metropolitan Airport. The Flight 1482 aircraft was heavily damaged and caught fire. Eight persons died and 21 were injured in that incident.

March 10, 1993 Comstock (Kalamazoo Co.) Passenger Train Accident

On March 10, 1993, an Amtrak passenger train with 45 passengers collided with a liquid propane tanker truck in Comstock Township, killing the driver of the truck and injuring the train's engineer. The truck had been exiting a private drive when it slid into the path of the train, which was traveling eastbound at approximately 62 miles per hour. Upon impact, the liquid propane tank exploded with a large fireball. The train engine received considerable damage from the impact and explosion. The windows were blown out, causing the train engineer to receive second degree burns from the fireball. One passenger was transported to a nearby hospital for treatment. The private crossing at which this accident occurred, 11 other private crossings, and a public highway crossing in this area were all eliminated in 1996.

January 9, 1997 Monroe County Passenger Airplane Crash

On January 9, 1997 Comair Flight 3272, a commuter jet from Cincinnati, Ohio, bound for Detroit Metropolitan Airport, crashed on final approach in Monroe County, killing its 26 passengers and 3 crew. The plane was flying at approximately 4,000 feet on its approach when it suddenly and inexplicably did a barrel roll and nose dived, striking the ground 17 seconds later. The cause of the crash was determined by the National Transportation Safety Board to be failure on the part of the crew to adequately manage ice buildup on the wings.

July 9, 1999 Harrison (Clare County) Passenger Bus Accident

A tour bus filled with international exchange students slid off of rain-slicked highway U.S. 27 near Harrison, injuring 40 passengers. Most of the injured were treated and released at a nearby hospital. One passenger was hospitalized overnight, with an eye injury.

July 31, 1999 Marine City (St. Clair County) Passenger Airplane Crash

A commercial skydiving plane crashed shortly after its takeoff from Marine City Airport, killing all 10 persons aboard. The plane was carrying its pilot and nine skydivers, who were about to make an early morning jump. The plane cleared a 90-foot power line on takeoff, then sharply veered left before crashing and exploding in a hay field adjacent to the end of the runway. The National Transportation Safety Board determined that pilot error was the probable cause of the crash.

### September 14, 2000 Wixom (Oakland County) School Bus Accident

A Northville High School bus carrying 34 football players, 14 cheerleaders, and several coaches collided with an automobile. The car's driver was killed and the car's passenger was injured. Ten bus passengers suffered injuries.

### October 16, 2000 St. Clair County Passenger Bus Accident

A semi-trailer smashed into the rear of a charter bus on Interstate 94 in St. Clair County, injuring 44 senior citizens aboard (three critically).

### December 17, 2000 Battle Creek (Calhoun County) Passenger Train Accident

An Amtrak passenger train with 161 passengers partially derailed near the train station in Battle Creek, forcing the closure of the railroad tracks in both directions for an extended period of time. The train, composed of a locomotive and five coach cars, was traveling at a low rate of speed when the locomotive and first coach car ran off the tracks a half mile east of the Battle Creek station. The entire train remained upright and the derailed cars were lifted by crane back onto the track. No injuries were reported.

### January 21, 2002 Muskegon County School Bus Accident

One person was killed and nearly two dozen high school students were injured when a school bus collided with two cars. About 22 persons were taken to area hospitals with injuries.

### October 10, 2002 Monroe County School Bus Accident

A school bus on a field trip was carrying 43 children and 17 adults, and pulled in front of a steel-hauling truck, causing a major collision. Almost all of the passengers were sent to a nearby hospital. Five children were reported to be in critical condition.

### June 13, 2003 Detroit (Wayne County) City Bus Accident

At least 20 people were injured when a car ran a red light and crashed into a city bus. Fortunately, none of the people who were transported to local hospitals sustained life-threatening injuries.

### August 15, 2006 Kincheloe (Chippewa County) Passenger Airplane Crash

In August 2006, a plane crash occurred outside the Chippewa Correctional Facility in Kincheloe, resulting in four fatalities. Federal officials say that pilot error caused the twin-engine plane to crash. This incident is more significant than many similar small airplane crashes due to the fact that it had hit the outer perimeter fence of the Chippewa Correctional Facility. Had the crash been closer to the facility, the magnitude of its effects would have been much greater.

### June 4, 2007 Lake Michigan Passenger Airplane Crash

An unfortunate incident occurred when a plane carrying a team of surgeons and technicians from Milwaukee to Ann Arbor crashed into Lake Michigan. All six passengers died in the incident, including the two pilots, two University of Michigan surgeons, and two technicians due to prepare an organ for transplant surgery at the University of Michigan Health System hospital in Ann Arbor that same afternoon. The National Transportation Safety Board said that one of the pilots had reported severe difficulty steering the plane because of trouble with its trim system, which controls bank and pitch.

### August 16, 2008 Grayling (Crawford County) School Bus Accident

A school bus accident occurred while taking kindergartners and preschoolers to a field trip, resulting in 12 injuries. The driver was going too fast, crossed to the other side of the road, and smashed into a pickup truck, injuring both drivers.

### October 9, 2008 Washtenaw County Passenger Bus Accident

On the afternoon of October 9, 2008, an accident on highway US-23 occurred when a tractor-trailer crashed into an overloaded bus carrying members of an Amish church, sending 14 of the 21 total passengers, including a number of children, to a hospital in nearby Ann Arbor. Six passengers from the bus that had tipped over on its side were considered to be in serious condition.

### February 6, 2009 Grand Rapids (Kent County) Passenger Bus Accident

A school bus carrying about 40 students in Grand Rapids collided with a car, resulting in 16 injures.

### February 16, 2009 Detroit (Wayne County) Passenger Bus Accident

Fifteen people were injured when a van drove through a stop sign and crashed into a Detroit Department of Transportation bus on Detroit's West side.

### March 1, 2010 Detroit (Wayne County) Passenger Train Accident

On March 1, 2010, a Chicago-bound Amtrak train, with 76 people aboard, struck a Detroit fire truck that had stopped on the tracks in southwest Detroit. The fire truck was responding to a previous crash involving a car and a semi truck. Several passengers sought treatment for minor injuries like head and back pain, and there was $600,000 damage to the ladder truck.

### February 7, 2011 Detroit (Wayne County) Passenger Bus Accident

Eleven people were injured when a Detroit City bus crashed into a mail truck in Detroit.

### March 24, 2011 Detroit (Wayne County) Passenger Bus Accident

A Detroit Department of Transportation bus hit a car, then slammed into a building in Detroit, resulting in 13 injuries.

### January 31, 2013 – Detroit (Wayne County)

A 30-vehicle accident occurred on southbound I-75, resulting in 3 deaths and more than a dozen injuries. Blinding snow, strong winds, and slick road conditions had made driving hazardous. The involved vehicles included multiple semi-trucks as well as numerous passenger vehicles.

### August 1, 2013 – Charleston Township (Kalamazoo County)

On westbound I-94 in Charleston Township, a semi truck collided with a Greyhound bus that was carrying 48 passengers. A total of 22 persons were injured, including one front-seat passenger (who was in serious condition) and the driver (who was also hospitalized). Fortunately, most of these injuries were minor.

### February 21, 2014 – Isabella County

Because of winter storm whiteout conditions, a jackknifed semi truck and multiple vehicle accidents caused the U.S. 127 highway to close down in both directions, from the Gratiot/Isabella county line to the interchanges south of Mt. Pleasant.

**Top 10 Worst Aviation Disasters in the United States**

| Fatalities | Date | Location | Carrier | Type |
|---|---|---|---|---|
| 2740* | 9/11/2001 | New York, New York | American / United Airlines | B767 / B767 |
| 273 | 5/25/1979 | Chicago, Illinois | American Airlines | B747 |
| 265 | 11/12/2001 | Belle Harbor, Queens, New York | American Airlines | A300 |
| 230 | 7/17/1996 | off of East Moriches, New York | Trans World Airlines | B747 |
| 217 | 10/31/1999 | off of Nantucket, Massachusetts | Egypt Air | B767 |
| 189 | 9/11/2001 | Arlington, Virginia | American Airlines | B757 |
| **156** | **8/16/1987** | **Romulus, Michigan** | **Northwest Airlines** | **MD82** |
| 153 | 7/09/1982 | Kenner, Louisiana | Pan American World | B727 |
| 144 | 9/25/1978 | San Diego, California | Pacific Southwest / Private | B727 / C172 |
| 135 | 8/02/1985 | Fort Worth-Dallas, Texas | Delta Air Lines | L1011 |

*Two separate planes hit the World Trade Center, minutes apart. The total number of fatalities includes passengers and crew on both planes, and those killed in the buildings and on the ground.
Source: Planecrashinfo.com

**Train Accidents and Vehicle–Rail Crashes in Michigan: 1990-2009**

| Year | Vehicle-Rail Crashes | Fatalities |
|---|---|---|
| 1990 | 203 | N/A |
| 1991 | 176 | N/A |
| 1992 | 153 | N/A |
| 1993 | 133 | N/A |
| 1994 | 147 | N/A |
| 1995 | 121 | N/A |
| 1996 | 119 | N/A |
| 1997 | 124 | N/A |
| 1998 | 90 | N/A |
| 1999 | 110 | N/A |
| 2000 | 125 | N/A |
| 2001 | 97 | 9 |
| 2002 | 89 | 7 |
| 2003 | 104 | 7 |
| 2004 | 89 | 9 |
| 2005 | 67 | 4 |
| 2006 | 57 | 6 |
| 2007 | 61 | 3 |
| 2008 | 54 | 4 |
| 2009 | 44 | 10 |

The 2009 total of 44 vehicle-train crashes marked a decrease of 64.8 percent over the preceding 10 year period.

***Michigan Great Lakes Ship Accidents***

Due to the large size of the Great Lakes, there have been many shipwrecks during Michigan's history. The lakes are prone to sudden and severe storms, especially from late October to early December, resulting in hundreds of ships having met their end on the lakes. Reefs are also a common cause of shipwreck disasters. The greatest concentration of shipwrecks in Michigan lies near Thunder Bay, on Lake Huron, near the point where eastbound and westbound shipping lanes converge. Also, on Lake Superior, the vicinity of Whitefish Point became known as the "Graveyard of the Great Lakes" because more vessels have been lost in there than in any other part of Lake Superior. The Whitefish Point Underwater Preserve serves to protect the many shipwrecks in the area. The Great Lakes Shipwreck Museum uses the approximate figures of 6,000 ships and 30,000 lives lost. There are a total of 12 protected underwater preserves in the State of Michigan Great Lakes areas, with a total surface area of over 2,400 square miles. The Michigan Underwater Preserve Council oversees activities relating to all of Michigan's Underwater Preserves. Michigan's Underwater Preserves are considered to be "underwater museums" and protect concentrations of shipwrecks, unique geologic features, and other submerged sites through public awareness and interest. The program does not currently receive any funding from the State of Michigan and does not offer any extra legal protection for the sites in the preserves. However, it is a felony to remove or disturb underwater artifacts in the Great Lakes.

**Michigan's Underwater Ship Preserves**


Source: Wikipedia online encyclopedia

The number of shipwrecks occurring in the Great Lakes has decreased dramatically from the 1800s to around the 1930s. Not only have travelers tended to favor other means of transportation in recent years, but the decrease in marine accidents can be credited to better weather prediction and communication abilities, radar technologies, and improved ship designs and construction quality. The most recent significant accident occurred with the sinking of the Edmund Fitzgerald in 1975. The U.S. Coast Guard and Canadian Coast Guard maintain stations around the Great Lakes. To prevent fatal accidents in the Great Lakes, lighthouses, ship lighting, shipping regulations, floating navigation aids, and LORAN stations have been implemented and enhanced over time. Also, the U.S. Army Corps of Engineers and other agencies maintain the harbors and seaways to limit groundings, through dredging and seawall projects. Below is a table of some of the most significant shipwreck disasters (primarily those with at least 10 known fatalities) occurring in Michigan's portion of the Great Lakes:

| Date | Location | Name | Fatalities |
|---|---|---|---|
| November 10, 1835 | Mt. Clemens, MI | Bridget | 14 |
| November 25, 1839 | Little Point Sable, MI | Neptune | 18 |
| November 19, 1846 | Lake Erie (Pt. Mouillee, MI) | Lexington | 13 |
| June 13, 1847 | Munising, MI | Merchant | 14 |
| **November 20, 1847** | **Lake Michigan (Sheboygan, WI)** | **Phoenix** | **161+** |
| September 13, 1848 | Lexington, MI | Goliah | 18 |
| **June 17, 1850** | **Lake Erie (near Cleveland, OH)** | **G.P. Griffith** | **250 to 325** |
| **August 20, 1852** | **Lake Erie** | **Atlantic** | **150 to 250 (of 600+)** |
| November 24, 1853 | Beaver Island, MI | Robert Willis | 10 |
| October 8, 1854 | Detroit River | E.K. Collins | 23 |
| December 7, 1854 | Lake Michigan | Westmoreland | 17 |
| August 8, 1855 | Lake Michigan | L.M. Hubby | 10 |
| April 27, 1856 | Port Austin, MI | Northerner | 12 (of 142) |
| **September 24, 1856** | **Lake MI (Port Washington, WI)** | **Niagara** | **70+ (of 140)** |
| October 22, 1856 | Lake MI (Port Washington, WI) | Toledo | 40 to 55 |
| October 30, 1856 | Pictured Rocks Lakeshore, MI | Superior | 35 |
| November 4, 1856 | St. Joseph, MI | John V. Ayer | 10 |
| November 26, 1856 | Manistee, MI | Cherokee | 10 |

| | | | |
|---|---|---|---|
| October 19, 1857 | Big Sable Point | Reindeer | 23 |
| October 24, 1859 | Pte. Aux Barques, MI | Troy | 23 |
| **September 7, 1860** | **Winnetka, IL (Lake Michigan)** | **Lady Elgin** | **297 (of 400)** |
| November 6, 1860 | Lake Michigan | Globe | 16 |
| November 10, 1861 | Port Austin, MI | Keystone State | 33 |
| August 9, 1862 | Munising, MI | Oriole | 12 |
| August 28, 1863 | Keweenaw Point, MI | Sunbeam | 28 |
| November 11, 1863 | Au Sable, MI | Water Witch | 28 |
| November 8, 1864 | Lake Michigan | Mojave | 10 |
| **August 9, 1865** | **Thunder Bay, MI** | **Pewabic** | **75 to 100** |
| **April 9, 1868** | **Lake Michigan (Waukegan, WI)** | **Seabird** | **102** |
| September 8, 1868 | St. Joseph, MI | Hippocampus | 26 |
| September 16, 1868 | Lake Huron | Persian | 10 |
| November 5, 1869 | Lake Huron | J.B. Martin | 10 |
| November 15, 1869 | Lake Superior | W.W. Arnold | 11 |
| November 17, 1869 | Straits of Mackinac | Robert Burns | 10 |
| September 22, 1871 | Lake Michigan | Charles H Hurd | 11 |
| October 15, 1871 | Pte. Aux Barques, MI | R.G. Coburn | 32 |
| September 15, 1873 | Grand Haven, MI | Ironsides | 20 |
| December 4, 1873 | Saginaw Bay | City of Detroit | 20 |
| October 22, 1874 | Wyandotte, MI | Brooklyn | 22 |
| August 26, 1875 | Whitefish Bay | Comet | 11 |
| September 10, 1875 | Lake Michigan | Equinox | 25 |
| September 10, 1875 | Lake Michigan | Mendota | 12 |
| July 9, 1876 | Ontonagon, MI | St. Clair | 26 |
| November 22, 1879 | Lake Huron | Waubuno | 22 |
| August 29, 1880 | Alcona, MI | Marine City | 9 to 20 (of 158) |
| **October 15, 1880** | **Lake Michigan** | **SS Alpena** | **100+** |
| November 24, 1880 | Lake Huron | Simcoe | 13 |
| September 10, 1881 | Frankfort, MI | Columbia | 16 |
| November 26, 1881 | Lake Huron | Jane Miller | 30 |
| May 18, 1882 | Lake Huron | Manitoulin | 11 to 25 |
| September 14, 1882 | Lake Huron | Asia | 123 |
| December 1, 1882 | Lake Michigan | R. G. Peters | 14 |
| May 20, 1883 | Lake Michigan | Wells Burt | 10 |
| November 16, 1883 | Lake Superior | Manistee | 23 |
| December 14, 1883 | Lake Superior | Mary Ann Hulbert | 20 |
| **May 24, 1881** | **Thames River** | **Victoria** | **181 (of 600)** |
| November 7, 1885 | Isle Royle | Algoma | 37 |
| June 16, 1887 | Charlevoix, MI | Champlain | 22 |
| October 25, 1887 | Lake Michigan | Vernon | 36 to 41 |
| August 30, 1892 | Deer Park, MI | Western Reserve | 26 |
| October 1, 1892 | Lake Michigan | W.H. Gilcher | 21 |
| October 4, 1892 | Lake Huron | Nashua | 15 |
| November 7, 1893 | Pte. Aux Barques, MI | Philadelphia | 16 to 24 |
| January 21, 1895 | St Joseph, MI | Chicora | 25 |
| October 9, 1895 | Lake Huron | Africa | 13 |
| October 24, 1898 | Lake Michigan | L.R. Doty | 17 |
| May 24, 1901 | Au Sable, MI | Baltimore | 13 |
| September 16, 1901 | Eagle River, MI | Hudson | 25 |
| November 22, 1902 | Lake Superior | Bannockburn | 21 |
| October 3, 1903 | Menominee, MI | Erie L Hackley | 11 |
| September 2, 1905 | Keweenaw, MI | Iosco | 19 |
| October 20, 1905 | Lake Huron | Kaliyuga | 17 |
| November 22, 1906 | Lake Huron | J.H. Jones | 26 |
| April 12, 1907 | Big Sable Point | Arcadia | 14 |

| | | | |
|---|---|---|---|
| October 11, 1907 | Deer Park, MI | Cyprus | 22 |
| December 1, 1908 | Lake Superior | D.M. Clemson | 24 |
| May 1, 1909 | Whitefish Bay | Adella Shores | 18 |
| July 12, 1909 | Whitefish Bay | SS John B. Cowle | 14 |
| December 8, 1909 | Lake Erie | Clarion | 15 |
| December 9, 1909 | Marine City, MI | Badger State | 15 |
| May 23, 1910 | Pte. Aux Barques, MI | Frank H. Goodyear | 16 |
| September 8, 1910 | Lake Michigan | Pere Marquette 18 | 25 |
| August 21, 1911 | Lake Huron | C.C. Martin | 10 |
| November 26, 1912 | Lake Michigan | Rouse Simmons | 17 |
| **November 7-11, 1913** | **Great Lakes Storm** | **12 ships sank** | **255+** |
| April 27, 1914 | Lake Superior | Benj. Noble | 22 |
| November 19, 1914 | Grand Marais, MI | C.F. Curtis | 14 |
| **July 24, 1915** | **Chicago River / Lake Michigan** | **SS Eastland** | **844** |
| May 8, 1916 | Eagle Harbor, MI | S.R. Kirby | 20 |
| November 24, 1918 | Lake Superior | Cerisoles | 38 |
| September 22, 1919 | Muskegon, MI | City of Muskegon | 29 |
| November 13, 1919 | Lake Superior | John Owen | 23 |
| November 23, 1919 | Whitefish Bay | Myron | 17 |
| August 20, 1920 | Whitefish Bay | SS Superior City | 29 |
| October 30, 1921 | Lake Michigan | Rosa Bella | 11 |
| April 19, 1922 | Whitefish Bay | Lambton | 22 |
| December 1, 1922 | Lake Superior | Maplehurst | 11 |
| September 22, 1924 | Oscoda, MI | Clifton | 27 |
| December 7, 1927 | Twelve O'Clock Point, Isle Royale | Kamloops | 22 |
| September 15, 1928 | Lake Huron | Manasoo | 16 (+116 cattle) |
| September 9, 1929 | Holland, MI | Andaste | 25 |
| October 22, 1929 | Lake Michigan | Milwaukee | 52 |
| October 29, 1929 | Lake Michigan (off Kenosha, WI) | Wisconsin | 18 |
| July 29, 1936 | Lake Michigan | Material Service | 15 |
| November 11, 1940 | Pentwater, MI | SS William B. Davock | 33 |
| November 11, 1940 | Pentwater, MI | Anna C. Minch | 24 |
| September 24, 1942 | Lake Huron | Wawinet | 25 |
| June 4, 1947 | Isle Royale, MI | Emperor | 12 |
| **September 17, 1949** | **Lake Ontario** | **Noronic** | **119** |
| May 11, 1953 | Isle Royale, MI | Henry Steinbrenner | 14 |
| November 18, 1958 | Lake Michigan | Carl D. Bradley | 33 |
| May 7, 1965 | Lake Huron | Cedarville | 10 |
| November 29, 1966 | Lake Huron | SS Daniel J Morrell | 28 |
| November 10, 1975 | Whitefish Bay | SS Edmund Fitzgerald | 29 |
| June 5, 1979 | Copper Harbor, MI | Cartiercliffe Hall | 7 (most recent) |

**Sources:** http://www.boatnerd.com/swayze/shipwreck/a.htm and http://greatlakeshistory.homestead.com/Alpha.html

### *Michigan Boating Accident Statistics*

Every year, the U.S. Coast Guard compiles statistics on reported recreational boating accidents. These statistics are derived from accident reports that are filed by the owners / operators of recreational vessels involved in accidents. The states, territories, and District of Columbia all submit accident report data to the Coast Guard for inclusion in the annual Boating Statistics publication. Modern boat accidents are common, as the following table shows.

**Michigan Boating Accidents**

| Year | Total Accidents | Total Fatal Accidents | Total Deaths |
|---|---|---|---|
| 1995 | 395 | 22 | 29 |
| 1996 | 478 | 19 | 20 |
| 1997 | 354 | 22 | 22 |
| 1998 | 451 | 21 | 25 |
| 1999 | 343 | 27 | 28 |
| 2000 | 227 | 26 | 31 |
| 2001 | 299 | 25 | 28 |
| 2002 | 226 | 36 | 37 |
| 2003 | 218 | 25 | 29 |
| 2004 | 143 | 26 | 27 |
| 2005 | 161 | 26 | 28 |
| 2006 | 185 | 24 | 30 |
| 2007 | 185 | 30 | 34 |
| 2008 | 187 | 30 | 34 |
| 2009 | 131 | 32 | 36 |

***Michigan Transportation Trends***

Michigan uses air, water, highway, and rail as its major means of transporting people and goods. Michigan has seen an increase in all sectors of transportation over the past few decades, except for the marine sector. As traffic in each sector of transportation increases, so does the risk of accidents. The following section describes the transportation trends in Michigan over the past few decades.

Air Traffic

Air traffic has increased significantly in recent years. With many travelers choosing to fly rather than drive, the airways have become more congested. As the following table shows, flying has also become a more popular way to ship cargo and mail. Total air operations in Michigan have increased greatly since 1990, making airways and runways more congested than in the past.

| Indicator | 1990 | 1995 | 2000 | % Change (1990-2000) |
|---|---|---|---|---|
| Control Tower Airport Operations | 2,077,400 | 2,019,389 | 2,191,931 | **+ 5.5%** |
| Non-Towered Airport Operations | 1,934,190 | 2,235,520 | 2,517,131 | **+ 30.1%** |
| Total Scheduled Air Carrier Passengers | 25,112,384 | 31,596,208 | 40,528,139 | **+ 61.4%** |
| Air Cargo, Express and Package Freight (tons) | 272,443 | 353,189 | 361,023 | **+ 32.5%** |
| Air Carried Mail | 78,955 | 130,322 | 99,718 | **+ 26.3%** |
| Total Operations (includes all control tower activities) | 4, 011,590 | 4,254,909 | 4,709,062 | **+ 17.4%** |

Highway Traffic

Highway travel in Michigan has increased at a far greater rate than the state's population. This increase in travel is attributed to the longer distances traveled to work and other places, and increases in tourism and recreation travel. Although the state highway system comprises only 8% of the Michigan roadway network length, it carries more than 53% of the total statewide traffic. (A map of highways appears at the end of this section.) MDOT traffic summary statistics indicate that I-696 from I-75 to Couzens Avenue was the busiest section of highway in 2001, carrying an average of 219,000 vehicles a day. I-696 actually had six out of the top eight busiest sections in the state for 2001. Although traffic continues to increase in Michigan, the number of traffic crashes continues to decrease. There were 290,978 total crashes statewide in 2009, a 31.5 percent decrease from the 2000 total of 424,675. More importantly, the total number of fatal crashes has decreased by an even larger percentage. In 2009, there were 806 fatal crashes, down 41.7 percent from 1,382 in 2000.

**Total Crashes (Including Total Fatal Crashes and Total Deaths):**

| Year | Total Crashes | Fatal Crashes | Total Deaths | Year | Total Crashes | Fatal Crashes | Total Deaths |
|---|---|---|---|---|---|---|---|
| **1990** | 387,180 | 1,396 | 1,563 | **2000** | 424,852 | 1,237 | 1,382 |
| **1991** | 364,847 | 1,290 | 1,425 | **2001** | 400,813 | 1,206 | 1,328 |
| **1992** | 344,942 | 1,179 | 1,300 | **2002** | 395,515 | 1,175 | 1,279 |
| **1993** | 363,636 | 1,269 | 1,414 | **2003** | 391,485 | 1,172 | 1,283 |
| **1994** | 398,050 | 1,262 | 1,419 | **2004** | 373,028 | 1,055 | 1,159 |
| **1995** | 421,073 | 1,386 | 1,537 | **2005** | 350,838 | 1,030 | 1,129 |
| **1996** | 435,477 | 1,339 | 1,505 | **2006** | 315,322 | 1,002 | 1,084 |
| **1997** | 425,793 | 1,283 | 1,446 | **2007** | 324,174 | 987 | 1,084 |
| **1998** | 403,766 | 1,235 | 1,367 | **2008** | 316,057 | 915 | 980 |
| **1999** | 415,675 | 1,249 | 1,386 | **2009** | 290,978 | 806 | 871 |
| **% Change of Total Crashes (1990-2009) -33%** | | | | | | | |

**Total miles traveled, in billions of miles:**

| Year | Travel (Billions of Miles) | Year | Travel (Billions of Miles) |
|---|---|---|---|
| **1950** | 22.0 | **2000** | 94.9 |
| **1960** | 33.1 | **2001** | 96.5 |
| **1970** | 53.1 | **2002** | 98.2 |
| **1980** | 61.5 | **2003** | 100.2 |
| **1990** | 81.2 | **2004** | 101.8 |
| **1995** | 85.7 | **2005** | 103.2 |
| **1996** | 87.7 | **2006** | 104.0 |
| **1997** | 89.2 | **2007** | 104.6 |
| **1998** | 91.6 | **2008** | 100.9 |
| **1999** | 93.1 | **2009** | 95.9 |
| **% Change (1990-2009) + 15.3%** | | | |

Marine Traffic

The St. Lawrence Seaway and the Great Lakes form a maritime transportation system extending more than 2,000 miles from the Gulf of St. Lawrence on the Atlantic Ocean to the western end of Lake Superior. Michigan has roughly 3,200 miles of shoreline and more than 100 ports serving commercial and recreational navigation. (See the map at the end of this section.) There are also 20 routes of ferry service in Michigan's waterways. Michigan has seen a steady increase in air, rail, and highway transportation over the past few decades, but marine transportation has remained relatively constant. Marine commerce has actually seen a decrease since the 1960s and 1970s, although it has begun to pick up again and has had a 10 percent increase since 1990. Most of Michigan's waterborne traffic is generated by the steel and construction industries and is susceptible to variations in the general economy and the effects of restructuring in the steel industry.

**Marine Shipping (Tonnage)**

| Year | Tonnage | Year | Tonnage |
|---|---|---|---|
| **1960** | 99,684,998 | **1981** | 75,685,806 |
| **1961** | 88,815,641 | **1982** | 51,312,257 |
| **1962** | 90,959,374 | **1983** | 62,416,537 |
| **1963** | 97,730,256 | **1984** | 75,067,451 |
| **1964** | 109,139,474 | **1985** | 71,981,889 |
| **1965** | 107,500,170 | **1986** | 72,527,695 |
| **1966** | 113,716,689 | **1987** | 79,430,130 |
| **1967** | 110,767,016 | **1988** | 88,243,048 |
| **1968** | 108,668,893 | **1989** | 91,459,033 |
| **1969** | 109,328,660 | **1990** | 85,765,857 |
| **1970** | 110,397,756 | **1991** | 78,952,003 |
| **1971** | 103,879,534 | **1992** | 84,622,726 |
| **1972** | 103,555,651 | **1993** | 87,701,134 |
| **1973** | 106,598,408 | **1994** | 93,990,253 |
| **1974** | 101,393,927 | **1995** | 93,610,750 |
| **1975** | 91,411,396 | **1996** | 93,613,000 |
| **1976** | 97,380,680 | **1997** | 98,673,521 |
| **1977** | 92,834,512 | **1998** | 101,306,079 |
| **1978** | 101,788,264 | **1999** | 96,493,819 |
| **1979** | 102,225,008 | **2000** | 94,285,388 |
| **1980** | 82,409,928 | **% Change (1990-2000) + 10%** | |

Railroads (Entire U.S.)

Freight railroads are critical to the economic well-being and global competitiveness of the United States. They move 42% of the nation's freight and connect businesses with each other across the country and with markets overseas. The United States has seen recent increases in railroad cargo weight. Increased railroad traffic and cargo weight may increase the risk of railway accidents, especially highway/rail incidents. Passenger railroad traffic has also been increasing recently, encouraged by higher fuel prices and increasing congestion within other types of transportation networks.

| Year | TOFC / COFC Loadings (in millions of units) |
|---|---|
| 1990 | 6 |
| 1995 | 7.8 |
| 2000 | 9 |
| **% Change (1990-2000) + 50%** | |

***Programs and Initiatives***

Air Transportation

The Michigan Aeronautics Commission of the MDOT administers several programs aimed at improving aviation safety and promoting airport development. The Commission's safety programs include: (1) registering aircraft dealers, aircraft, and engine manufacturers, (2) licensing airports and flight schools, (3) inspecting surfaces and markings on airport runways, and (4) assisting in the removal of airspace hazards at airports. The Commission's airport development program includes the provision of state funds for airport development and airport capital improvements, many of which contribute to overall air transportation safety.

The Federal Aviation Administration (FAA) contracts with the MDOT for the inspection of the state's 238 public-use airports on an annual basis. The FAA has regulatory jurisdiction over operational safety and aircraft worthiness. The National Transportation Safety Board (NTSB) investigates all aircraft crashes that involve a fatality, and regularly publishes reports on its findings (see the NTSB section below).

Local plane crash concerns may already have been analyzed by community airports or planners, in accordance with the Airport Zoning Act of 1950:
(see http://www.michiganlegislature.org/documents/mcl/pdf/mcl-act-23-of-1950-ex-sess..pdf).

## Land Transportation

*Bus Safety*

School bus safety programs and initiatives generally fall into two categories: (1) driver skill enhancement and competency training, and (2) physical inspections of buses' mechanical and safety equipment. All school bus drivers in Michigan must pass a bus driver education and training program, and then take regular refresher courses to maintain their certification to operate a school bus. School bus drivers must also pass an annual medical examination.

Local transit and intercity bus safety falls under the purview of the Michigan Department of Transportation (MDOT). Generally, the issue of intercity and transit bus safety is handled on a partnership basis with service providers, with MDOT providing oversight of the initiatives undertaken by the providers to ensure mechanical and operational safety.

*Railroad Safety*

The MDOT is the state regulatory agency for railroad-highway at-grade crossing safety issues. In this role, MDOT conducts biennial, on-site crossing reviews for Michigan's 5,535 public crossings, and reports observed crossing maintenance deficiencies to the responsible railroad or roadway authority. In addition, MDOT conducts diagnostic study team reviews at selected crossings to determine whether the current level of warning device requires enhancement. At the present time, 42% of Michigan's public crossings at least have automatic side-of-street flashing light signals, and 16% have automatic gates.

In January 2001, an amendment (2000 PA 367) to the Michigan Vehicle Code went into effect, allowing the MSP, MDOT, or specified local officials to install video cameras at railroad crossings to serve as a deterrent to motorists who might attempt to go around or through activated railroad crossing lights and gates. Although the ultimate purpose of this law is to reduce pedestrian and vehicular deaths and injuries at railroad crossings, the law will also likely reduce passenger train accidents caused by collisions with vehicles on the tracks, which is a major cause of many passenger train derailments.

Michigan's "Operation Lifesaver" Coalition—part of a national, non-profit education and awareness program dedicated to ending tragic collisions, fatalities and injuries at highway-rail at-grade crossings and on railroad rights of way—has helped reduce the number of serious crashes at railroad crossings in the state. The Operation Lifesaver coalition in Michigan is spearheaded by the MSP and MDOT and is composed of state and local government officials, law enforcement, and employees of the railroad companies operating in Michigan. The Operation Lifesaver program emphasizes education and enforcement, and its efforts appear to be working. Since 1996, the number of crashes, injuries, and fatalities at railroad crossings in Michigan has shown a steady decline. Any reduction in vehicle-train crashes at railroad crossings helps reduce the likelihood of a passenger transportation accident involving buses and trucks. Another MDOT program that can help to improve rail safety is the Michigan Rail Loan Assistance Program. Established under Act 1997 PA 117, this program was initiated to help finance capital improvements on Michigan's rail infrastructure. Although the program is designed primarily to help preserve and improve rail freight service, any improvements made to a portion of rail infrastructure that also serves passenger rail service can only help to improve passenger rail safety. Track rehabilitation is one of the eligible projects that can be funded under this program, and the safety value of a project is one of the primary selection criteria.

Water Transportation

All marine passenger ferries operating on the Great Lakes must pass regular inspections by the U.S. Coast Guard, for vessel safety and worthiness. In addition, all personnel operating marine passenger ferries must be trained to Coast Guard standards and meet annual certification requirements. Passenger ferries are equipped with individual life preservers and other rescue gear on board, in addition to having marine radios to request help should the need arise. Prior to departure, all passengers using ferry services are given brief instructions on what to do should the vessel somehow become disabled to such a degree that it is in danger of sinking.

Fortunately, Michigan has not suffered a significant water transportation accident involving a marine passenger ferry. Even with this unblemished safety record, the potential always exists for a serious water transportation accident to occur on the Great Lakes. Such an event would have the potential to be a significant mass casualty incident and possibly require a massive water rescue and recovery effort.

National Transportation Safety Board

The National Transportation Safety Board is an independent federal agency responsible for promoting aviation, highway, railroad, marine, pipeline, and hazardous materials transportation safety. The NTSB is mandated to investigate significant transportation accidents, determine the probable cause of such accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies that are involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews. Although the NTSB has no regulatory or enforcement powers, it has nonetheless been successful in seeing the adoption and implementation of over 80% of its transportation accident recommendations.

An example of an NTSB recommendation being implemented is the agreement between the FAA and the Boeing Aircraft Company to redesign the rudder system on the company's popular 737 jetliners and to replace the rudder valve system in every one of the 737 jets in service. The rudder retrofit program cost Boeing nearly one-quarter of a billion dollars. (The 737 rudder system came under the close scrutiny of the NTSB after crashes of 737s in 1991 and 1994 had resulted in over 150 deaths. The NTSB believed that the rudder system on the two jets might have been a contributing factor in the crashes.)

Final Rule on the Reflectorization of Rail Freight Rolling Stock

The Final Rule requires railroads and other companies owning rail cars to install yellow or white reflective materials on locomotives over a five-year timeframe, and on freight trail cars over a 10-year period. The reflective materials are to be installed on all newly constructed locomotives and freight rail cars, and on existing ones during periodic maintenance repair, unless alternate implementation plans have been developed that meet the deadlines. Nearly one quarter of all highway-rail crossing collisions involve motor vehicles running into trains occupying at-grade crossings. This new rule is the most recent effort by the Federal Railroad Administration (FRA) to increase the visibility of trains at highway-rail at-grade crossings.

Airport Zoning Act of 1950

Plane crash concerns may already have been analyzed by an area's airports or planners, in accordance with the Airport Zoning Act of 1950. Please refer to http://www.legislature.mi.gov/documents/mcl/pdf/mcl-act-23-of-1950-ex-sess-.pdf for more details.

***Hazard Mitigation Alternatives for Major Transportation Accidents***

- Improved design, routing, and traffic control at problem roadway areas.
- Railroad inspections and improved designs at problem railway/roadway intersections (at grade crossings, rural signs/signals for RR crossing).
- Long-term planning that provides more connector roads for reduced congestion of arterial roads.

- Use of designated truck routes.
- Use of ITS (intelligent transportation systems) technology.
- Airport maintenance, security, and safety programs.

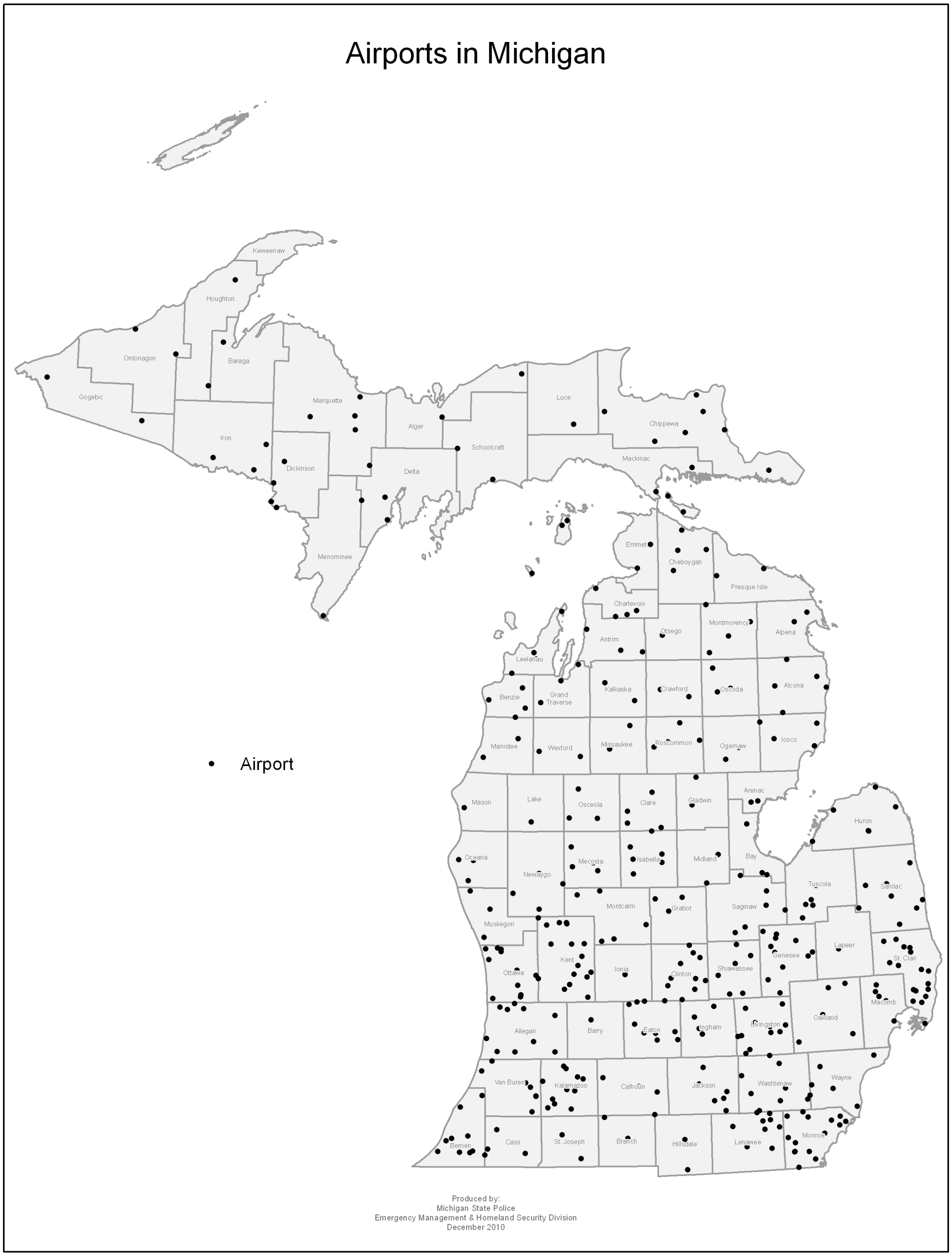
***Tie-in with Local Hazard Mitigation Planning***

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

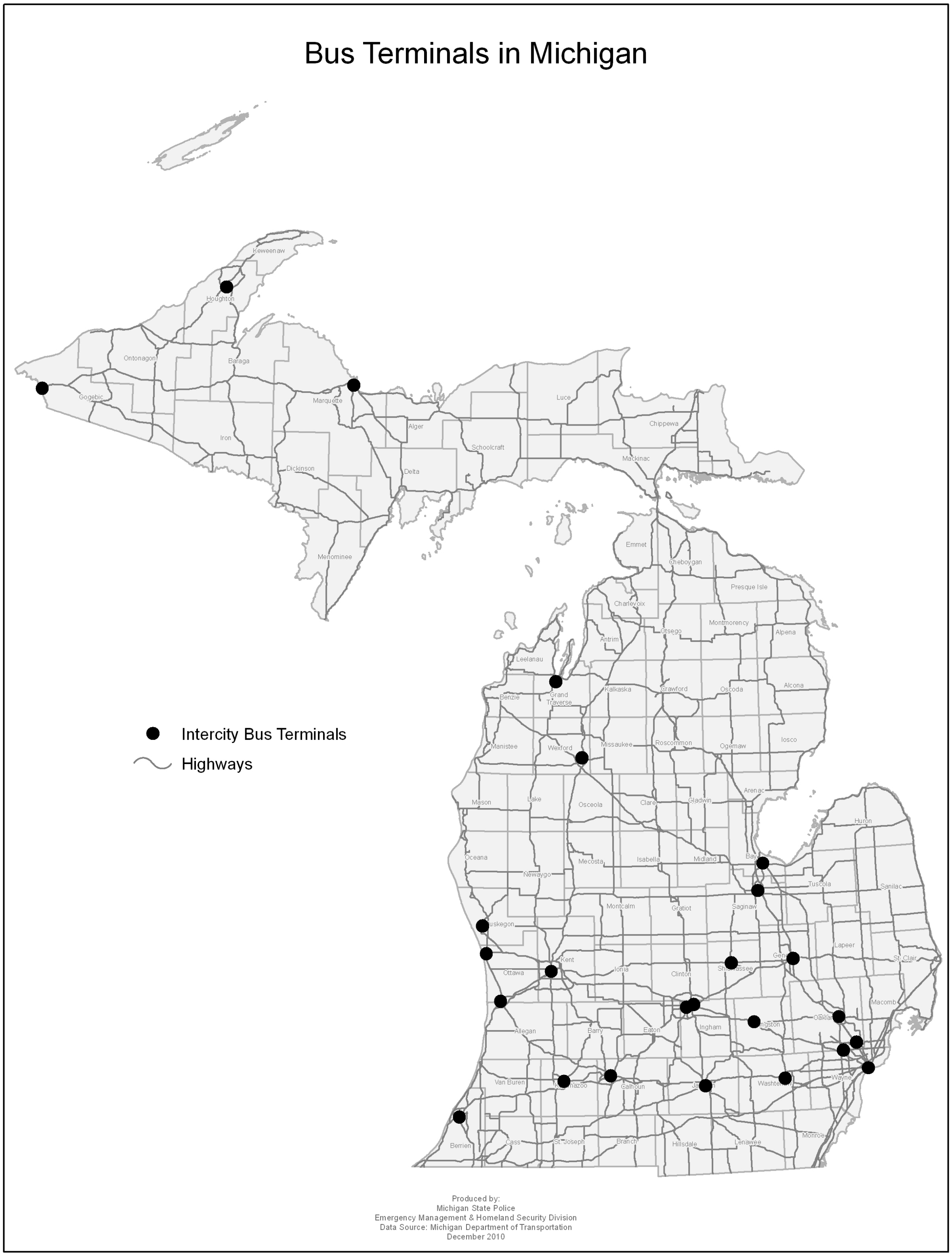
Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that transportation accidents were identified as one of the most significant hazards in the local hazard mitigation plan for Huron County.

## Michigan's Airports

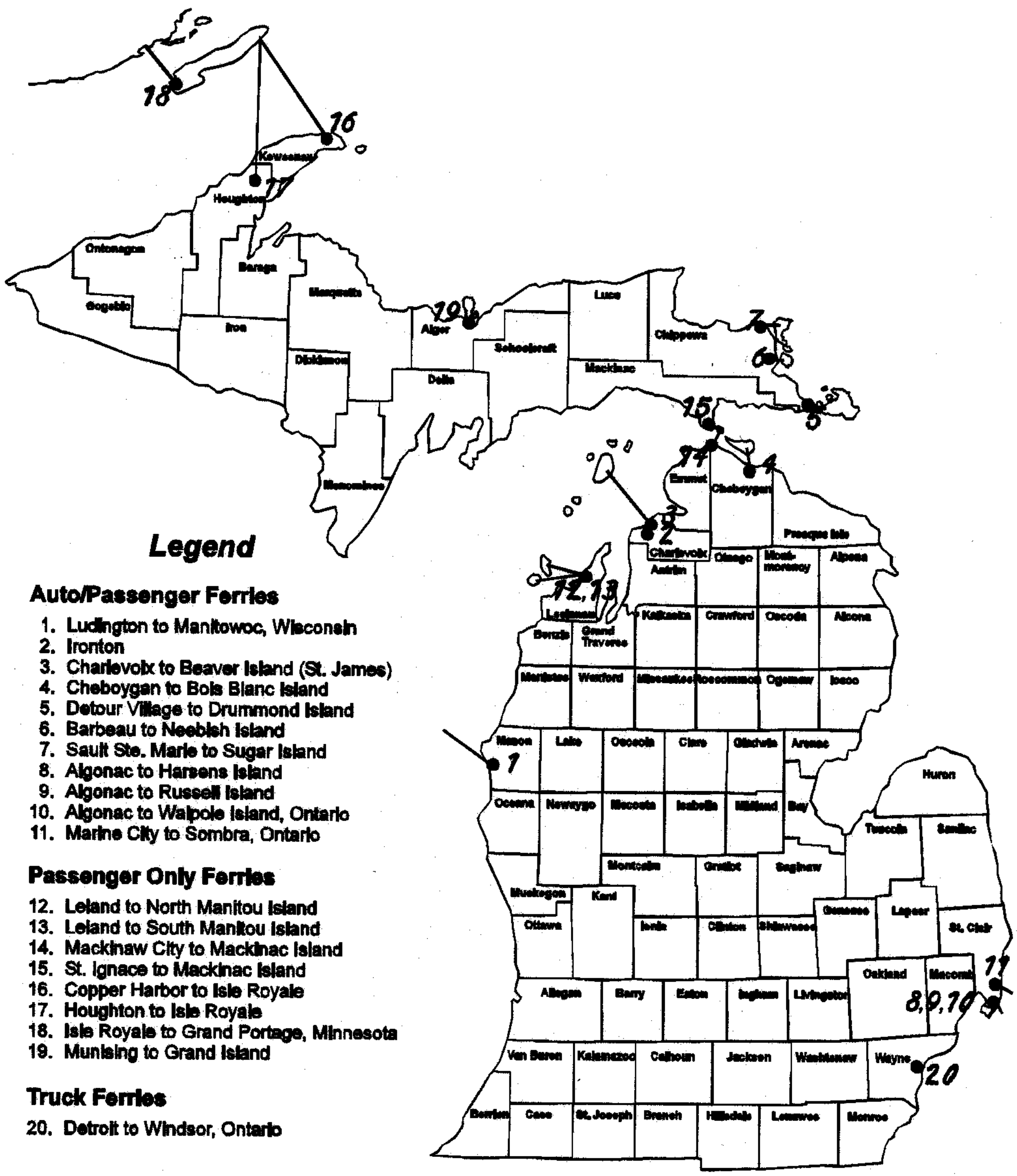


**Michigan Intercity Rail Passenger Transportation System**

## Michigan Intercity Bus Passenger Transportation System



## Michigan Marine Passenger Transportation System




Source: MDOT, Bureau of Transportation Planning, Travel Demand & Intermodal Services Section, Modal Services Unit

**Principal Ports in Michigan**