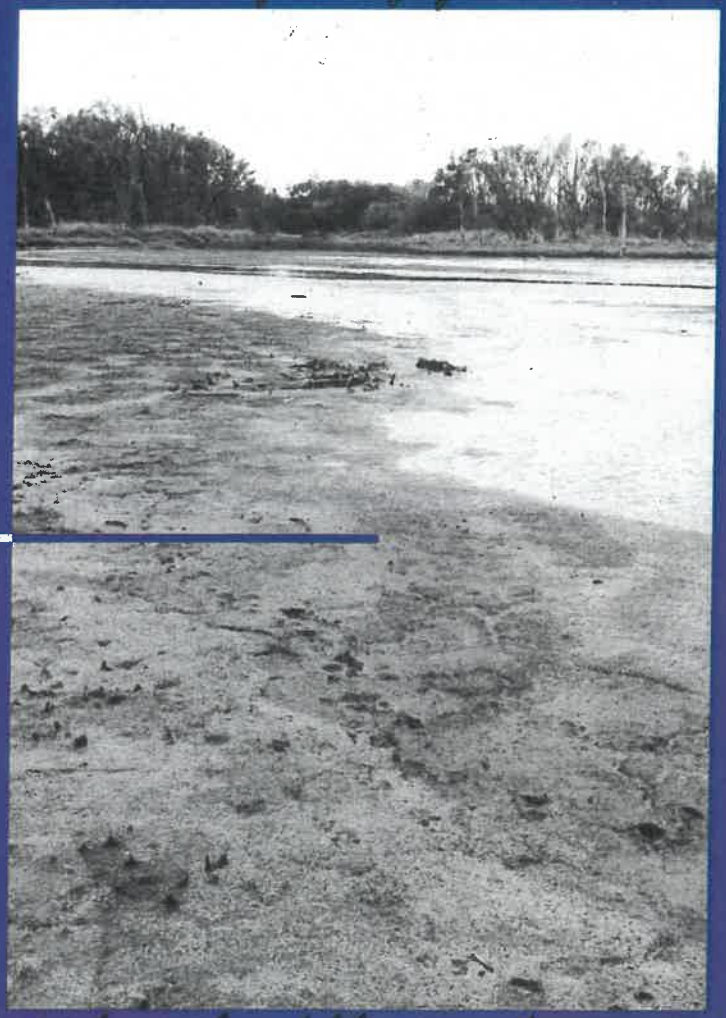
near the long-term average? How does a drought affect other water resources (rivers, smaller lakes, reservoirs, groundwater) in the Great Lakes Basin? How do changes in Great Lakes water levels affect public water supplies? Which federal and state/provincial agencies can a local government contact for information and forecasts on Great Lakes water level changes? Why is it important for the Great Lakes states and provinces to view drought and lake level management concerns as major regional issues? What are the main impacts of drought on public water supplies? Are climate modification techniques like cloud seeding successfully used to alleviate



A Guidebook

to Drought Planning, Management and Water Level Changes in the Great Lakes

state/provincial-owned lakes to provide emergency water supply for downstream municipalities? How can a local government or private resident determine if there is sufficient groundwater in the area to drill a well for an emergency supply? What is the difference between water conservation and demand management, and why is it important for local officials to consider both during drought? What changes in urban suburban landscaping should be encouraged to decrease overall water demand especially during times of drought? What are the

Great Lakes Commission

CONTENTS

PREFACE

Prompted by the severity of the drought of the summer of 1988, the Great Lakes Commission recognized the need to strengthen the region's ability to anticipate and respond to drought and its attendant impacts on Great Lakes water levels. At its November 1988 Annual Meeting, the Commission created the Task Force on Drought Management and Great Lakes Water Levels. This document is a product of that Task Force.

Task Force members, designated by the Commission, represented the eight Great Lakes states, the Province of Ontario, and numerous Canadian and U.S. federal agencies (see list in Appendix 3). They were charged with the following tasks:

- preparation of a guidebook to assist federal, state, provincial, and local officials address future drought impacts on Great Lakes water levels, the coastal zone and the Basin in general;
- the conduct of a lake levels forecasting symposium (and preparation of proceedings) providing a "post-mortem" analysis of forecasts in recent years and guidance as to how such forecasts can be strengthened to assist in coastal zone management decisions; and
- a policy statement establishing a framework for a coordinated, basin-wide response to future drought and attendant lake level and coastal zone impacts.

This guidebook addresses the first charge and is the culmination of a year-long effort of the Task Force on Drought Management and Great Lakes Water Levels. Appreciation is extended to all members of the Task Force, and to the individuals who participated in the Commission sponsored drought management workshop on October 3, 1989, in Ann Arbor, Michigan. Special thanks are extended to NOAA's Great Lakes Environmental Research Laboratory for hosting that workshop.

This publication was made possible due to financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resources Management, National Oceanic and Atmospheric Administration.

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Project management was provided by Thomas Crane, Natural Resources Management Specialist, with assistance from Richard Damberg, Research Associate. Production, editing and formatting assistance was provided by Carol Ratza, Communications Specialist and Rita Straith, Administrative Assistant. Project design and oversight was provided by Dr. Michael J. Donahue, Executive Director of the Great Lakes Commission.

Special recognition goes to Joseph Hoffman, of the Pennsylvania Department of Environmental Resources, chairman of Pennsylvania's Great Lakes Commission delegation and chairman of the Task Force on Drought Management and Great Lakes Water Levels.

Consultants contributing to the guidebook included Stanley Changnon (technical editing), Martha Walter (general editing), Dillard and Marie Murrell (design and production), and Karen Cogsdill (cover design).

Preparation of this report was made possible through a grant from the federal Office of Ocean and Coastal Resources Management (National Oceanic and Atmospheric Administration) under Section 309 of the federal Coastal Zone Management Act. Assistance was also provided by the Edna Bailey Sussman Fund.

All measurements and monetary values are in U.S. figures unless otherwise specified.

Chapter 1

HOW TO USE THIS GUIDEBOOK

This guidebook enables local officials and others affected by drought in the Great Lakes Basin to plan now for future drought events, and to act decisively and effectively when they occur.

The guidebook presents practical information that can be applied to each Great Lakes state and province. However, some of the material presented may not be directly applicable to all jurisdictions due to institutional and other differences.

Following this introduction (Chapter 1), this guidebook contains six additional chapters and a bibliography. Chapter 2 discusses various definitions of drought, reviews the 1988 drought, and describes the environmental, social and economic impacts of drought.

Chapters 3, 4 and 5 present, in a question-and-answer format, additional information about drought in the Great Lakes Basin, how to respond to drought, and planning for drought.

Chapter 6 provides brief descriptions of drought and water levels-related information and emergency assistance programs available from federal, state, and provincial governments, and from academic and private institutions.

Chapter 7 discusses key water supply issues in the Great Lakes Basin, such as the predicted effect of global climate change on the Great Lakes region, an historical perspective on lake level fluctuations in the Great Lakes, and diversions.

Appendix 1 presents a listing of literature useful to those involved in drought planning and management activities.

The guidebook is a practical tool: it presents and responds to commonly asked questions about drought, water level changes, expected impacts, and ways to minimize these impacts.

It emphasizes the need for communities to take an active role in the drought management process. Important recommendations include:

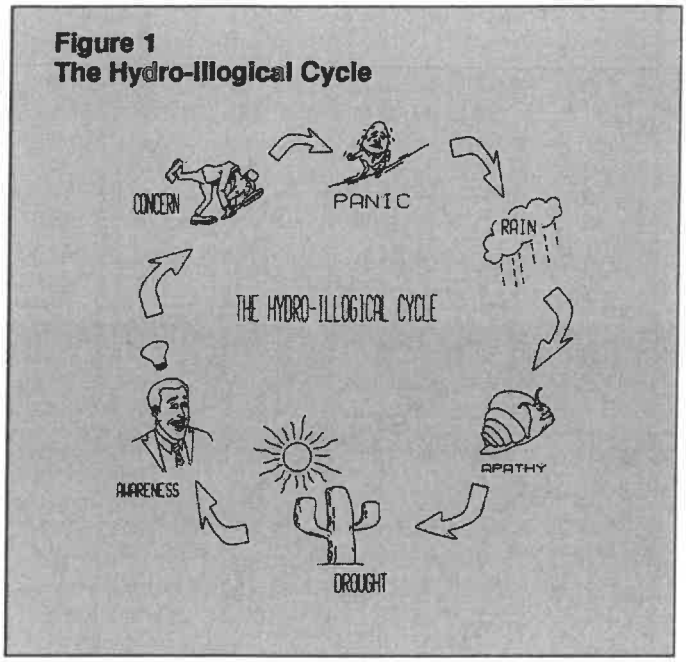
- forming interdisciplinary drought task forces in each Great Lakes state and province to ensure representation of key interests at all levels of government;
- establishing open lines of communication between state and provincial task forces and appropriate federal agencies; and
- developing contingency plans for emergency water supplies and water conservation efforts at all levels of government.

The drought of 1988 caught many citizens and government officials in the Great Lakes region by surprise. Much of the public's attention had recently been focused on the record high precipitation in 1985 that led to the historic high lake levels on four of the five Great Lakes (all but Ontario) between November 1985 and October 1986. The abrupt reversal of this trend in the two years that followed, and the rapid return to long-term average levels, was unprecedented in this century and certainly not expected.

Although the Great Lakes region is one of the most water-rich areas in the world, the 1988 drought demonstrated the unpredictability of meteorological events that have potential to cause economic, environmental, and social impacts. First-hand experience demonstrated to Great Lakes residents that drought is difficult to manage because it is a gradual phenomenon that has no well-defined beginning or ending.

Historically, efforts to anticipate and plan for drought have been limited in the Great Lakes Basin and beyond. Governments and society

Figure 1
The Hydro-Illogical Cycle



Adapted from *Planning for Drought: a Process for State Government*, by Dr. Donald Wilhite

typically wait for a drought to reach extreme stages and then quickly organize a crisis management response. Once the rains come and the drought passes, the tendency is to return to "business as usual," without taking the time to review response efforts or to suggest ways to improve future planning and response activities. The "Hydro-Illogical Cycle" (Figure 1) provides an entertaining yet realistic description of this tendency.

Studies of recent droughts have shown that unanticipated expenditures for crisis management activities by state, provincial, and local governments can cripple budgets and seriously restrict funding for other important government programs. It makes good sense for these governments to invest the time and resources needed to develop and update drought management plans proactively, rather than bearing the greater costs of crisis response at a later point.

Chapter 2
DROUGHT FACTS

A. WHAT IS DROUGHT?

Drought is difficult to define and many different definitions have emerged. Drought begins with prolonged precipitation deficiencies, followed by lowering of soil moisture, streamflows, and groundwater levels. Then crops are damaged, ponds dry up, and Great Lakes levels fall.

Some definitions of drought focus strictly on the physical condition of moisture deficiency for a certain period of time. Examples are *meteorological drought*, which usually focuses on precipitation shortfall, and *hydrologic drought*, which involves reduced streamflows, groundwater levels, or runoff.

Other definitions incorporate socio-economic factors by defining drought in terms of the impacts of below-normal precipitation on a specific sector of society. Examples here are *agricultural drought* and *urban drought*. Major economic consequences develop throughout society from such droughts.

Agriculture drought is a continued period of lack of moisture so serious that crops, orchards, or other vegetation fail to develop and be productive. Urban drought evokes the concept of "effective drought", where the effects of below-normal delivery of water through established systems, combined with actual drought, lead to a water shortage requiring modifications through water supply management, such as use of alternate supplies or conservation measures.

The lack of a single definition of drought has been one reason that policymakers have historically had problems implementing coordinated drought response efforts.

Several indices have been developed to help delineate the presence of drought, in terms of magnitude, severity and geographic extent. The best known and most widely used is the Palmer Drought Severity Index (PDSI). It is widely used in the United States and Canada to evaluate soil moisture conditions. Another index, the Palmer

Drought Hydrologic Index (PDHI), is used to measure long-term runoff and water table conditions. Degrees of wetness and dryness in each index are represented numerically, with values less than -4 indicating extreme drought, and values greater than +4 indicating extreme wetness (see Table 1). The Palmer Drought Indices are based on measurements of precipitation and temperature departures from average.

Table 1
Palmer Drought Severity Index
(Values indicate extent of departure from normal climate)

Numerical Value	Condition
above +4	Extreme Wetness
+3 to +4	Severe Wetness
+2 to +3	Moderate Wetness
-2 to +2	Near Normal
-2 to -3	Moderate Drought
-3 to -4	Severe Drought
below -4	Extreme Drought

Continuing precipitation shortages eventually lead to reduced groundwater levels, reduced streamflows, and lowered lake levels (hydrologic drought). The length of time before these reduced water levels occur can vary greatly, sometimes becoming noticeable within one to two months after a marked precipitation deficit begins, but usually three to twelve months after a precipitation deficit begins. The PDHI is useful in analyzing the presence of hydrologic drought.

B. CAUSES OF DROUGHT

Despite the difficulty of defining drought to everyone's satisfaction, experts agree on one key fact: drought occurs frequently in North America and is a basic feature of the highly variable North American climate. Below-average levels of precipitation in the United States and Canada are commonly attributed to changes in atmospheric circulation patterns, particularly changes in the position of the jet stream, which causes prolonged displacement of the frontal activity that produces much of the precipitation in any given portion of North America.

Major droughts result from persistent large-scale anomalies in the global circulation patterns of the atmosphere. The fundamental causes for these anomalies are not well understood. Certain potential causal mechanisms have been identified including the El Nino/Southern Oscillation, and other anomalies in sea surface temperature patterns, such as in the North Pacific. Once established, drought tends to be self-perpetuating. Drier soils yield less moisture to the air than usual, the drier air becomes warmer than normal, reducing cloud formation and rainfall.

A continuing lack of precipitation (and often above-average temperatures) disrupts the hydrologic cycle. This cycle is normally characterized by water moving from oceans and lakes to the atmosphere by evaporation. Water also moves to the atmosphere by evaporation from the soil and transpiration from plants. Total evapotranspiration is temperature dependent, and is a result of the combined evaporation of moisture from open bodies of water and from soils and transpiration of moisture by plants. Moisture returns to the earth through precipitation in the form of rain and snow. Some of this water runs off into streams, rivers, and lakes, and some water percolates through the soil to become part of the groundwater system. (Figure 2)

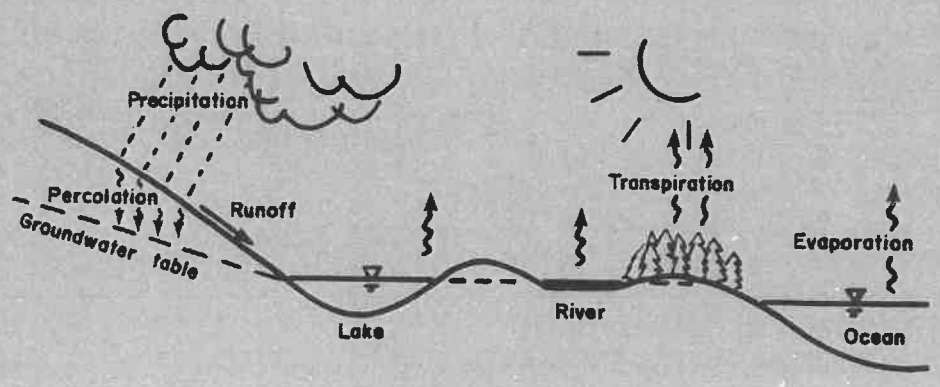
C. GEOGRAPHIC EXTENT AND DURATION OF DROUGHT

Drought can be difficult to define because its coverage can extend from small areas (part of a state or province) to very large regions (half of the United States or Canada). Typical droughts in the United States cover several states. The size and duration of droughts are closely linked; that is, long lasting droughts usually cover very large areas. The minimum duration of drought is considered to be three months but drought conditions have lasted for five to six consecutive years in some areas.

D. DROUGHT IN NORTH AMERICA

Drought has been a part of life in North America throughout recorded history. An analysis of growth rings of trees suggests that drought has been a common occurrence since at least 500 A.D. Long-term studies do not reveal any distinct cycle or pattern of drought, however. The length of drought periods varies considerably as well. No real meteorological skill exists for predicting

Figure 2
Hydrologic Cycle



Source: *Environmental Pollution and Control* by P. Aarne Vesilind

future droughts, although once a drought occurs, the probability of continuation can be determined, based on climatological records.

Drought in North America has occurred most frequently in the midcontinent region. This area extends eastward from the Rockies and includes the Great Plains of the United States and Canada and the Midwest. Since 1930, several regions of the United States and Canada have been subjected to drought conditions; see Table 2.

Table 2
Drought in U.S. and Canada, 1930-1988

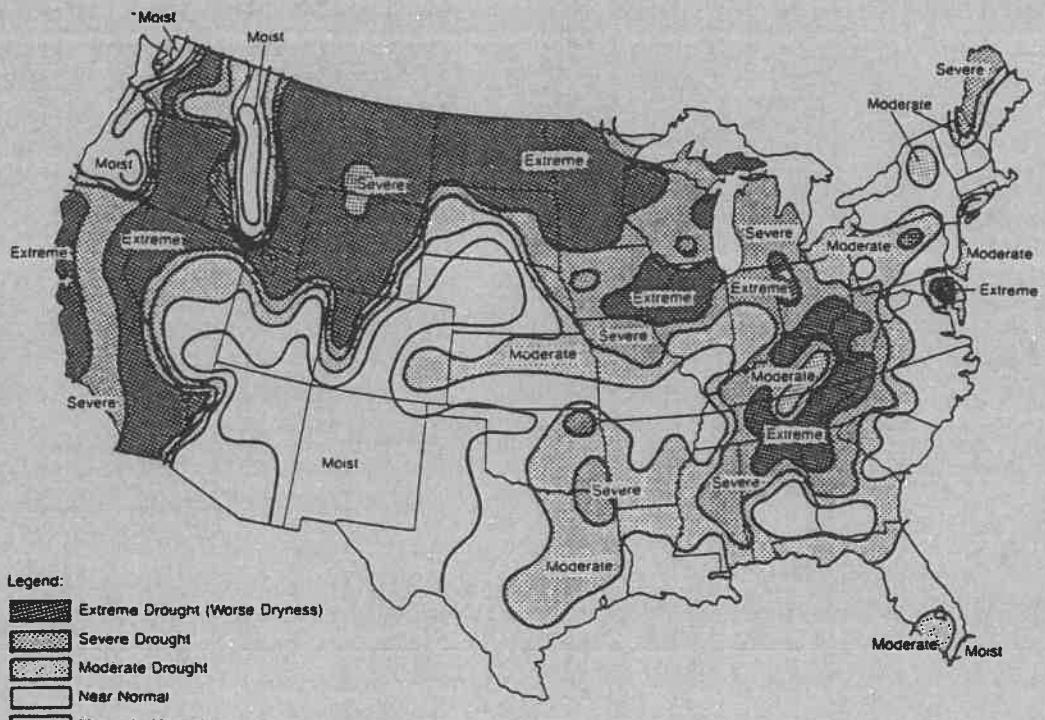
1989	Far West, North Central Plains
1987-88	Northern Plains, Corn Belt, Far West
1986	Southeastern United States
1984-85	Appalachian Region
1980-81	New York, Pennsylvania, and Southeastern United States
1976-77	Great Lakes Region, Great Plains to Western U.S. and Southern Canada
1974-76	Great Plains
1962-64	Northeastern United States, south to Washington D.C.
1952-57	Southern Great Plains and Southeastern United States
1931-39	Great Plains eastward to Great Lakes (1934 and 1936 most severe)

E. THE DROUGHT OF 1988

1. Severity

The damaging effects of the drought beginning in 1984-85 were fully experienced in 1988. By July 1988, the drought extended throughout the United States and southern Canada, with 24 states and 3 provinces experiencing extremely severe conditions. The area ranged eastward from Montana and Wyoming across all states in the Great Plains and Corn Belt, south to Arkansas and Mississippi, and southeastward into North Carolina and Maryland (see Figure 3). Experts ranked the 1988 drought as one of the three worst droughts in the United States since 1895, when

Figure 3
Palmer Drought Severity Index - July 23, 1988
(Indicates only U.S. conditions)



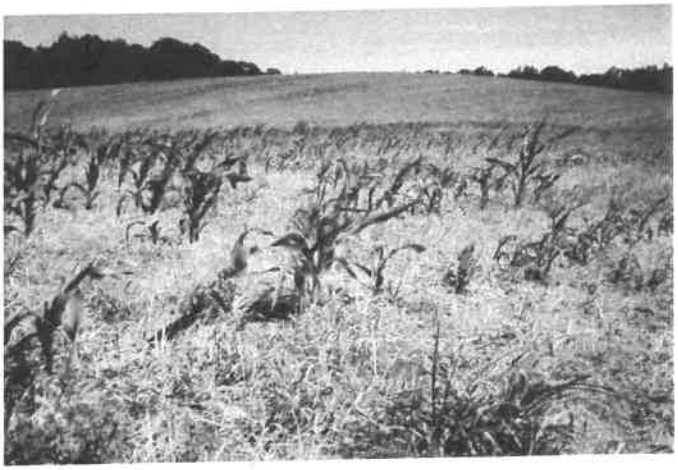
Source: NOAA/USDA Joint Agricultural Weather Facility

comprehensive record-keeping began. At the peak of the drought in mid-July 1988, the PDSI indicated that 45% of the country was experiencing severe or extreme drought conditions.

However, the drought was relatively short lived in the Great Lakes Basin, and ended during the winter of 1988-89.

2. Impacts

Grain production across the United States in 1988 was down 29 percent. Crops most affected were corn, soybeans, and wheat. Some estimates suggest that total crop losses due to the 1988 drought equaled $40 billion, making it the worst natural disaster in U.S. history in terms of dollar costs. The magnitude of these losses is due in large part to the unfortunate timing of the drought. The drought was strongest from March to July, which are the critical months for crop development. Another major factor was the unusually high temperatures that accompanied the low precipitation. Minnesota and Wisconsin, for instance, each had the hottest May-June period ever recorded, and up to 5,000 persons died from heat stress, largely in major cities in the northeastern United States.



In the Great Lakes states and provinces, the severity of the 1988 drought varied widely. At the end of June 1988, precipitation over the entire basin was 25% below the long-term average. Conditions were even more extreme in some areas. Lake Michigan basin precipitation was 35% below average and Lake Erie basin precipitation was 40% below average. The six westernmost states experienced the greatest drought severity, with Minnesota, Wisconsin and Illinois being hit the hardest. New York, Ontario and Pennsylvania did not experience such drastic impacts, but still had to contend with some water supply and other problems. However, the 1988 drought in the Great Lakes Basin was not as extreme nor as long lasting as those in the Basin of the 1930s or 1960s.

3. Specific State and Provincial Impacts and Adjustments

Selected notable impacts and adjustments undertaken by each state and province in reaction to the 1988 drought are listed below.

Illinois

- Record low levels on the Mississippi River and the lower Ohio River led to navigation blockages and required emergency dredging.
- Due to record low flows on the Mississippi River that caused numerous shipping bottlenecks, Governor Thompson requested the Lake Michigan Diversion at Chicago to be increased from 3,200 cubic feet per second (cfs) to 10,000 cfs for 100 days. (One cubic foot per second equals 646,316 gallons per day or 448.8 gallons per minute.)
- Total crop production (corn, soybeans, sorghum, wheat, oats, and barley) was down 38% overall from 1987 levels, with the corn harvest down 45% and soybean production down 29%.
- USDA Agricultural Stabilization and Conservation Service payments to farmers totaled $376 million for drought relief programs.

Indiana

- The state experienced the driest June on record (15% of normal rainfall).
- Total crop production (corn, soybeans, sorghum, wheat, oats, and barley) was down 37% from 1987 levels.
- Withdrawals from high-capacity wells in Jasper and Newton counties in northern

Indiana resulted in substantial declines in groundwater levels and caused the DNR to restrict pumpage on weekends.

- Ten public water suppliers invoked mandatory conservation measures while many more requested voluntary measures.
- Electric generation facilities on some rivers were at times forced to lower generation capacity because of cooling water supply problems.
- During June, barges on the Ohio River were forced to carry approximately 40% less cargo due to low flows. Shipping revenue for the month declined by more than 25%.
- The DNR received 40 well interference complaints and 60 complaints regarding surface water withdrawal conflicts.

Michigan

- Rainfall in the Lansing area during May and June was only 0.83 inches (86% less than the long-term average), shattering the previous record of 2.27 inches set in 1925.
- Lansing experienced record heat from May through July, with temperatures in excess of 90 degrees Fahrenheit on 37 days. Record usage of electrical power was recorded in mid-summer in southern Michigan.
- Total crop production (corn, soybeans, sorghum, wheat, oats, and barley) was down 35% from 1987 levels.
- Low flows on the Raisin River in southeast Michigan led to water use conflicts between municipalities and irrigators.

Minnesota

- The entire state, excluding the northeast portion, was classified in the "extreme drought" (according to the PDSI) category in late summer, and the April-July period was the second driest in the past 100 years.
- Flows on the Mississippi River reached a low of 842 cfs, approaching the record low levels of 1934 and 1976. Local officials were concerned about maintaining adequate public water supplies for the Twin Cities, which obtain nearly all of their water from the Mississippi. Area-wide restrictions on nonessential uses were instituted.
- Total crop production (corn, soybeans, sorghum, wheat, oats, and barley) was down 49% from 1987 levels. Agriculture losses were estimated at $1.2 billion.
- Groundwater levels throughout the state reached new record low levels.

New York

- The state issued a revised Drought Management Plan in December 1988. New York City commenced a 10-year program to install 630,000 water meters in order to increase water conservation.
- Fifty counties were eligible for farmers' emergency loan assistance. Total crop production (corn, soybeans, sorghum, wheat, oats, and barley) was down 21% from 1987 levels.
- A drought emergency was declared for New York City on May 1, invoking severe conservation measures. Reservoirs were only filled to 71% of capacity during the season when they are usually full. The city also pumped as much as 100 million gallons per day from the Hudson River to supplement reservoir supplies.

Ohio

- Ohio had the driest June on record and the driest April-June period on record. The January-June period was the second driest, exceeded only in 1934.
- Streamflows were less than 60% of normal for the entire year. More than 35% of the state's observation wells reached record low groundwater levels. The DNR's Division of Water was besieged with requests for increased groundwater

monitoring, complaints about competing water uses, and inquiries about the state's system of water rights.

- Total crop production (corn, soybeans, sorghum, wheat, oats, and barley) was down 34% from 1987 levels.
- Farmers in southern Ohio raised funds to conduct a cloud seeding project to increase rain during July and August.
- The state issued a Drought Response Plan in April 1989 in response to the 1988 drought.

Ontario

- Precipitation in southwestern Ontario was generally less than 40% of average from May 1 to mid-July. June streamflows in southern Ontario ranged from 20% to 80% of the June long term average.
- Agricultural producers realized province-wide average field crop yields from 14 to 30% lower than the previous five year average.
- Increased water demand during hot spells in June and July in many municipalities necessitated water restrictions on lawn watering, car washing, and other nonessential water uses.
- The 1988 forest fire season was the second worst since record keeping began in 1917. A total of 3,260 fires (double the 20 year average) were reported, destroying more than 390,000 hectares (954,000 acres) of forest.
- Dredging activity for recreational boating and commercial navigation increased and the levels of many docks had to be adjusted to accommodate the lower water levels on the Great Lakes.
- In the spring of 1988, some reservoirs used for hydroelectric generation could not be filled as they normally would be. This resulted in limited discharges for the electric generation needed to meet record setting peak demands in the hot summer. The low reservoir levels also caused a loss of enjoyment for the riparian cottage owners.

Pennsylvania

- All of the state's 67 counties showed precipitation deficits for the first six months of 1988.
- Due to drought conditions, a statewide drought watch was issued in July. Conditions worsened over the next month, causing a drought warning to be issued for 42 counties in late August.
- Also in late August, mandatory water use restrictions were imposed by 122 public water suppliers serving 272,500 people in 38 counties.
- Total crop production (corn, soybeans, sorghum, wheat, oats, and barley) was down 27% from 1987 levels.

Wisconsin

- Total crop losses were estimated at $1.3 billion. Corn and hay, the primary feed crops for dairy and livestock farmers, accounted for $1.1 billion (or 85%) of these losses. Total crop production (corn, hay, soybeans, sorghum, wheat, barley, and oats) was down 55% from 1987 levels.
- Benefits collected from the USDA feed and crop assistance programs totaled nearly $400 million.
- The legislature approved the Governor's Special Session Drought Proposals, which included a $35 million drought assistance loan program, extension of emergency water diversion permits for irrigation, and a $30,000 appropriation for operation of a farmer assistance hotline.
- The legislature also passed a bill providing an estimated $21 million in property tax credits for farmers.
- The impact of the drought was an especially severe blow for many of the state's 80,000 farmers, 25%-33% of which had debts amounting to 40% of total assets in early 1987.

- Forest fire-fighting costs exceeded the DNR's budget for fire fighting by $500,000. In addition, an estimated 60%-70% of the seedlings planted over the past 3 years were lost due to the dry weather.
- Hydropower companies experienced a 40%-45% energy production loss from June through August due to low streamflows.
- Rainfall for April-June was only 47% of average.

4. The Key Lesson

The 1988 drought caught the Great Lakes region by surprise, incurring significant costs and losses. In reviewing their responses to the drought of 1988, many state and provincial governments found that, if comprehensive drought management plans had been in place, a significant portion of these problems could have been reduced or avoided.

Chapter 3

DROUGHT IN THE GREAT LAKES BASIN

A. DROUGHT CHARACTERISTICS

1. What is drought?

Please refer to Chapter 2, Section A, *What is Drought?* for a discussion of this question.

2. Are there different kinds of drought?

Yes. Some droughts are more severe and last longer than others. Also, the geographic extent of droughts can vary from small regions in one state to multi-state or multi-provincial coverage. (Please refer to Chapter 2, Section A, for further information.)

3. Are water shortages always caused by or associated with drought?

No. Water shortages can be caused by a number of factors unrelated to drought. Increased water demand in a community can cause water shortages. Also, antiquated delivery systems and inadequate water supplies can cause water shortages even during non-drought years. Therefore, it is important for communities to engage in demand management and forecasting activities to ensure a reliable water supply at all times.

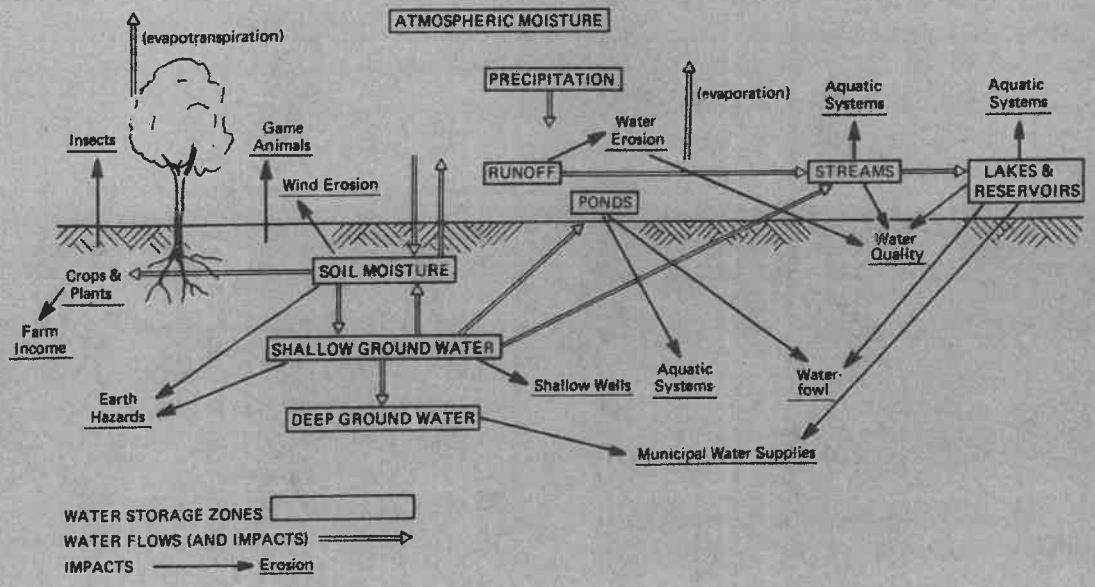
4. What are the common indicators of drought?

Many jurisdictions look to changes in the elements of the hydrologic cycle as common indicators of drought. These indicators include changes in precipitation, reservoir and lake storage and recharge as well as streamflow and groundwater levels. Soil moisture is also a key parameter because of its importance to agriculture production (see Figure 4).

5. How is the severity of a drought determined?

Drought severity depends on the degree of water deficiency and the activity being affected (crops, cattle, urban water supplies, recreation, shipping). Methods of measuring drought severity differ, depending on the actual definition of

Figure 4
Hydrologic Conditions Affected by Drought, and Related Impacts



Source: *Detecting Drought Conditions in Illinois*, by Stanley A. Changnon

drought that is being used. One common measurement of drought is the Palmer Drought Severity Index. This Index represents degrees of soil wetness and dryness with numerical values. Values less than -4 indicate extreme drought and values greater than +4 indicate extreme wetness (see Table 1). However, the Palmer Index was designed for broad regional use, and it may not accurately portray local situations, particularly those related to urban and industrial water supplies. Hence, several Great Lakes states and provinces have developed their own definitions of drought severity that reflect the highest priority uses of water. New York, for example, uses a State Drought Index, which assigns weight to four main hydrologic factors, based on their significance to public water supply in each of the state's drought regions.

Drought severity indices are very important at the local level because they can be used to trigger water conservation measures and other community activities. Each community or public water supplier should develop its own indicators of drought severity reflecting local hydrologic characteristics, geography, and demands for water. Local response "trigger levels" can then be based on reservoir and/or groundwater levels in concert with the locally-developed indicators.

6. Is drought caused by the greenhouse effect?

The greenhouse effect is the natural process by which solar radiation reflected from the Earth's surface is trapped by carbon dioxide and other gases in the atmosphere, and thereby prevented from radiating back into space. This phenomenon results in a global average annual temperature of about 15 degrees Celsius (59 degrees Fahrenheit). Without this process, the global average temperature would be much colder.

Researchers agree that concentrations of carbon dioxide and several other trace gases (methane, nitrous oxide, chlorofluorocarbons) are increasing because of human activities, including the burning of fossil fuels. This will eventually strengthen the greenhouse effect, thereby leading to higher average global temperatures at some future time. Some believe that global warming could lead to greater variations of the Earth's climate and greater frequencies of extreme climatic events, including drought. There is no conclusive evidence, however, that recent

droughts such as the 1988 North American drought were caused by the greenhouse effect.

7. Can drought be predicted?

No. There is currently no reliable method for predicting drought cycles or patterns, although much research is being done on climate predictions. However, once drought has begun, the likelihood of it continuing or terminating in the coming three to six months can be calculated using historical precipitation data.

Without the ability to conclusively predict the occurrence of drought, scientists and policymakers agree that local governments must focus on monitoring basic hydrologic factors and drought indices, and on developing drought management plans.

8. How long do droughts usually last and are they becoming worse?

There is no "average" duration for drought. Some droughts have lasted for only a few months and some areas have experienced drought conditions for several consecutive years. There is no evidence that droughts are occurring more frequently or with more severity.

9. How wide an area can be affected by drought?

The severity and impacts of drought can differ greatly within a relatively small area, such as from one county to the next. Droughts are usually widespread, affecting large portions of a state or province, or large regions of a country. The drought of 1988 illustrates this point: in late July, more than 45% of the contiguous U.S. was experiencing severe to extreme drought conditions. The area affected included the Great Plains, Midwest, and Southeast.

10. Why was 1988 considered a drought year when the annual precipitation of the Great Lakes Basin was near the long-term average?

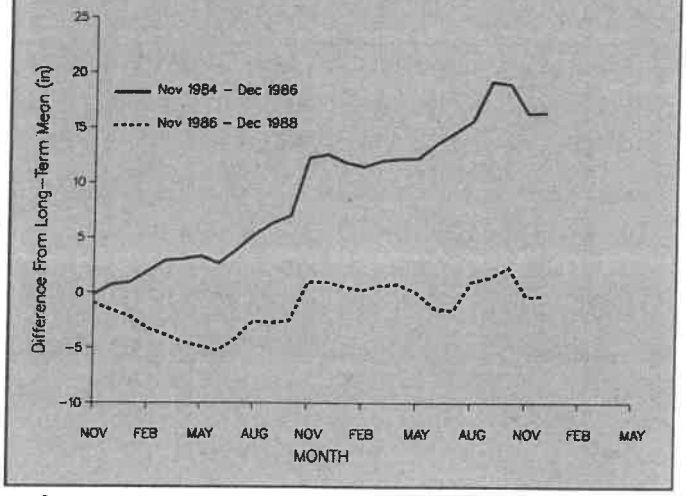
There are several reasons. Snowfall in the winter of 1987-88 was significantly lower than normal, leading to a light spring runoff and reduced groundwater recharge.

Also, precipitation in the Great Lakes Basin for the first seven months of 1988 was 19% below average. May and June were exceptionally dry. Several states (Indiana, Michigan, Ohio, and Minnesota) set all-time records for low precipitation amounts during these two months, which is a critical period for planting and crop development. The drought conditions were more pronounced in the Basin's western portions than in the eastern portions.

In addition, the dryness was intensified by record high temperatures during the same period. High temperatures and low humidity caused evaporation rates to increase for reservoirs, lakes, and wetlands, in turn leading to rapid lowering of water levels. High water demand in both urban and rural areas quickened the depletion of water supplies.

Rainfall in the Great Lakes Basin for August through December of 1988 was 33% above average, however, bringing the annual rainfall total to 4% above long-term averages. Thus, the timing and placement of the precipitation deficit in late 1987 and the spring of 1988 were the key factors leading to the serious conditions that peaked during the summer. (See Figure 5.)

Figure 5
Cumulative Great Lakes Precipitation



Source: National Oceanic and Atmospheric Administration

B. DROUGHT AND GREAT LAKES WATER LEVELS

11. Are changes in Great Lakes water levels related to the hydrologic cycle?

Yes. Changes in Great Lakes water levels are closely related to the hydrologic cycle. Lake levels are determined by the interaction of natural and artificial factors which increase and decrease the total amount of water to and from the lakes. The natural factors affecting Great Lakes levels include precipitation, runoff, streamflow, groundwater flow, and evaporation. Precipitation is the key factor.

In the Great Lakes region, precipitation comes in the form of rain or snow. Much of the snow that falls during winter remains until spring thaw. The resulting snow melt in the spring contributes a significant amount to the total water supply of the lakes. The highest water levels on the Great Lakes generally occur in the summer months due to snow melt and to the fact that the year's heaviest rains normally occur in summer.

12. How does drought affect the water levels of the Great Lakes?

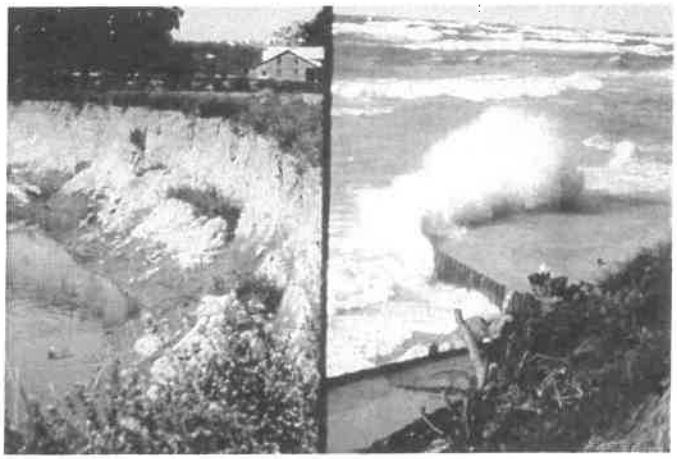
Drought periods reduce the overall water supply to the Great Lakes by reducing runoff and causing Great Lakes levels to drop over time. The precise effect of a drought, however, depends on several factors, including the timing of the drought, air temperatures, and evaporation from the lakes. Droughts occurring in the winter and early spring have a greater effect on levels than mid-summer droughts, since winter and spring precipitation is the key to maintaining lake levels. If a drought is accompanied by lower than average air temperatures, evapotranspiration will be less and the effect on lake levels will not be as severe as a drought accompanied by above average air temperatures, which is the normal condition during droughts.

Precipitation from November 1986 through June 1987 was the lowest November-June total on record in the Great Lakes Basin and caused lake levels to fall by 2.7 feet on Lakes Michigan and Huron and 1.9 feet on Lake Erie by December 1987; down from the record high levels of October 1986. The March-July 1988 precipitation was also the Basin's lowest March-July amount on record, and resulted in Lakes Michigan and Huron levels and Lake Erie levels of December 1988 being about 0.8 feet and 1.2 feet, respectively, below the levels of December 1987.

Another factor that can lower water levels during drought is increased demand for water, especially withdrawals for irrigation, public supplies, and domestic uses. (Please refer to Chapter 7 for more information.)

13. How does a drought affect other water resources (rivers, smaller lakes, reservoirs, and groundwater) in the Great Lakes Basin?

Drought can lead to decreased availability of all of these water resources. The most limited resources are affected first, through a combination of two key factors: 1) increased demand for water; and 2) decreased runoff into streams and lakes that, in turn, recharge groundwater supplies.



In some cases, reduced streamflow may also lead to higher concentrations of pollutants in the water, which can negatively affect fish and wildlife populations and human health. Water use conflicts among users of surface and groundwater are common in this scenario. Well interference complaints commonly arise when a user withdraws large quantities of water from a high-capacity well and thereby restricts the withdrawal capability of a domestic user's smaller well.

14. How do changes in Great Lakes water levels affect public water supplies?

Many public water utilities in the Great Lakes region obtain their water directly from the Lakes. These suppliers should not be adversely impacted when lake levels drop, because the intake systems are designed to withdraw sufficient quantities of water to meet demand and are generally located in deep water. However, low lake levels can be an issue for public water suppliers if nearshore pollutant concentrations have increased, thereby requiring additional treatment.

15. Which federal and state/provincial agencies can a local government contact for information and forecasts on Great Lakes water level changes?

The U.S. National Ocean Service of the National Oceanic and Atmospheric Administration (NOAA), the U.S. Army Corps of Engineers (COE), and Environment Canada are the three primary federal agencies that a local official should contact for Great Lakes water levels information. The National Ocean Service in Rockville, Maryland, is the agency responsible for the collection, verification, and distribution of historic and current U.S. water level data. With regard to legal disputes, all data must be obtained from them.

To assist in the operation of ships on the Great Lakes, the Corps of Engineers (COE), Detroit District, obtains both U.S. and Canadian daily water level information, and maintains statistics such as long-term average and maximum and minimum levels. State and provincial natural resources agencies may also be helpful, but they generally receive their water levels data from the federal agencies. The COE publishes monthly water level forecasts for the Great Lakes and their connecting channels. NOAA's Great Lakes Environmental Research Laboratory (GLERL) also conducts research on this issue and has developed several forecasting models. Environment Canada produces a six-month forecast which is coordinated with the COE-published forecasts. (Please refer to Chapter 6 for more information.)

16. Why should the Great Lakes states and provinces view drought and lake level management concerns as major regional issues?

The Great Lakes are a vital resource that provide economic and environmental benefits for riparian states and provinces. Water-dependent industries in the Basin employ hundreds of thousands of workers directly and affect many more indirectly. Twenty-five million residents rely directly upon the Lakes as their source of drinking water.

Also, the Great Lakes Basin is a natural system that must be managed using an ecosystem approach. Activities and events affecting one area will ultimately affect the whole system. Finally, the Great Lakes are an international resource whose conservation, protection and use are shared responsibilities between the United States, Canada, and the Great Lakes states and provinces.

C. IMPACTS OF DROUGHT ON THE COASTAL ZONE AND THE GREAT LAKES BASIN

17. What are the main impacts of drought on public water supplies?

Extended periods of below-average rainfall contribute to reduced lake levels, surface water flows, groundwater levels, and reservoir levels. For public water suppliers who are not using Great Lakes water as their primary source, emergency or alternative water supplies may be needed and can be obtained by deepening existing wells, drilling new wells, building temporary dams, changing supply from groundwater to surface water, or extending pipelines to deeper water or to different sources. Conflicts over water may occur between competing users such as between domestic users and irrigators.

Some public water suppliers may sell excess water to other suppliers/communities experiencing shortages. The opportunity to purchase excess supplies from water-rich suppliers during drought may actually be a disincentive for water-short communities to implement water conservation programs. Also, increased customer demand and use during drought can produce higher revenues for public suppliers. Hence, imposing restrictions to reduce demand during drought may in turn reduce revenues.

18. What are the main impacts of drought on commercial and industrial water users?

Drought-induced impacts to commercial and industrial water users may be similar to those experienced by public water suppliers. Access to high quality water for industrial and commercial processes may be a problem if near-shore water quality is reduced due to lower lake levels. Changes in water temperatures may affect industrial cooling processes. Emergency or alternative water supplies may be needed to accommodate declining lake levels, reduced streamflows, or lowered groundwater levels.

19. What are the main impacts of drought on agriculture?

Low soil moisture may result in loss of arable land and reduced crop productivity, causing farm revenues to drop. Low yields of feed crops (corn and hay) can lead to feed shortages and cause problems for dairy farmers, cattle ranchers, and other livestock operations.

Some shallow wells, ponds, and wetlands dry up during drought. Farmers and rural residents may need to drill new wells, deepen old wells, or transport water from other sources. Many increase their irrigation activities, thereby reducing streamflows, reservoirs and groundwater levels. This may conflict with other uses. Conflicts between irrigators and domestic water users are common, particularly when wells provide the principal source of water. New withdrawals may create conflicts between irrigators by preventing existing irrigation systems from obtaining adequate amounts of water to meet their needs.

As vital topsoil loses moisture, it becomes more susceptible to wind erosion. Topsoil erosion can

reduce agricultural productivity by as much as 30% to 40%, depending on the soil properties and the adaptive capabilities of the crop.

Some farmers benefit during times of drought. Farmers in regions less affected by drought, or those able to irrigate sufficiently, may experience substantial increases in total income due to higher unit prices.

20. What are the main impacts of drought on wetlands?

Wetland vegetation depends on a groundwater table that is on or close to the surface, which can dry up during drought (for example, 2 million acres of prairie wetlands dried up in the Dakotas, Manitoba, and Saskatchewan during the 1988 drought). When wetland areas are reduced, a reduction in many important values and functions also occurs, such as groundwater discharge and recharge; habitat for fish, waterfowl, and other wildlife; and recreation such as hunting, fishing, and canoeing.

During drought, many former shoreline wetland areas will be targets for development, thus causing a permanent loss of wetlands. Wetlands may also be sacrificed to expand agricultural production during times of drought. Wetlands may be unintentionally affected by some assistance programs. In the United States, emergency haying and grazing activities are permitted on marginal lands (commonly including wetlands) that could be set aside from production under the Conservation Reserve Program of the 1985 Food Security Act.

Coastal wetlands are often used as places to deposit sediment dredged from navigation channels in lakes or rivers. Thus, dredging, which increases in times of low water levels, can disrupt wetland ecosystems and may contaminate them with pollutants in the sediment. Wetlands also provide highly productive fish and wildlife habitat. Deposition of contaminants may therefore increase the likelihood of contaminant uptake in the food chain.

Drought and changing lake levels can also have a beneficial effect on both inland and coastal wetlands by allowing dormant seeds to germinate and broaden the diversity of plant life.

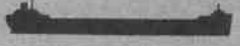
21. What are the main impacts of drought on navigation and the shipping industry?

Navigation on the Great Lakes/St. Lawrence River system and, in particular, its harbors and connecting channels, is significantly affected during drought due to lower water levels and flows. A controlling depth of 27 feet (low water datum) provides for a maximum 25.5-foot commercial navigation vessel draft in the Great Lakes and connecting channels and a 26-foot vessel draft on the St. Lawrence River. Lower water levels translate into reduced vessel draft and therefore less carrying capacity. The Lake Carriers' Association has determined that the incremental change in carrying capacity per one inch of draft ranges from 71 net tons for a small lake freighter to 267 tons for a 1000-foot supercarrier. During low water periods, cargo volume is reduced and trip frequency is adjusted. These changes compromise efficiency by increasing transportation costs and decreasing revenue (See Figure 6).

Recreational harbors also pose some navigation problems during low water periods, with the impacts of drought compounded by substantial sediment loads from nearby shorelands and rivers.

Navigation channel and harbor dredging may be needed during low water periods. Many commercial harbors and all of the Great Lakes connecting channels are maintained by the U.S. federal government, with dredging accomplished mainly through private contractors.

Figure 6
Impact of Lake Levels on Vessel Carrying Capacity
(net tons)

Great Lakes Bulk Carriers	Vessel Length (feet)	Per-Trip Carrying Capacity	Capacity Per Inch Of Draft*
	1,000	69,664	267
	806	34,720	146
	767	28,336	127
	635	22,064	107
	501	13,776	71

*Capacity per inch of draft reflects the incremental tonnage carried at normal loaded draft

Source: Lake Carriers' Association

Some recreational harbors are dredged by the federal government, but are given a low dredging priority and may have to be privately maintained. Scheduling of dredging work and budgeted costs are subject to change if low water requires emergency attention or extensive work.

The U.S. Army Corps of Engineers dredges channels to authorized project depths below low water datum. Corps dredging operations cannot go below these specified elevations. Thus, although drought impacts may be lessened by dredging of navigation channels, the effect is limited since the Corps is not authorized to dredge beyond certain depths.

Dredging of commercial harbors, canals, and navigation channels can remove a large volume of polluted sediments, although a small percentage may be resuspended. Disposal of this material can be difficult and expensive if it does not meet state and provincial environmental requirements for open water disposal. On-land or in-water confined disposal areas/facilities are not easily established or accessed (particularly under emergency conditions) and pose their own set of environmental concerns.

22. What are the main impacts of drought on the electric power generation industry?

One common problem for power companies during drought is meeting environmental standards for the discharge of cooling water from thermal generating facilities into rivers or lakes. Lower water levels during drought cause water temperatures to rise, thus reducing dissolved oxygen levels which can be hazardous to fish and other aquatic animals. For this reason, power company discharges are typically limited during drought conditions. The net result is that a power company may need to reduce its energy production, thereby limiting its revenues and possibly disrupting electricity supply.

Another consequence of drought is reduction of hydroelectric power generation in Great Lakes connecting channels and tributaries due to decreased streamflows.

Reduced power generation forces some utilities to satisfy demand by purchasing higher priced electricity from other suppliers, with increased costs usually passed on to consumers.

23. What are the main impacts of drought on fisheries, wildlife, and recreation?

Generally, low streamflows result in raised water temperatures, reduced dissolved oxygen content, and increased concentrations of pollutants, particularly sewage effluents. All of these factors are detrimental to the aquatic ecosystem, which in turn affects recreational activities such as fishing and boating. Some local economies are very dependent on recreation and thus can be seriously affected during drought.

Drought can alter wetlands, which provide habitat for waterfowl and other animals. For example, duck populations frequently decline for several years following a drought.

Wildlife can benefit in the short term if winter snowfall is light, providing species with more exposed vegetation to feed on and less severe wintering conditions. This situation can reverse itself in a short time, however, if populations grow too rapidly and increase the competition for food.

If drought lowers lake levels significantly, pleasure boats may not be able to access some marinas and harbors. Docking can also be a problem during periods of lowered lake levels. Docks may need to be extended or lowered. Ladders may also be required to get from existing docks to boat level. Continued exposure of the typically submerged portions of wooden docks can lead to dry rot and require extensive repair or replacement.

Applications for dredging permits typically rise during drought, and dredging can be costly for marina operators and local governments. Dredging also stirs up heavy metals and other pollutants in sediments. Wetlands are frequently selected as disposal sites for polluted dredged material, causing damage to wetland functions and fish and waterfowl habitat.

Drought accompanied by lower snowfall negatively affects the winter sports industry due to reduced downhill and cross country skiing and snowmobiling opportunities.

24. What are the main impacts of drought on forests?

Insufficient precipitation limits wood and fiber production until soil moisture content returns to normal. This reduces economic return when the forest is harvested. Insufficient precipitation can also stress certain tree species, making them more susceptible to pests and disease. Establishment and growth of recently planted seedlings is difficult during drought and, in severe situations, a high percentage of seedlings may not survive. Forest fires also increase during drought, causing loss of forest habitat, economic loss, increased fire-fighting costs, increased monitoring of forest conditions, and increased danger to inhabitants.

25. What are the main impacts of drought on residential shoreline property interests?

Shoreline property interests will generally benefit from lower lake levels due to drought. Shore erosion, particularly during storms, is reduced. Also, low lake levels may expose enough beach to enable on-shore winds to form dunes. These dunes can protect shoreline property during storms. Beach-goers often benefit because beaches on natural lakes become wider. Some reservoirs and man-made lakes, however, can be rendered unusable during periods of lower water levels.

26. What are the major impacts of drought on residents in general?

Beyond the impacts identified earlier, drought and the high temperatures that often accompany it can cause serious problems in both urban and rural areas. Homeowners may experience reductions in available water supplies, high costs for electrical power service due to increased use of air conditioning, and high food prices due to reduced crop yields. Landscaping (trees, bushes, and grass) may be badly damaged in droughts, particularly when home irrigation is limited by imposed conservation measures.

The prolonged economic effects of drought and uncertainty over drought duration can lead to considerable anxiety, particularly among farmers. (Anxiety workshops were conducted in Midwestern communities during the 1988 drought by agricultural cooperative extension offices.)

Above-normal summer temperatures are common with severe Midwestern droughts, and recent hot periods during droughts in the Great Lakes Basin (1980 and 1988) led to many heat-related deaths, particularly in urban areas. The establishment of "cool centers" within urban areas, as well as timely warnings of heat stress danger, can be of great benefit.

Chapter 4

HOW TO RESPOND TO DROUGHT

A. MONITORING AND DECLARING DROUGHT

1. How do each of the Great Lakes states/provinces monitor for drought, and where should a local official go for information on current drought conditions?

In each of the Great Lakes states and provinces, several different agencies (federal and state/provincial) are responsible for monitoring hydrologic factors (groundwater, streamflow, lake levels, precipitation, etc.) that indicate drought.

Hydrologic factors and the key agencies with primary monitoring and reporting responsibilities are:

Water levels	U.S. Army Corps of Engineers; Environment Canada
Precipitation and Temperature	NOAA-National Weather Service; Environment Canada
Streamflows	U.S. Geological Survey; Environment Canada
Groundwater	U.S. Geological Survey; Ontario Ministry of the Environment
Soil Moisture	USDA-Soil Conservation Service; NOAA-National Weather Service; Agriculture Canada

One agency typically serves as the main point of contact for information on current drought conditions in each Great Lakes state and province. (Please refer to Chapter 6, Category 1: *Information on Great Lakes Water Levels and Drought Conditions*, for the key agency to contact in your state/province.)

2. What type of monitoring should a local government or public water supplier perform?

Most local governments receive information on drought conditions from federal and state/provincial agencies. Some local governments are involved in testing wells and developing new water supplies and might be able to assist with groundwater monitoring activities as well.

If the appropriate data is not readily available from state/provincial agencies, public water suppliers should monitor their own sources of water (reservoirs, lake levels, streams, groundwater). Many state/provincial drought management plans recommend more frequent monitoring by public water suppliers as drought conditions move from one stage of severity to the next. In some instances, local governments may want to develop their own indices based on their sources.

3. How does each Great Lakes state/province declare that a drought has begun?

In the Great Lakes states, declaration of drought response or preparedness is usually made by the governor upon the recommendation of a drought task force, or is triggered in stages based on specific criteria adopted by the state.

In Ontario, there is no formal drought declaration procedure. According to need, local, provincial or federal agencies may declare and respond to a drought affecting their jurisdictions. (Please refer to Chapter 6, Category 2, *Drought Planning/Drought Task Force*, for information on the drought declaration process in your state/province.)

4. How do we know when a drought is over?

There is no universal indicator of the end of a drought, since different sectors respond differently. For example, the agricultural impacts of the 1988 drought ended in the Corn Belt with the harvest in September, but water supply problems continued through 1989 in many communities.

Heavy rainfall is obviously a good sign, but drought experts warn against assuming that drought is over simply because the "dry spell is over." From a meteorological perspective, a drought can be considered over only when monitoring of key hydrologic factors and drought indices shows improved conditions.

The definition and extent of drought are extremely important. Timing, location, geographic impact and "personal interpretation" all come into play. However, it can take society a long time to recover from the effects of drought on people, businesses, and natural resources. (Please refer to Chapter 6, Category 1, *Information on Great Lakes Water Levels and Drought Conditions*, for the key agency to contact in your state/province.)

B. FINANCIAL AND TECHNICAL ASSISTANCE

5. Are resources available to assist local governments or individuals during drought?

Yes. Federal, state, and provincial governments can provide financial, technical and educational assistance to communities. Generally, programs can be separated into two types: 1) assistance activated only when locations are declared national, state or provincial disaster areas, or 2) assistance generally available for existing or potential drought situations. (Descriptions of current federal, state and provincial programs are provided in Chapter 6.)

6. How can the effects of drought on various economic and environmental sectors be quantified?

The economic effects are usually quantified by industry experts, insurance industry representatives, or government agencies that estimate the direct costs (or losses) experienced during the drought. Costs to the shipping industry for example, might be calculated by comparing revenues during the drought to average revenues for the same period over the past several years taking into account the change in total cargo and cargo carrying capacity. Costs to a local government might include accessing alternate water supplies, purchase of energy from other utilities and loss in water-based tourism revenue. Useful information on the general magnitude of economic losses can be obtained from the news media which has access to most sources of reliable loss information.

The effect of drought on human welfare, natural resources and the environment cannot be estimated with great accuracy. Environmental damages often are delayed, with the effects to many plants and animals appearing months and years later. Some states quantify forestry losses by assigning a dollar value to a tree and multiplying by the estimated number of trees lost. It is difficult to assess public health costs associated with drought, although deaths due to heat stress associated with summer drought can be monitored easily.

C. EMERGENCY WATER SUPPLIES / WATER USE RESTRICTIONS

7. What authority does a local government have to impose water restrictions on residents or implement a water allocation plan?

Ordinances (or by-laws in Ontario) are the most common form of authority used by local governments to require citizens to restrict water use during drought. Some state agencies such as the Pennsylvania Department of Environmental Resources (PADER), provide model ordinances

and other forms of technical assistance to local governments (see Appendix 2). In Ontario, municipalities can restrict water use from a public supply but lack the authority to restrict private use. (Please refer to Chapter 6 for additional information on local ordinances for your jurisdiction.)

8. What authorities, guidelines, and restrictions should a local government be aware of when developing an emergency water supply?

States and provinces have regulations requiring any party planning to develop an emergency water supply (such as a new dam, well, or intake system) to obtain a permit from one or more agencies. Health departments commonly require a permit for a new drinking water supply. Most state/provincial environmental protection or natural resource agencies require permits for construction on state/provincial waterways. Some state/provincial water allocation programs require permits for water withdrawals greater than a certain daily volume. Under drought conditions, however, many of these agencies are given the authority to grant emergency permits immediately or within one to two days. (Please refer to Chapter 6, Category 4, *Emergency Water Supply*, and Category 5, *Water Rights/Permits/Restrictions*, for additional information for your jurisdiction.)

9. Can a state/province release water not allocated for public supply from state/provincial-owned lakes to provide emergency water supply for downstream municipalities?

Many state/provincial natural resource departments have the authority to release water from publicly owned lakes under conditions of extreme emergency. Some states/provinces also release emergency water because of regulations or legislation which require the agency to maintain a minimum flow (known as an instream flow requirement) to protect fish and wildlife. States and provinces can also request that water be released from a federally owned reservoir or other source. The federal agency has the authority to approve or disapprove the request. (Please refer to Chapter 6, Category 4, *Emergency Water Supply*, and Category 5, *Water Rights/Permits/Restrictions*, for additional information for your jurisdiction.)

10. How can a local government or private resident determine if there is sufficient groundwater in the area to drill a well for emergency supply?

The key state/provincial agency to contact for information on drought conditions has a groundwater unit that monitors groundwater during drought. This unit should be contacted if you are considering drilling a new well. In addition, many state/provincial health departments provide technical assistance for local governments wishing to develop a new water supply. (Please refer to Chapter 6, Category 1, *Great Lakes Water Levels & Drought Conditions*, or Category 4, *Emergency Water Supply*, for additional information for your jurisdiction.)

11. Can weather modification be used to increase water supplies in droughts?

Cloud seeding to increase rainfall has been undertaken on several occasions within the Basin over the past 20 years. Farm groups in Illinois (during 79-81) and in Ohio (during 1988) supported projects to increase rainfall during drought. Subsequent scientific analysis of certain projects revealed no hard evidence of increased or decreased rainfall as a result. The Illinois State Water Survey is conducting a major long-term experiment to determine if Midwestern rainfall can be increased and, if so, what the impacts are. Work to date indicates that local (multi-county) increases in rain would not affect rainfall downwind of these areas. Cloud seeding experiments in the 1960s along the lee shore of Lake Erie showed encouraging results regarding altering snowfall under certain weather conditions.

The future of cloud seeding projects in drought situations involves six key issues: 1) the scientific uncertainty of accomplishing an increase in precipitation; 2) a lack of suitable clouds in most drought periods; 3) the potential liability associated with claims of increased severe storms (or decreased precipitation) due to cloud seeding, a condition that requires sizable but available insurance coverage; 4) funding for the projects (federal, state, or private sources);

5) regulations to ensure use of credible scientific procedures and technical personnel (some states have laws regulating weather modification projects including Illinois, with a model law, Pennsylvania, and Wisconsin); and 6) evaluation procedures to determine whether precipitation patterns were altered.

The Illinois State Water Survey has a meteorological group with 30 years of expertise in all facets of weather modification, and can provide information on all aspects upon request.

How to save water

Use	Normal	Conservation
Shower	Water running 25 gallons	Wet down, soap up, rinse off 4 gallons
Brushing Teeth	Tap running 2 - 3 gallons	Wet brush, rinse briefly 1/2 gallon
Tub Bath	Full 36 gallons	Minimal water level 10 to 12 gallons
Shaving	Tap running 5 gallons	Fill basin 1 gallon
Dishwashing	Tap running 30 gallons	Wash and rinse in dishpans or sink 5 gallons
Automatic Dishwasher	Full cycle 16 gallons	Short cycle 7 gallons
Toilet Flushing	Depending on tank size 5 to 7 gallons	Using tank displacement bottle 4 to 6 gallons
Washing Machine	Full cycle, top water level 60 gallons	Short cycle, minimal water level 27 gallons
Outdoor Watering	Average hose 5-10 gallons per minute	Lowest priority Eliminate

Source: Western States Water Council

D. WATER CONSERVATION AND DEMAND MANAGEMENT

12. What is the difference between water conservation and demand management, and why is it important for local officials to consider both during drought?

Water conservation measures reduce the total amount of water used by a community. Ordinances requiring water-efficient plumbing fixtures, a leak detection program, or a pricing system that charges more for water as consumption increases, are examples of water conservation measures in use by local governments today.

Water conservation is important to consider during drought because it quickly reduces water demand, while imposing relatively low costs. Water conservation provides many benefits that are realized at all times, not just during drought: 1) it reduces water and sewer bills for households and businesses; 2) it may postpone or eliminate the need to build or expand supply systems to increase capacity; and 3) it can provide higher streamflows for fish and wildlife habitat, water quality, power generation, agriculture, transportation and recreation.

Why water conservation?

- Reducing water consumption may eliminate the need for your city to build an expensive new reservoir or deep well!
- The cost of energy used to pump water is the *fastest* rising expenditure in most water system budgets!
- In your household, about 20% of your energy costs go for heating water!
- Decreasing unnecessary water use can save you money in operating your water softener!
- Using water wisely means less water must be treated in your sewage system or septic tank!
- Reduced water use means water and sewage capacity without new construction! Wise water use is good for the system.
- Because it's easy to do! . . . *and* . . . it can save you money!

Source: Illinois Interagency Water Management/ Conservation Committee

During the drought of 1988, many municipalities temporarily reduced water use by up to 25% through voluntary conservation measures such as reduced lawn watering and car washing. A list of 12 water conservation measures is provided in Table 3.

One important water conservation measure is leak detection. For example, Illinois indicates that a community with a 3 million gallon per day water system and a 20% unaccounted-for flow will cut consumption by 360,000 gallons per day if it reduces the unaccounted-for flow rate to 8%.

Table 3
Local Strategies for Water Conservation

1. Reduce municipal water use
2. Meter all water uses
3. Adopt a pricing scheme to encourage conservation
4. Adopt water efficient plumbing and building codes
5. Find and repair leaks in distribution system
6. Organize a program to retrofit plumbing fixtures in older buildings
7. Adopt a water efficient landscaping ordinance
8. Adopt a groundwater protection ordinance
9. Reduce outdoor water use
10. Require water conservation by developers
11. Include conservation measures in forecasting future demand
12. Educate water users

Adapted from *A Citizen's Guide to Community Water Conservation*, National Wildlife Federation, 1989

At a purchase price of 89 cents/1000 gallons, this represents an annual savings of about $117,000. This should be more than adequate to run a leak detection and repair program.

Demand management involves the redistribution of total demand rather than the reduction of total use. An example is requiring homeowners to water their lawns during non-peak hours so more water is available for other more critical uses. By effectively redistributing total demand, a community will not experience the periods of critically high demand that can damage the water supply system and drastically reduce water pressure, vital for such services as fire-fighting.

13. What changes in urban and suburban landscaping should be encouraged to decrease overall water demand, especially during times of drought?

Many landscaping practices can help conserve water. Homeowners should consider the following:

1) install water-efficient sprinkling systems;

2) adjust sprinkling systems to water only the lawn and not the pavement;

3) convert lawns - replace with groundcover or tall grasses;

4) cultivate drought-resistant plants;

5) water before 9:00 am and after 6:00 pm, not in the heat of the day;

6) water only when needed;

7) mulch plants to retain moisture; and

8) encourage tree planting to provide shade.

14. What is the difference between water withdrawal and consumptive use?

A *water withdrawal* takes water from a river, lake or groundwater for domestic, commercial, industrial, or institutional purposes. The water may or may not be returned to its source after the withdrawal.

A *consumptive use* is that portion of a water withdrawal that is lost or otherwise not returned to its source, due to evaporation, incorporation into products, or other processes. Examples of activities with high consumptive use are agricultural irrigation, livestock watering, and some residential uses (e.g., drinking water).

15. As water withdrawals and consumptive uses increase with urban and industrial development, will the impacts of drought become more severe?

Yes. Developing municipalities place a higher demand on water resources. If public water supplies are not expanded (or if conservation/demand management measures are not instituted), the water distribution system will experience higher peak levels of demand. As a result, the impacts of drought could become more severe over time. For small communities or subdivisions relying on wells with limited aquifer systems, increased development can result in water well failure, especially during times of drought.

16. Where can a local official obtain educational or training materials to help the community respond to drought and increase public awareness of the problems associated with drought?

Water conservation brochures and other educational materials are available from the Great Lakes state and provincial governments. (Please refer to Chapter 6, Category 6, *Water Conservation/Public Education*, for information on your jurisdiction.)

E. WATER RIGHTS / WATER LAWS

17. What system of water rights is used in the Great Lakes states and provinces?

The water rights systems in all Great Lakes states and provinces follow the same general doctrine: the riparian doctrine of reasonable use. This doctrine provides owners of land adjacent to or containing surface or groundwater the right to make reasonable use of that water as long as it relates to some beneficial activity on the adjacent or overlying land. Water users must be cautious during drought periods, because activities which are normally considered reasonable, such as irrigation, may be considered unreasonable when streamflows or groundwater levels are low.

Minnesota, Wisconsin and Ontario require large water users to obtain water withdrawal permits. Of the Great Lakes states and provinces, only Minnesota has a formal system defining water use priorities. In practice, domestic use of water generally has the highest priority in all Great Lakes jurisdictions. Public water suppliers often have priority over individual users to serve public needs. Differences do exist between water rights systems in each state and province. (Please refer to the appropriate section of Chapter 6 for more information on your jurisdiction.)

18. How do water rights limit water withdrawals during a drought?

In jurisdictions which abide by the riparian reasonable use doctrine, water withdrawals must be reduced during times of drought in order for them to be considered reasonable. A user who believes that other users are withdrawing an unreasonable amount from surface or groundwater supplies can usually file a complaint with the state/provincial water resources management agency. Water users also might seek a legal remedy by suing another user in court.

Water rights, such as the riparian doctrine, are not changed or modified during drought conditions. Only the definition of what is considered to be a reasonable withdrawal will change. Key factors relate to the public interest and resource protection.

19. Can individuals or corporations who are not riparians make withdrawals from a river or lake (e.g., accessing the water from a bridge or other public structure)?

No. Under the riparian doctrine, non-riparians have no right to withdraw surface water from such sources. They do have the right to make reasonable withdrawals from groundwater resources located beneath their land, however.

20. Should drought management strategies be pursued on a watershed basis?

If possible, yes. The severity of a drought can vary significantly within a relatively small geographic area, and drought experts generally agree that drought management by watershed makes it easier to coordinate monitoring and assistance activities. For example, in 1987, Michigan's Great Lakes and Water Resources Planning Commission recommended that water resources in the Basin be managed on a watershed basis. Use of watersheds as drought management areas makes sense for two reasons: 1) they directly relate to the hydrologic characteristics of the area (rather than to political boundaries), and 2) they allow state/provincial and

local governments to focus resources and media attention on specific regions with the greatest need.

Several states use the climatological divisions of the National Weather Service or the USDA's Crop Reporting Districts for drought management areas. Other states, such as Oregon, define drought management areas based on watersheds.

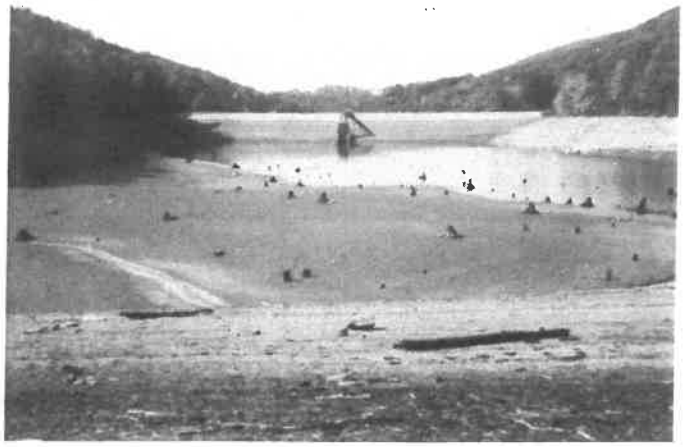
The formation of a standing "drought task force" for a watershed or region can be useful in developing and implementing contingency plans. Its members should include representatives from regional organizations, (e.g., watershed councils) key federal, state, provincial and local agencies and private interests, where appropriate.

Because watershed boundaries do not correspond to political boundaries, drought management efforts require the coordination of water use and planning activities of multiple local governments. Existing watershed councils can be of assistance through their established contacts with municipalities in the area. Members of watershed councils may be excellent candidates to serve on local drought task forces. Watershed councils can also play a key role in resolving water use conflicts by facilitating communication and negotiation between neighboring communities. They can also help communities adopt and implement water conservation measures within a watershed.

21. How can communities assess the damage done by a drought?

A first step in assessing damage involves the formation of a task force comprised of individuals representing sectors affected by drought.

Task force members can be organized into smaller working groups, each of which can identify drought-related impacts on a specific sector. Working group members should have the appropriate expertise to make reasonably accurate impact estimates. Key sectors to evaluate might include: public water supply, agriculture, commerce and tourism, wildlife, hydropower, transportation and shipping, coastal impacts, health, and wildfire protection.



Damage assessments can be useful planning tools, whether undertaken as an estimation of potential or actual drought damages.

F. EVALUATING DROUGHT IMPACTS AND RESPONSES

22. How can a community improve its drought management planning and response efforts?

A community should answer several important questions in the aftermath of a drought.

The following list was adapted from one developed by the Kentucky Department of Environmental Protection, Division of Water.

1) What unit of your agency was active in water shortage response? How was this decided?

2) What are the normal responsibilities of this section? Has water shortage response been incorporated into the operations of this unit?

3) How were upper level managers kept informed of drought-related activities? With what frequency?

4) What are the responsibilities of your agency in case of drought-related water shortages? What information or cooperation do you need from other agencies to carry them out? Was this communication and activity adequate during the drought? How could it be improved?

5) What other agencies did you report to during the drought? What media were used and with what frequency? Who was responsible (name and title)? Was the result satisfactory?

6) What other agencies reported to yours? What media were used by those agencies and with what frequency? Who was responsible (name and title)? Was the result satisfactory?

7) What contact did your agency have with the media? What was the purpose? Was the contact satisfactory, accurate, and realistic?

8) Were the actions taken by your agency effective in mitigating the impacts of drought? Which measures were effective and which were not? What activities could be added?

9) What financial and human resources were allocated to the relief effort? Where did the resources come from and how were they controlled? How much time and money were involved?

10) What were the impacts of drought, including costs, losses, and gains, in terms of dollars and/or the impact on the environment and resource base?

Chapter 5

PLANNING FOR DROUGHT

1. What is a drought management plan and why is it beneficial for a local or state / provincial government to have one?

A drought management plan outlines the actions that should be taken by citizens, industry, government, and others both in advance of and during drought to lessen some of the impacts and conflicts which can occur. The plan is a practical tool developed by state/provincial or local governments.

Before a plan can be developed and implemented, the jurisdiction or lead agency will need the necessary authority. This will usually be obtained through the legislative process. A drought management plan is best approached through existing state/provincial or local water resources planning and management agencies and should contain demand management and water conservation measures to ensure adequate supply even under drought conditions.

Over the past century, and especially during the past decade, governments have generally used a reactive "crisis management" approach in responding to drought. A drought management plan addresses this problem by coordinating the responses of different government agencies providing assistance in a more equitable and predictable manner. Many millions of dollars can ultimately be saved. Table 4 presents a model adapted from a ten-step process developed by Dr. Donald Wilhite, University of Nebraska. (Please refer to Appendix 1 for the complete reference of Dr. Wilhite's 1989 paper, *Planning for Drought: A Process for State Government.*)

Table 5 lists the state/provincial agencies responsible for drought planning and management in the Great Lakes Basin.

Table 4
Developing a Drought Management Plan

1) ***The city council, mayor, or county commissioners should appoint a local Drought Task Force (DTF).*** The DTF should include representatives from local government agencies, key water use sectors, and citizen, public interest, and environmental groups. A state/provincial DTF should have a Drought Advisory Committee (DAC) made up of representatives from key local drought task forces from around the state or province.
2) ***Develop a drought policy and specific objectives of the plan.*** Important objectives for local DTF's might include:
   a) To clearly define the geographic area to be addressed in the plan using a watershed basis where possible.
   b) To establish proper criteria to trigger the phase-in and phase-out of various local response actions.
   c) To provide an organizational structure that assures a smooth information flow between the local DTF, state/provincial agencies, and the media.
   d) To define the duties of local agencies and other organizations in responding to drought.
   e) To provide a mechanism to perform timely and accurate assessments of drought impact on various economic and environmental sectors.
   f) To provide a coordinated strategy for the equitable allocation of water during shortages and the expansion of water conservation efforts in the community.
3) ***Avoid and resolve conflicts between competing water users*** by obtaining input from citizen, public interest, and environmental groups. Two-way communication between local citizens and policy makers during the planning process lends credibility and support to future drought planning and response actions.
4) ***Conduct an inventory of natural and human resources, and of financial and legal constraints.***
   a) Natural resources- Determine the location, quantity available, and quality of current and alternative local water supplies.
   b) Human resources- Identify agencies and organizations with personnel that can access water sources, lay pipeline, haul water and hay, and generally provide assistance to citizens.
   c) Financial constraints- Identify costs of activities mentioned above.
   d) Legal constraints- Identify water rights of large local users. Review state statutes requiring such things as public water supplier contingency plans and local water conservation ordinances.
5) ***Develop the actual drought plan.*** Establish specific functions and procedures of the local DTF. At a minimum, key functions should include:
   a) Develop trigger levels and associated response activities for progressive stages of drought severity.
   b) Facilitate open communication with state agencies to obtain updated information on drought conditions and to notify them of local drought impacts.
   c) Perform impact assessments.
   d) Coordinate local response activities such as development of emergency water and hay supplies and implementation of water conservation measures.
   e) Request assistance from the state or province when needed.
6) ***Identify and eliminate information and communication gaps*** within communities as well as between communities, and state/provincial agencies.
7) ***Implement the drought plan.*** The local governing body should formally adopt the plan in the form of an ordinance. Implementation should occur promptly and should not wait for the peak drought period. The plan should be publicly announced and publicized through the local media.
8) ***Develop educational and training programs.*** Programs should be aimed at educating the media, the general public, and local industry. These programs should be long-term and directed at all age groups and water use sectors. Special assistance should be provided to large water users as water contingency plans are developed.
9) ***Develop system evaluation procedures.*** Evaluation procedures should be developed for post-drought periods and for periodic review during non-drought periods. The evaluation should be performed by an unbiased group (university, consulting firm) representing several different disciplines. It should not be performed by the DTF.

Post-drought review should evaluate the effectiveness of local actions taken and the adequacy of assistance provided to the community from state/provincial and federal agencies. Comments, complaints, and recommendations should be communicated to the state/provincial agencies. Periodic review should be performed every two or three years to see if changes are needed in public water supply trigger levels or response actions due to changes in local population or water demand.

Adapted from *Planning for Drought: a Process for State Government,* by Dr. Donald Wilhite

Table 5
Key State/Provincial Agencies Responsible for Drought Planning, and Corresponding Publications

Illinois	*Key agency:*	Department of Transportation, Division of Water Resources.
	Publication:	Drought Contingency Planning: A Special Report of the Illinois State Water Plan Task Force. June 1983.
Indiana	*Key agency:*	Indiana Dept of Natural Resources; Division of Water.
	Publication:	Indiana Drought Advisory Committee Report. September 1988.
Michigan	*Key agency:*	Department of Natural Resources, Office of Water Resources.
	Publication:	Drought Response Plan. July 1988.
Minnesota	*Key agency:*	Department of Natural Resources, Division of Waters.
	Publication:	Drought Contingency Plan for the Mississippi River (Focus is on public water supply for Minneapolis/St. Paul). 1989.
New York	*Key agency:*	New York State Department of Environmental Conservation.
	Publication:	New York State Drought Plan. December 1988.
Ohio	*Key agency:*	Ohio Emergency Management Agency.
	Publication:	Drought Response Plan. April 1989.
Ontario	*Key agency:*	Ontario - Ministry of the Environment.
	Publication:	Water Management: Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. May 1989.
Pennsylvania	*Key agency:*	Department of Environmental Resources, Bureau of Water Resources Management.
	Publication:	Drought Contingency Plan for the Delaware River Basin. March 1985.
Wisconsin	*Key agency:*	Wisconsin Department of Natural Resources.
	Publication:	Drought and Emergency Water Allocation Strategy; Final Draft , September 1989.

Note: State/provincial planning does not replace the need for local planning.

2. What obstacles should be anticipated in developing a drought management plan and how can they be overcome?

Key obstacles include 1) an inadequate understanding of drought by policymakers and government officials; 2) uncertainty about the economic benefits of drought planning versus the costs of drought; 3) apathy during non-drought years; 4) failure to include all key players in the planning process; and 5) uncertainty about local government authority to adopt and implement a plan. Drought has traditionally been perceived as an extreme event; a quirk of nature. It must be understood, however, that drought is a normal part of the North American climate and, as such, will inevitably recur in a periodic yet unpredictable manner.

Drought planning can be difficult because the process requires an investment of financial and human resources. Policymakers need to understand, however, the potential magnitude of drought impacts and the consequences of inaction. Beyond costs to residents and water dependent industries, impacts on the environment add to the total costs resulting from drought.

3. What are the most effective ways to increase public awareness of drought problems and the importance of water conservation activities before, during, and after a drought?

Water conservation programs are most successful when designed as long-term programs. Effective ways to increase public awareness include:

1) Media sources (newspapers, television, radio, magazines);

2) Formal education programs (local school systems);

Table 6
Local Successes in Water Conservation

San Jose, California adopted an ambitious conservation program to reduce wastewater flow and defer a $180 million wastewater treatment plant expansion by four years or more. Door to door delivery of a three-part residential conservation kit (toilet dam, showerhead, and leak detection tablets) to 210,000 households, along with installation of this kit on request, dropped water use in those neighborhoods by over 10%, and saved 11.5 gallons per person daily in participating households. (Source: National Wildlife Federation)

Quakertown Borough in Bucks County, Pennsylvania is a good example of the successful development and implementation of a water conservation ordinance. The Borough experienced problems obtaining enough water from its wells in 1980. With technical assistance from the Pennsylvania Department of Environmental Resources, the Borough developed a water conservation ordinance and adopted it in August 1981. The new law specified the installation of water efficient plumbing fixtures in all new building construction and remodeling. Enforcement was not a problem because permits and final building inspections are required for new construction and renovations. The water shortage situation and reasons for implementing the new ordinance were widely publicized through news releases, informational brochures, local displays of water conserving equipment, and advertisements of new product lines in hardware and plumbing supply stores. (Source: Pennsylvania Department of Environmental Resources)

3) Adult and public education programs (lectures and publications); and

4) Municipality and public water supplier involvement (informational brochures, different pricing structures, more frequent billings).

See Table 6 for two local water conservation success stories.

4. Should drought contingency plans be developed by local governments?

Local government involvement ensures that contingency plans are responsive to local needs and involve local units of government and water use sectors in development and implementation. Plans at the state/provincial level are important but cannot provide the specificity needed to address unique local situations. An example of a comprehensive planning process that involves both local and state agencies is Pennsylvania's Drought Contingency Plan for the Delaware River Basin. The plan requires municipalities and public water suppliers to develop local drought contingency plans. Technical assistance and model drought contingency plans are provided to local governments by the Conservation/Technical Assistance Section of the Pennsylvania Department of Environmental Resources.

These local contingency plans are to be based on drought indicator trigger levels which identify the onset of drought but do not trigger actions so prematurely or frequently that the public disregards them. Drought trigger levels are tailored to each individual water supply system and set by water supply managers. (See Table 7 for a list of questions local water managers can use to help them determine drought trigger levels.) Drought responses to each successive stage of drought severity (Pennsylvania recommends three stages) are to be included in the contingency plan. The Pennsylvania plan was developed in 1983-1984 and successfully implemented at state and local levels during drought conditions in 1985. (See Appendix 2 for a copy of Pennsylvania's model Local Drought Contingency Plan.)

5. Have regional approaches to drought planning and management been developed?

Yes. A good example of regional drought planning is found in the efforts of the Western States Water Council (WSWC); a regional organization that assists Western governors in developing consensus on water policy and planning initiatives.

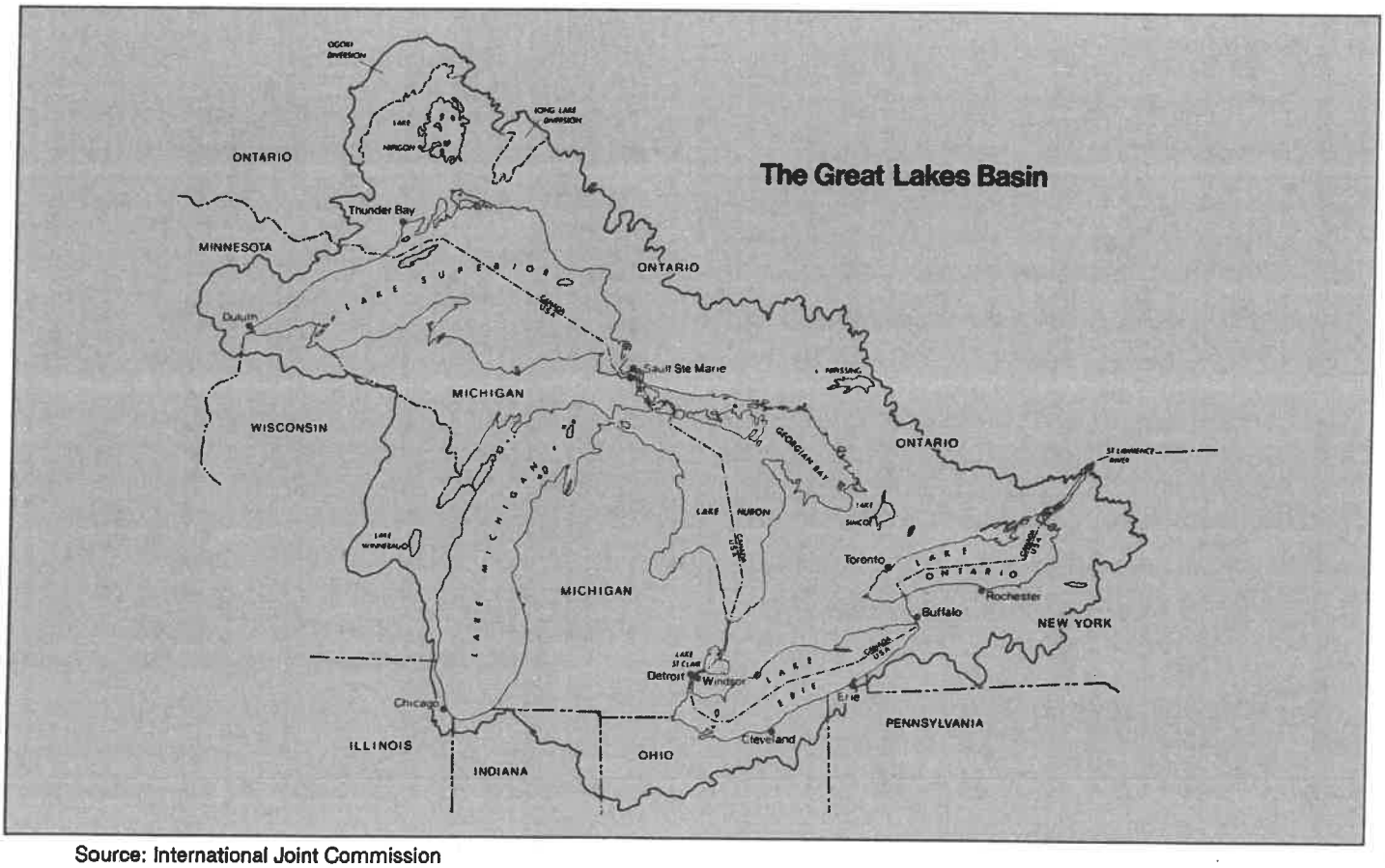
During the 1976-77 drought, western governors designated the WSWC as the lead agency for regional drought policy and program development activities. The WSWC served as a clearinghouse for information on drought conditions, state drought-related mitigation and water conservation efforts, and federal assistance programs. The WSWC also provided the core staff for the Western Regional Drought Action Task Force which eventually included 21 states. Each state named state drought coordinators,

Table 7
Ten Questions To Help Local Water Managers Set Drought Trigger Levels

1) What local water supplies are currently available?
2) Has a complete inventory of these supplies been taken recently?
3) What alternate water supplies can be utilized during a drought?
4) What are the water use needs of both urban and rural users?
5) How vulnerable are water supplies to drought impacts?
6) How vulnerable are water supplies to contamination that may render them useless?
7) Have potential reservoir sites been identified from soils data, geographic information, and geologic data?
8) Has a strategy been developed to implement these sites?
9) What is the threshold level of the water supply/use ratio at which mandatory water use restrictions should be implemented?
10) Has a local information/education network been established to disseminate current data on drought conditions and needed actions?

Adapted from *Planning for Drought: a Process for State Government*, by Dr. Donald Wilhite

and a representative from the Task Force was assigned to Washington, D.C. to work closely with a White House drought coordinator. In October 1987, the WSWC released *A Model for Western State Drought Response and Planning*. This report has provided western states with a general framework to use when tailoring a drought management plan to their specific needs. For more information, contact: *Western States Water Council, Creekview Plaza, Suite A- 201, 942 East 7145 South, Midvale, Utah 84047, (801) 561-5300.* Multi-state (and state-provincial) planning agencies and institutional arrangements exist throughout North America and many are capable of providing these types of services.



Source: International Joint Commission

Chapter 6

WHERE TO OBTAIN HELP: DROUGHT INFORMATION, ASSISTANCE, AND RESPONSE PROGRAMS

This chapter outlines federal, state and provincial programs providing drought assistance, water levels and emergency response information.

Federal program information for both the United States and Canada is summarized by agency in alphabetical order.

Information for each state and provincial jurisdiction is organized under the following categories:

1) Great Lakes Water Levels and Drought Conditions
2) Drought Planning/Drought Task Force
3) Financial and Technical Assistance
4) Emergency Water Supply
5) Water Rights/Permits/Restrictions
6) Water Conservation/Public Education
7) Key Agencies (addresses and phone numbers of contacts providing information in Categories One through Six)

To use this system, the reader should first locate the jurisdiction of interest (e.g., Illinois) and then the appropriate category (e.g., Financial Assistance) within that section. Note: Information for this chapter was provided by state, provincial and federal task force members or contacts; descriptions will vary in level of detail.

A. FEDERAL ASSISTANCE PROGRAMS — UNITED STATES

U.S. Department of Agriculture (USDA)
Office of the Secretary
Washington, D.C. 20250
(202) 447-3631

The USDA produces a publication, "Natural Disaster Assistance Available From the U.S. Department of Agriculture", that presents the various programs available to farmers under different drought scenarios. Specific information on assistance programs is provided by the following USDA branch services:

USDA - Soil Conservation Service (SCS)
1405 S. Harrison Road, Room 101
East Lansing, MI 48823
(517) 337-6702

The Michigan office of the SCS is the designated office for coordination of Great Lakes activities. All SCS offices provide technical assistance on soil and water conservation issues, and offer expertise to assist in:

1) protecting surface reservoirs and streams from excessive sedimentation;
2) increasing available supplies of water through pond and impoundment construction;
3) establishing irrigation schedules for users; and
4) implementing ASCS financial assistance programs for landowners.

For further information contact the SCS District Office listed in the telephone directory under "Federal Government, U.S. Department of Agriculture", or the appropriate state office:

Illinois	(217) 398-5267
Indiana	(317) 290-3200
Minnesota	(612) 290-3675
New York	(315) 423-5521
Ohio	(614) 469-6962
Pennsylvania	(717) 792-2202
Wisconsin	(608) 264-5577

USDA - Agricultural Stabilization and Conservation Service (ASCS)
1405 S. Harrison Road, Room 116
East Lansing, MI 48823
(517) 337-6659

Services include the Emergency Feed Program, Emergency Feed Assistance Program, Haying and Grazing Program, and others. Each county has an ASCS office.

In the event of a drought, farmers should contact the local ASCS office to request implementation of USDA emergency assistance programs. Programs are also initiated in response to re-

quests from Congressional or Senate offices. The Secretary of Agriculture triggers certain programs as well.

For further information contact the ASCS District Office listed in the telephone directory under "Federal Government, U.S. Department of Agriculture", or the appropriate state office:

Illinois	(217) 492-4180
Indiana	(317) 290-3030
Minnesota	(612) 290-3651
New York	(315) 423-5176
Ohio	(614) 469-6735
Pennsylvania	(717) 782-4547
Wisconsin	(608) 264-5301

USDA - Farmers Home Administration (FmHA)
U.S. Department of Agriculture
Washington, D.C. 20250
(202) 447-4323

Drought assistance programs include the Emergency Loan Program, Business and Industry Loans, Farm Operating Loans, Farm Ownership Loans, and Soil and Water Loans. Information is available from county and state FmHA offices.

For further information contact: FmHA local or state offices listed in telephone directories under "Federal Government, U.S. Department of Agriculture".

U.S. Army Corps of Engineers (COE)
North Central Division
536 S. Clark Street
Chicago, IL 60605
(312) 353-6310

The COE generates substantial data on Great Lakes water levels and flows, and produces several publications of interest to officials involved in drought planning:

1) "Monthly Bulletin of Lake Levels for the Great Lakes," a representation of historical Great Lakes water levels for the previous year and current year to date, and a forecast for the next six months.

2) "Weekly Great Lakes Water Level Record," a summary of present water levels and a forecast one month into the future.

3) "Great Lakes and Connecting Channels Water Levels and Depths," a biweekly publication for navigation purposes that provides the depths of the Great Lakes, connecting channels, and St. Lawrence River.

The COE also has authority to construct wells and transport water in areas determined by the Chief of Engineers to be drought distressed. COE assistance requires a written request, and all other reasonable means of securing water supplies must have been exhausted. Communities should contact the appropriate state agency, which will in turn arrange for COE assistance (see address above).

Local governments can receive water level and other COE information by contacting the appropriate district office:

Buffalo District	
New York, Pennsylvania, Ohio	(716) 879-2200
Chicago District	
Illinois	(312) 353-6400
Detroit District	
Indiana, Michigan	(313) 226-6762
St. Paul District	
Minnesota, Wisconsin	(612) 220-0300

U.S. Department of Commerce
National Oceanic and Atmospheric Administration (NOAA)
National Ocean Service (NOS)
Office of Public Affairs
Rockwall Bldg., Room 108
11400 Rockville Pike
Rockville, MD 20852
(301) 443-8279

The National Ocean Service is the primary source of information on Great Lakes water levels. The NOS provides this information through two key publications:

1) *Monthly Summary of Great Lakes Water Levels*

2) *Annual Report of Great Lakes Water Levels*

NOAA - Great Lakes Environmental Research Laboratory (GLERL)
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-1593
(313) 668-2235

GLERL conducts research and system-wide modeling of basin runoff, lake evaporation, net basin water supplies, lake levels, and connecting channel flows. System-wide simulations can assist planners and managers in developing and assessing different strategies for coping with climatic extremes.

NOAA - National Weather Service (NWS)
Office of Public Affairs
Grammax Bldg, Room 401
8060 13th Street
Silver Springs, MD 29010
(301) 427-7243

The NWS collects detailed information on precipitation and temperature throughout the United States. The NWS also provides daily weather forecasts, monthly outlooks, and 3-month outlooks. There are NWS monitoring sites in each state. The Climate Analysis Center of the NWS produces the "Weekly Climate Bulletin" which concisely indicates current surface climatic conditions in the United States and around the world.

NOAA - National Climate Program Office (NCPO)
Regional Climate Centers

Midwestern Climate Center
2204 Griffith Drive
Champaign, Illinois 61820
(217) 244-8226

Northeast Regional Climate Center
Atmospheric Science Unit
Box 21, Bradfield Hall
Cornell University
Ithaca, New York 14853
(607) 255-1751

Regional Climate Centers in the Great Lakes Basin offer sources of climate and drought information. The Midwestern Climate Center in Illinois is responsible for information for Minnesota, Michigan, Illinois, Indiana, Ohio, and Wisconsin. The Northeast Regional Climate Center in New York is responsible for data and information for Pennsylvania and New York. These two centers monitor drought using special regional indices, and have updated (daily) drought information on computer-based systems that can be easily accessed by personal computers or telephone.

Federal Emergency Management Agency (FEMA)
Office of Public Affairs
500 C St., S.W.
Washington, D.C. 20472
(202) 646-4600

Assistance is available to a state only if a Presidential Disaster Declaration is made. Declaration is made after the governor of the state makes a formal request to the President, demonstrating that state emergency assistance resources have been exhausted. It is very difficult to obtain a declaration (no declarations were made for any state during the 1988 drought).

If a declaration is made, however, those seeking assistance should contact the local FEMA Disaster Assistance Center. Programs that might be available are SBA loans for individuals, Individual Family Grants, and Public Assistance Loans for damage of public facilities.

Following are the phone numbers for the FEMA regional offices in the Great Lakes:

Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin	(312) 886-7248
New York	(212) 264-4699
Pennsylvania	(215) 597-1410

Small Business Administration (SBA)
1441 L St., N.W.
Washington, D.C. 20416
(202) 653-6879

The SBA definition of "disaster" includes only sudden, short-term events such as floods and tornadoes. Drought is not generally included under the SBA activities. SBA assistance is provided to victims of drought only when the Secretary of Agriculture declares a state, portions of a state or a county to be a disaster area.

If such a disaster declaration is made, the Economic Injury Disaster Loan Program becomes available to small businesses and agricultural cooperatives that depend on other agriculture related businesses for their livelihood. The filing period expires eight months after the date of disaster declaration. Loans are for working capital only; the interest rate is 4%, and the maximum loan is $500,000. Disaster assistance staff travels a circuit through drought-affected areas to provide assistance to local communities.

For further information contact:

Disaster Area 1:	
New York	1-800-221-2091
Disaster Area 2:	
All other Great Lakes States	1-800-334-0309

B. FEDERAL ASSISTANCE PROGRAMS — CANADA

Agriculture Canada
Canadian Crop Drought Assistance Program
Policy Branch
Sir John Carling Building
930 Carling Avenue
Ottawa, ONT K1A 1J3
(613) 995-5880

Agriculture Canada administers a program of transfer payments and subsidies to help farmers affected by droughts. Under the Canadian Crop Drought Assistance Program (CCDAP), benefits are provided over and above funds received through crop insurance and are paid at the same level to both insured and uninsured producers. For the drought of 1988, the federal government worked closely with the Ontario Ministry of Agriculture and Food to develop yield loss data and define payment rates for each drought area in Ontario.

Emergency Preparedness Canada
Regional Director
Ontario Region
20 Holly Street, Ste. 205
Toronto, ONT M4S 3B1
(416) 973-6343

Under the Disaster Financial Assistance arrangements with the provinces, Emergency Preparedness Canada administers a financial assistance program when the cost of dealing with a disaster places an undue burden on the provincial economy.

Environment Canada
Atmospheric Environment Service (AES)
Canadian Climate Centre
Hydrometerology and Marine Division
4905 Dufferin St.
Downsview, ONT M4H 5T4
(416) 739-4343

Environment Canada
Atmospheric Environment Service (AES)
Ontario Region
25 St. Clair Avenue East, Room 301
Toronto, Ontario M4T 1M2
(416) 973-5554

The AES collects and disseminates information on weather and climate in Canada and coordinates the climate change-related research efforts of government, academic, and private sectors under the Canadian Climate Program. Monitoring activities also include air quality, lake temperature and soil moisture status. Modeling activities include climate, air quality, lake levels storm surges and lake evaporation. Also, several studies have investigated the potential impacts of global warming on various regions of Canada, including the Great Lakes.

Environment Canada
Conservation and Protection Service
Water Planning and Management Branch
P.O. Box 5050
867 Lakeshore Road
Burlington, ONT L7R 4A6
(416) 336-4712

The Water Planning and Management Branch provides technical support to the International Joint Commission (IJC) in operations and research related to the regulation of the outflows of Lakes Superior and Ontario. It also issues a monthly forecast of Great Lakes water levels for the next six months. These forecasts are published in the "Monthly Bulletin of Lake Levels for the Great Lakes".

Environment Canada
Great Lakes Water Level Communications Centre
P.O. Box 5050
867 Lakeshore Road
Burlington, ONT L7R 4A6
(416) 336-4581

The Great Lakes Water Levels Communications Centre was established by Environment Canada to provide the public with a federal focal point for information and warnings about Great Lakes water levels and the approach of severe storms which could result in flood and erosion damages.

Environment Canada
Water Survey of Canada
75 Farquhar Street
Guelph, ONT N1H 3N4
(519) 821-0110

The Water Survey of Canada operates and maintains a network of streamflow, water level and sediment stations throughout Ontario and the Great Lakes system, jointly funded with the Province of Ontario. It also publishes annual summaries of the data collected.

C. STATE AND PROVINCIAL PROGRAMS

Illinois

1. Great Lakes Water Levels and Drought Conditions

Great Lakes Water Levels. Information is available from the Illinois Department of Transportation (IDOT), Division of Water Resources; and the Illinois Department of Energy and Natural Resources (IDENR), Geological Survey Division.

Hydrologic Factors. The State Water Survey Division of IDENR is the main source of information on water resources in the state. The IDENR publishes the "Water and Climate Summary" monthly, which contains information on precipitation, streamflows, reservoir and lake levels, soil moisture, and groundwater levels.

Agricultural Information. The Illinois Department of Agriculture (IDA), Natural Resources Division publishes a weekly crop report that includes the condition of crops during the growing season and the status of soil moisture.

2. Drought Planning/Drought Task Force

Drought Task Force. The Illinois Drought Task Force is co-chaired by the Director of the Division of Water Resources (IDOT) and the Manager of the Public Water Supply Section, Illinois Environmental Protection Agency (IEPA). Other representatives on the Task Force are from the Department of Agriculture; Department of Commerce and Community Affairs (DCCA); Emergency Services and Disaster Agency (ESDA); Department of Energy and Natural Resources, State Water Survey (DENR/SWS); and Department of Conservation (DOC), Resource Management Division.

The Task Force issues public notices on drought conditions, coordinates drought response activities, and recommends a disaster declaration to the governor if conditions become serious enough.

3. Financial and Technical Assistance

Emergency Services and Disaster Agency (ESDA). ESDA is concerned with the emergency and short-term effects of natural disasters, including drought. It coordinates responses to drought from all state agencies. In addition, ESDA serves as the state coordinator for all federal disaster assistance programs. There are more than 500 local ESDA units.

State Disaster Relief Fund. This program is available once a disaster declaration is made by the governor. The Fund is administered by the ESDA. The state legislature generally appropriates $500,000 to the Fund annually.

Community Development and Assistance Program. This program, administered by DCCA, provides grants for the improvement of public facilities, including emergency water supplies. For example, a community used a 1988 grant of $225,000 to redrill wells and reset pumps in an area of high irrigation pumpage.

Water Conservation Ordinances. Technical assistance is provided by IDOT and DCCA. (See the section below on Water Conservation/Public Education.)

Technical Assistance for Public Water Suppliers. IEPA provides assistance to local governments and public water suppliers to ensure that they have adequate supplies to maintain public health and safety during drought periods.

4. Emergency Water Supply

Water Supply Augmentation. Sources can include emergency dams, temporary pipelines to gravel pits, quarries and reservoirs, new wells, redevelopment of abandoned wells, water hauling, and emergency interconnections with other supplies. Emergency permits required from the state can be expedited. All water delivered for public consumption must meet drinking water quality standards.

Emergency Releases from State-Owned Lakes. Illinois does not generally release water from state-owned lakes. The DOC does, however, have emergency use guidelines which specify minimum lake levels below which emergency withdrawals would not be allowed.

Equipment. The ESDA has emergency pumping and piping equipment, chlorination equipment, water tankers, and National Guard equipment available for distribution in Illinois where needed to tap into alternate water supplies during emergencies.

5. Water Rights/Permits/Restrictions

Well Interference Complaints. In certain areas of the state, well owners can file a complaint against another well owner with the Soil and Water Conservation District. The complaint is forwarded to the IDENR Water Survey Division, which conducts a field investigation. If a well is found to be affected by withdrawals from a high capacity well, the IDA Natural Resources Division has the authority to decrease pumpage from the offending well.

Water Use Restrictions. Local governments in Illinois which own and operate a water distribution systes have broad authority to impose water use restrictions. (See discussion of water conservation ordinances in the next section Water Conservation/Public Education.)

Water Withdrawal Permits. A permit from the IDOT Division of Water Resources is required for construction of any water withdrawal facility. In such a permit, IDOT can require that withdrawals be reduced during periods of low flow.

Lake Michigan Allocation Permits. The IDOT, Division of Water Resources administers a permit program for allocating the state's limited supply of Lake Michigan water, as allowed under a 1967 U.S. Supreme Court ruling.

Water Rights. Illinois' system of water rights is a unified system for all ground and surface waters based on the riparian doctrine of reasonable use. Illinois water law is unique in that it applies the surface water riparian doctrine of reasonable use to both ground and surface waters. The riparian doctrine of reasonable use states that a landowner has the right to make use of water to meet "natural wants" and to meet a fair share of "artificial wants". Wasteful or malicious uses are not considered reasonable.

"Natural wants" are limited to domestic uses of water that are essential for survival. They include drinking, cooking, bathing, cleaning, sanitation, watering of a garden for food, and water for livestock (excluding commercial herds).

"Artificial wants" include water for commercial purposes, such as irrigation, manufacturing, and power generation. Any artificial use of water made where all natural uses have not first been satisfied is an unreasonable use.

Although Illinois does not have an established water use priority system, in practice, domestic household supply has the highest priority during times of shortage. The governor can, if necessary, invoke extraordinary powers to limit withdrawals by public and private water users under the Emergency Services and Disaster Agency Act of 1975.

Under Illinois law, most riparian owners cannot sell or transport water for use off the owner's property. Only with statutory authority can water be sold to others or transported off the property. Such authority is granted to numerous water utilities, municipalities, conservancy districts, and water authorities. These water utilities also have the power of condemnation over local groundwater users who are affected unreasonably.

6. Water Conservation/Public Education

Materials and Workshops. DCCA provides materials on drought management and water conservation. It also provides workshops for local officials on drought management and on developing water conservation ordinances. During times of drought, local officials can also obtain this information by contacting the Drought Task Force directly.

Outside Water Use Ordinance for Communities. All communities in Illinois that rely on Lake Michigan for their water supply (and therefore have a Lake Michigan Water Allocation Permit) are now required to adopt an outside water use ordinance. Ordinances will be reviewed by the IDOT Division of Water Resources. The ordinance must provide, at a minimum, that unrestricted lawn sprinkling will not be allowed from May 15 through September 15 each year. The IDOT Division of Water Resources also recommends that the ordinance limit the frequency of lawn sprinkling to every other day, prohibit sprinkling from noon to 6 pm, and ban all outside water uses in the event of an emergency water shortage.

Modification of Local Plumbing Codes/Ordinances. All communities that receive a Lake

Michigan Water Allocation Permit must modify their local plumbing code or ordinances to require that:

1) all new water services be metered;
2) all existing unmetered services be metered as a part of any major remodeling;
3) all new or replaced fixtures must meet efficiency standards (3.0-3.5 gallons per flush, or 3.0 gallons per minute);
4) all new or replaced water cooled air conditioning equipment be a closed system type;
5) all lavatories for public use be equipped with metering or self-closing faucets; and
6) all new or remodeled car wash installations be equipped with a water recycling system.

Water System Management and Leakage Control Standards. The IDOT Division of Water Resources has developed standards for leakage and unaccounted-for flow in municipal water systems. IDOT allows an unaccounted-for flow of up to 8%. Communities which exceed an unaccounted-for flow of 12% are required to participate in enforcement hearings where they will report on a plan of action and schedule to comply with the Department's standard of 8%. Leak detection and repair programs are highly recommended because they can basically finance themselves.

7. Key Agencies

Illinois Department of Transportation
Division of Water Resources
Lake Michigan Management Section
310 S. Michigan Ave., Rm. 1606
Chicago, IL 60614
Phone:(312) 793-3123
FAX:(312) 793-3434

Illinois Department of Energy and Natural Resources
State Water Survey Division
Support Services Unit
2204 Griffith Drive
Champaign, IL 61820
(217) 333-2210

Illinois Dept. of Agriculture
Natural Resources Division
State Fairgrounds
P.O. Box 19281
Springfield, IL 62794
(217) 782-6271

Illinois Environmental Protection Agency
Public Water Supply Section
2200 Churchill Rd.
Springfield, IL 62708
(217) 785-8653

Illinois Dept. of Commerce and Community Affairs
620 E. Adams
Springfield, IL 62701
(217) 785-6079

Illinois Dept. of Conservation
Resource Management Division
600 N. Grand W.
Springfield, IL 62701
(217) 785-8285

Illinois Emergency Services and Disaster Agency
110 E. Adams St.
Springfield, IL 62706
(217) 785-8626

Illinois Department of Energy and Natural Resources
Geological Survey Division
Natural Resources Building
615 E. Peabody Drive
Champaign, IL 61820
Phone:(217) 333-4747
FAX:(217) 244-7004

Indiana

1. Great Lakes Water Levels and Drought Conditions

Lake Levels. Information on Great Lakes levels is available from the Indiana Department of Natural Resources (IDNR), Division of Water.

Hydrologic Data. Information on drought conditions (precipitation, streamflows, groundwater levels) is available from IDNR.

Monthly Bulletin. The IDNR Division of Water publishes "Water Line", a monthly summary of lake level and hydrologic information.

2. Drought Planning/Drought Task Force

Drought "Trigger" Levels. Criteria for drought response trigger levels are being developed by Purdue University under contract to IDNR. For more information contact the IDNR Division of Water.

3. Financial and Technical Assistance

Model Water Conservation Ordinance. Available from the Indiana Department of Environ-

mental Management (IDEM) for local governments. (See the section below on Water Conservation/Public Education.)

Assistance for NPDES Permit Holders. The IDEM Office of Water Management provides technical assistance to all holders of National Pollutant Discharge Elimination System (NPDES) permits in order to maintain water quality standards during periods of low streamflows.

4. Emergency Water Supply

Releases from Reservoirs and Lakes. Indiana owns water supply storage in Brookville, Patoka, and Monroe Reservoirs. The IDNR has indicated that the uncontracted water supply could be made available for allocation if the need arises. If needed, IDNR would also seek approval to release water from several flood control reservoirs managed by the U.S. Army Corps of Engineers. There are hundreds of natural lakes in the northern part of the state that could serve as another source of raw water in an emergency.

Army and Air National Guard. If ordered by the governor, these organizations can transport water and provide water storage in the event of an emergency. An inventory of sites and storage capacity has been taken.

Department of Civil Defense. Provides assistance with emergency operations planning, training, and damage assessment.

Indiana Code. Gives the Utility Regulatory Commission the authority to substantially curtail water usage and to alter water rates in times of emergency.

5. Water Rights/Permits/Restrictions

Ground and Surface Water Withdrawal Registration. Required for all users having withdrawal capacity (not actual use) greater than 100,000 gallons per day. These users report monthly and annually to the IDNR Division of Water. During dry periods, high-capacity users in areas where ground and/or surface water declines are most severe are alerted.

Ground And Surface Water Withdrawal Complaints

Groundwater withdrawal complaints. If a small well is affected by the groundwater withdrawals of a high capacity facility, IDNR can require the owner of the high capacity facility to repair or replace the affected wells. If the high capacity user does not comply, or if continued groundwater withdrawals would exceed the recharge capability of the aquifer system, IDNR can restrict pumpage by the high capacity withdrawal facilities.

Surface water withdrawal complaints. In most cases, IDNR lacks authority to arbitrate disputes over surface water withdrawals.

Indiana Code. The Indiana Civil Defense and Disaster Law gives the governor broad authority to implement any measures necessary to deal with a drought emergency.

6. Water Conservation/Public Education

Model Water Conservation Ordinance. Developed in 1988, this ordinance was developed to assists public water suppliers and municipalities in addressing drought situations. The ordinance establishes three levels of water conservation measures: voluntary conservation, mandatory conservation, and rationing. Each successive measure is applied as conditions of water shortage become progressively worse. The current level of conservation is determined by the local city government, conservancy district, or rural water corporation. There are no specific "trigger levels" for the three levels, however.

Water Conservation at Home. An educational guide for homeowners is available from the Indiana Department of Commerce, Energy Information Center.

7. Key Agencies

Indiana Department of Natural Resources
Division of Water
2475 Directors Row
Indianapolis, IN 46241
(317) 232-4160

Indiana Department of Environmental Management
Public Water Supply Section
105 South Meridian Street
P.O. Box 6015
Indianapolis, IN 46225
(317) 232-8603

Indiana Department of Commerce
Indiana Energy Information Centre
Office of Energy Policy
1 North Capitol, Suite 700
Indianapolis, IN 46204-2288
1-800-382-4631

Indiana Utility Regulatory Commission
Room 913 State Office Building
100 N. Senate Ave.
Indianapolis, IN 46204
(317) 232-2737

Indiana Department of Civil Defense
State Emergency Management Agency
Room 315 State Office Building
100 N. Senate Ave.
Indianapolis, IN 46204
(317) 232-3830

Purdue University
Cooperative Extension Service
Agricultural Administration Building
West Lafayette, IN 47907
(317) 494-8489

Michigan

1. Great Lakes Water Levels and Drought Conditions

Great Lakes Water Levels. Information is available from the Michigan Department of Natural Resources (MDNR) through its Land and Water Management Division and the Office of the Great Lakes.

Hydrologic Data. MDNR provides information on streamflows and groundwater levels through its Hydrologic Studies Unit. In cases of low streamflows, the MDNR Hydrologic Studies Unit will initiate additional monitoring. Precipitation and temperature information is monitored by the National Weather Service.

Agricultural Information. The Michigan State University Cooperative Extension Service provides several services to the agricultural community during drought, including a technical assistance guide entitled *Coping With Drought,* technical bulletins on drought-stressed crops, and personal assistance from Extension Service district agents.

Crop and Weather Information. The Michigan Department of Agriculture (MDA) Agricultural Statistics Service publishes a weekly "Crop-Weather Report" which includes data on crop progress, soil moisture, temperature and precipitation.

Drought Hotline. The MDA operates a drought hotline during dry conditions. The number is: 1-800-346-FARM.

2. Drought Planning/Drought Task Force

The Drought Response Management Task Force coordinates short-term and long-term strategies for addressing drought in Michigan. The MDNR Office of Water Resources will conduct periodic briefings on drought conditions for the Task Force, which includes the Departments of Natural Resources, Agriculture, Commerce, Public Health, and the Attorney General's office. This office also provides briefing materials for state legislators so they can effectively respond to questions from their constituents and the media.

7. Key Agencies

Michigan Department of Natural Resources
Land and Water Management Division
Great Lakes Shorelands Section
P.O. Box 30028
Lansing, MI 48909
(517) 373-1950

Michigan Department of Natural Resources
Land and Water Management Division
Land, Lake and Stream Protection Section
P.O. Box 30028
Lansing, MI 48909
(517) 373-0133

Michigan Department of Natural Resources
Land and Water Management Division
Hydrologic Studies Unit
P.O. Box 30028
Lansing, MI 48909
(517) 373-0208

Michigan Department of Natural Resources
Office of the Great Lakes
P.O. Box 30028
Lansing, MI 48909
(517) 373-3588

Michigan Department of Natural Resources
Office of Water Resources
P.O. Box 30028
Lansing, MI 48909
(517) 373-0014

Michigan Department of Agriculture
P.O. Box 30017
Lansing, MI 48909
(517) 373-1050

Michigan Department of Agriculture
Agricultural Statistics Service
P.O. Box 20008
Lansing, MI 48901
(517) 373-0014

Cooperative Extension Service
Agriculture Hall
Michigan State University
East Lansing, MI 48824-1039
(517) 334-6001

or contact: County Cooperative Extension Service office listed under Human Services Department in the telephone directory.

Minnesota

1. Great Lakes Water Levels and Drought Conditions

Lake Levels. Information on the Great Lakes and inland lakes is available from the Minnesota Department of Natural Resource (MDNR), Division of Waters.

Hydrologic Factors. The MDNR Division of Waters is the main point of contact for information on streamflow, groundwater levels, and reservoir levels. Streamflow, groundwater, and precipitation data are gathered by the MDNR in cooperation with several federal agencies.

Agricultural Data. Crop and weather information is provided twice monthly in the "Agri-View Bulletin" published by the Minnesota Agricultural Statistics Service.

2. Drought Planning/Drought Task Force

Drought Task Force. Coordinated by MDNR Division of Waters. The governor can declare a "Critical Water Shortage," thereby initiating emergency powers vested in the Commissioner of Natural Resources. If voluntary water conservation measures are not implemented, the Commissioner has the power to force water supply districts to conserve water.

Drought Contingency Plan for Mississippi River. In response to the problems encountered during low flow periods on the Mississippi in 1988, the Twin Cities Water Supply Task Force developed a drought contingency plan outlining specific actions and water withdrawal rates to be followed for five stages of drought by the following parties: the Minneapolis and St. Paul Public Works Departments, the Metropolitan Waste Control Commission, Northern States Power, and the Department of Natural Resources. The five stages are as follows: Normal Conditions, 7000 cfs; Drought Watch, 2000 cfs; Conservation Phase, 1200 cfs; Restriction Phase, 1000 cfs; and Emergency Phase, 800 cfs.

3. Financial and Technical Assistance

Technical Assistance. The MDNR Division of Waters provides technical assistance to local governments for siting new wells, working with hydropower companies to develop contingency water plans, and promoting water conservation efforts.

4. Emergency Water Supply

Permits. To develop an emergency water supply, a permit is required from MDNR Division of Waters and a water sample must be approved by the Department of Health. If the water supply does not meet state drinking water standards, the Minnesota Pollution Control Agency is notified.

Minnesota Department of Public Safety. In certain instances, this agency can provide reimbursement to communities for purchase of supplemental water supplies.

5. Water Rights/Permits/Restrictions

Water Appropriation Program. A permit from MDNR Division of Waters is required for any appropriation of surface or groundwater in excess of 10,000 gallons per day or 1,000,000 gallons per year. Permits for withdrawals are only available to those owning land adjacent to a surface water source or overlying a groundwater source.

Suspended Permits. The MDNR Division of Waters has the authority to suspend water appropriation permits during dry periods.

Priority Classes for Water Appropriations. Minnesota is the only state in the Great Lakes region that has formally outlined priority classes for appropriation and use of water. These classes are primarily used for resolving water use conflicts during times of water shortage. The classes were most recently updated in 1989. They are listed below, in descending order:

1) first priority is shared by two user groups:

a) domestic water supply, excluding industrial and commercial uses of municipal supplies; and

b) power production, providing the power company has an MDNR-approved water supply contingency plan;

2) any use of water involving consumption of less than 10,000 gallons per day;

3) agricultural irrigation and processing of agricultural products;

4) power production, with appropriation of water in excess of the amount provided in the contingency plan.

5) all other uses, involving consumption in excess of 10,000 gallons per day (includes non-essential public water supply uses.)

Water Use Restrictions. The authority for water use restrictions rests with individual municipalities. An ordinance must be passed to require mandatory restrictions. During low flows on the Mississippi River, some cities like Minneapolis and St. Paul have instituted water use restrictions on non-essential uses such as lawn sprinkling and car washing.

6. Water Conservation/Public Education

Conservation. The MDNR Division of Waters promotes water conservation through rules promulgated for the use of surface and groundwater and through the Bureau of Information and Education.

7. Key Agencies

Minnesota Department of Natural Resources
Division of Waters
DNR Building
500 Lafayette Rd.
St. Paul, MN 55155-4032
(612) 296-4810

Minnesota Department of Natural Resources
Bureau of Information and Education
DNR Building
500 Lafayette Rd.
St. Paul, MN 55155-4032
(612) 296-3336

Minnesota Agricultural Statistics Service
P.O. Box 7068
90 W. Plato Blvd.
St. Paul, MN 55107
(612) 296-2230

Minnesota Department of Public Safety
Division of Emergency Management
B5 Capitol
75 Constitution Avenue
St. Paul, MN 55155
(612) 296-2233

Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55155
(612) 296-6300

Minnesota Department of Health
717 Delaware St., S.E.
Minneapolis, MN 55414
(612) 623-5000

New York

1. Great Lakes Water Levels and Drought Conditions

Hydrologic Factors. Local governments should contact the Department of Environmental Conservation (DEC), Division of Water, for information on drought conditions. The DEC uses information on four hydrologic factors (precipitation, reservoir and lake storage, streamflow, and groundwater levels) to determine the State Drought Index (SDI). Each factor is weighted in accordance with its significance for public water supply in each of the eight drought regions established in New York.

2. Drought Planning/Drought Task Force

New York State Drought Management Task Force. The New York State Drought Management Task Force was established in 1980 to coordinate state drought response activities and to assist localities. The Task Force includes the Departments of Environmental Conservation (lead agency); Health; Transportation; Economic Development; Agriculture and Markets; Office of Parks, Recreation and Historic Preservation; Public Service Commission; Division of Military and Naval Affairs; and the Division of Budget.

3. Financial and Technical Assistance

Technical Assistance/Equipment. The State Emergency Management Office (SEMO) within the Disaster Preparedness Commission provides technical assistance and loans emergency equipment to local governments.

Drought Management Workshops. The DEC sponsors workshops to provide local water suppliers with information on drought management planning and response.

Crop Insurance Programs. Information is available from New York State Department of Agriculture and Markets.

4. Emergency Water Supply

Emergency Water Supplies. The New York State Department of Health sets guidelines and restrictions for local governments that need to develop emergency water supplies.

Local Drought Contingency Plans. Public water suppliers with gross operating revenues of $125,000 or more are required by a 1988 law to develop a drought contingency plan for approval by the Department of Health or DEC. Plans should address the following issues: 1) criteria used to determine different stages of drought response; 2) alternative emergency water sources; 3) actions to be taken in drought emergency; and 4) a description of local emergency equipment (pipes, pumps, etc.) available.

If the governor declares a drought emergency, the Disaster Preparedness Commission directs local governments to impose water restrictions in accordance with approved plans.

Equipment. The SEMO maintains a stockpile of pipe, pumps, water filters, and other equipment which may be used by local governments during drought. The Departments of Health and Transportation will assist SEMO in responding to requests from localities.

Releases from State-Owned Lakes and Reservoirs. The state has the authority to release water from state-owned lakes and reservoirs to mitigate drought impacts.

5. Water Rights/Permits/Restrictions

Restrictions. During drought warning and drought emergency conditions, uses such as augmented withdrawals for fisheries and recreation are eliminated. Restrictions are also imposed on commercial consumptive uses such as car washes, laundromats, etc.

6. Water Conservation/Public Education

Information. The Departments of Environmental Conservation and Health have the primary responsibility for providing materials on water conservation and drought impacts.

7. Key Agencies

New York State Department of Environmental Conservation
Division of Water
50 Wolf Road
Albany, NY 12233
(518) 457-6674

New York State Disaster Preparedness Commission
State Emergency Management Office
Building #22
State Campus
Albany, NY
(518) 457-9996

New York State Department of Health
Bureau of Public Water Supply Protection
Room 406
2 University Place
Albany, NY 12203
(518) 458-6423

New York State Department of Agriculture and Markets
1 Winners Circle
Capitol Plaza
Albany, NY 12235-0001
(518) 457-2737

Ohio

1. Great Lakes Water Levels and Drought Conditions

Great Lakes Levels. Lake levels information is available from two divisions of the Ohio Department of Natural Resources (ODNR), the Division of Water and the Division of Geological Survey.

Hydrologic Factors. Ohio monitors for drought using the Crop Moisture Index, the Palmer Drought Hydrological Index, and the Palmer Drought Severity Index. The ODNR and the federal National Weather Service (NWS) monitor precipitation, groundwater levels, streamflows and snowfall and report their findings on a monthly basis to the Ohio Emergency Management Agency (OEMA).

2. Drought Planning/Drought Task Force

Stages of Response. Ohio has four phases of drought response utilizing the Palmer Drought Severity Index as a general guide: Phase 1) Normal Conditions, greater than -1.00; Phase 2) Drought Alert, -1.00 to -1.99; Phase 3) Conservation Phase, -2.00 to -3.99; Phase 4) Drought Emergency; -4.0 and below.

Drought Assessment Committee (DAC). The DAC is activated when the Palmer Drought Severity Index reads -1.0 for at least three of Ohio's ten climatic divisions. The DAC consists of representation from:

1) Ohio Department of Natural Resources, Division of Water
2) Ohio Environmental Protection Agency, Division of Public Drinking Water
3) Department of Agriculture
4) Emergency Management Agency
5) Ohio State Extension Office
6) State of Ohio Climatologist
7) National Weather Service - Columbus

Based on resource information, the DAC will coordinate the dissemination of information to state and local decision makers. The DAC will report to the State Drought Coordinator (Adjunct General) and make recommendations for proposed State actions.

Drought Executive Committee (DEC). When the Palmer Index reads -2.0 and below and significant unmet needs of local governments and individuals exist, the governor will declare a drought to exist and will activate the DEC, consisting of:

1) Director, Department of Natural Resources
2) Director, Ohio Environmental Protection Agency
3) Director, Department of Health
4) Director, Department of Agriculture
5) Director, Department of Commerce
6) State Representative as named by the Speaker of the House
7) State Senator as named by the President of the Senate
8) Attorney General
9) Administrator, Bureau of Employment Services
10) Chairman, Public Utilities Commission of Ohio

The DEC is responsible for developing short and long-term recommendations and options for the governor in the areas of agricultural assistance and protection of public and private water supplies.

Drought Response Plan. The Ohio Drought Response Plan was initiated during the 1988 drought and finalized in April 1989. The OEMA is the lead agency in coordinating state agency drought response. The plan specifies the tasks, organizational arrangements, and operational methods of all state government under varying drought conditions, and acts as a guide for local government in their response to such an emergency.

3. Financial and Technical Assistance

Emergency Operations Center (EOC). The OEMA maintains the EOC during phase IV of a drought. The EOC is staffed by representatives from EPA, DNR, EMA, Health, Agriculture and other agencies to coordinate state responses to the drought.

Water Supply Planning and Conservation. The ODNR reviews regional water supply plans for each community and provides technical assistance in the development of water conservation plans and programs.

4. Emergency Water Supply

Releases from State-Owned Lakes. The ODNR has the authority to allocate emergency water supply from state-owned lakes. It has no authority over impoundments owned by other entities. The amount of water available for allocation is dependent on the priority uses of the lake, such as recreation, wildlife, or water supply.

Contingency Plans. Ohio EPA has recommended that communities develop and update water supply contingency plans for drought as part of their emergency operations plans required under rules of the Ohio Administrative Code.

5. Water Rights/Permits/Restrictions

Water Withdrawal Registration. Any water user that withdraws greater than 100,000 gallons of water a day from the waters of the state must register the facility with the ODNR Division of Water and submit annual reports.

Water Diversion Permit. Any user planning to divert more than 100,000 gallons of water per day out of the Lake Erie or Ohio River Basins must first obtain a permit from the director of ODNR. Approval of any permit for water diversion out of the Great Lakes Basin is contingent upon approval of the governors and premiers of the other Great Lakes States and Provinces.

6. Water Conservation/Public Education

Water Conservation Planning for Communities. Technical assistance is provided by the ODNR Division of Water.

7. Key Agencies

Ohio Emergency Management Agency
2825 West Granville Rd.
Columbus, OH 43235-2712
(614) 889-7176

Ohio Department of Natural Resources
Division of Water
Fountain Square, Bldg. E-3
Columbus, OH 43224
(614) 265-6717

Ohio Department of Natural Resources
Division of Geological Survey, Lake Erie Section
P.O. Box 650
Sandusky, OH 44870
(419) 626-4296

Ohio Department of Health
246 N. High St.
P.O. Box 118
Columbus, OH 43266-0588
(614) 466-3543

Ohio Department of Agriculture
65 S. Front St.
Columbus, OH 43266
(614) 466-2732

Ohio Environmental Protection Agency
P.O. Box 1049
1800 WaterMark Dr.
Columbus, OH 43266-0149
(614) 644-3020

Ontario

1. Great Lakes Water Levels and Drought Conditions

Great Lakes Levels. Information on Great Lakes levels and forecasts is available from the Great Lakes Water Level Communications Centre of Environment Canada. (See Federal Assistance Programs - Canada for more information.)

Hydrologic Data. The regional offices of the Ontario Ministry of the Environment (OMOE) provide information on surface and groundwater supplies. The Conservation Authorities and Water Management Branch of the Ontario Ministry of Natural Resources (OMNR) and the Water Survey of Canada provide information on surface flows and water levels. (See Federal Assistance programs - Canada.)

Climate Data. The Atmospheric Environment Service of Environment Canada monitors and forecasts weather. A weekly bulletin, "Climate Perspectives," provides information on precipitation, temperature, growing season degree-days, soil moisture, etc. (See Federal Assistance Programs - Canada for more information.)

2. Drought Planning/Drought Task Force

A province-wide drought management strategy has not been developed. Rather, provincial ministries and regional municipalities, in many cases, manage particular impacts of drought in their jurisdictions. For example, the Ontario Ministry of Agriculture and Food (OMAF) has established the Adverse Weather Committee to ensure that farmers receive technical advice to cope with drought events.

3. Financial and Technical Assistance

Crop Insurance. The OMAF administers the Canada-Ontario Crop Insurance Program, which makes available insurance coverage for the effects of many natural hazards including drought.

Agricultural Information. The OMAF's Adverse Weather Committee provides technical assistance to farmers on the management of drought stress on crops and livestock.

Water Supplies. Regional offices of the OMOE provide technical assistance and information on

groundwater and surface water supplies. OMNR staff provide advice on the location of dams for water supplies.

Short-Term Programs. During an extreme drought, the province may provide short-term financial assistance programs to assist those who are severely affected. These short-term programs are administered by the appropriate ministry of the government. An example of such a program was the Canada-Ontario Livestock Drought Assistance Program, which provided payments to livestock producers in areas affected by the 1988 drought to help maintain breeding herds.

5. Water Rights/Permits/Restrictions

Permit to Take Water Program. The OMOE has the authority under the Ontario Water Resources Act to regulate the amount of water taken from surface and groundwater sources. Any water supply taking in excess of 50,000 liters/day requires a permit except for domestic use, livestock watering or fire fighting. The Ministry also has the power to order a reduction in the amount taken during drought.

Approvals for Dams. The Lakes and Rivers Improvement Act requires anyone planning a dam, diversion, stream-connected pond or channel improvement to a watercourse to obtain approval from the OMNR for the location and the design of the undertaking.

Water Restrictions. Municipalities that own and operate water distribution systems have the authority to impose water use restrictions on users of their system.

6. Water Conservation/Public Education

Water Conservation Strategy. Ontario is presently developing a water conservation strategy that will promote public awareness about water consumption and conservation, promote water conservation practices and technologies, implement demand management alternatives to encourage water conservation, and coordinate inter-agency water management programs. The lead agency is the OMNR Conservation Authorities and Water Management Branch.

7. Key Agencies

Ontario Ministry of the Environment
Water Resources Branch
135 St. Clair Avenue West
Toronto, ONT M4V 1P5
(416) 323-4941

Northwestern Region, Thunder Bay	(807) 475-1205
Northeastern Region, Sudbury	(705) 675-4501
Southeastern Region, Kingston	(613) 549-4000
West Central Region, Hamilton	(416) 521-7640
Central Region, Toronto	(416) 424-3000
Southwestern Region, London	(519) 661-2200

Ontario Ministry of Agriculture and Food
Soil and Water Management Branch
Guelph Agricultural Centre
P.O. Box 1030
Guelph, Ontario N1H 6N1
(519) 767-3561

Ontario Ministry of Natural Resources
Conservation Authorities and Water Management Branch
Room 5620, Whitney Block
Queen's Park
Toronto, Ontario M7A 1W3
(416) 965-6295

Pennsylvania

1. Great Lakes Water Levels and Drought Conditions

Hydrologic Factors. Information on drought conditions is available from the Department of Environmental Resources (PADER), Bureau of Water Resources Management. Data is collected by a variety of federal agencies in cooperation with the PADER.

Drought Bulletin. This bulletin is provided during dry periods by the PADER Bureau of Water Resources Management. It includes drought stage designations by county, suggested water conservation measures, and advice on developing drought response plans and water shortage ordinances.

2. Drought Planning/Drought Task Force

Drought Management Task Force. The Task Force established under the Drought Contingency Plan for the Delaware River Basin is expanded as needed on a statewide basis. It is chaired by a representative from the PADER, which provides the Task Force with staff to carry out drought response activities in coordination with the activities of the Pennsylvania Emergency Management Agency (PEMA). Other departments and

agencies represented are: Community Affairs; Emergency Management Agency; Agriculture; Office of General Counsel; Office of Attorney General; Fish Commission; Governor's Energy Council; Public Utility Commission; and Commerce. Declaration of progressive drought stages is made by the governor in consultation with the PEMA and the PADER. During the drought period of 1988, a smaller task force, the Governor's Drought and Energy Task Force, was chaired by the lieutenant governor and assumed the responsibilities described above.

Drought Contingency Plan. The Pennsylvania Drought Contingency Plan for the Delaware River Basin is used as a guideline for drought operations in other parts of the state including the Great Lakes area. It includes specific criteria for precipitation, groundwater levels, reservoir storage and streamflow, as well as the Palmer Drought Severity Index for use in determining progressive stages of drought severity. In order for a given drought stage to trigger, three out of the five drought parameters must indicate a given stage. These stages are, in order: drought watch, drought warning, and drought emergency.

3. Financial and Technical Assistance

Technical Assistance. The Water Conservation/Technical Assistance Section of the PADER provides a wide range of technical assistance services to municipalities and public water suppliers. The Section provides guidance in the development of several different plans and ordinances, including: 1) guidelines for a public water supply drought contingency plan; 2) a model water conservation ordinance; 3) a water conservation plumbing ordinance; 4) guidelines for designing a municipal water conservation program; 5) guidelines for developing drought trigger levels for public water suppliers; 6) a model local water rationing plan, and 7) water audit/leak detection procedures. The PEMA is authorized to review and approve local water rationing plans.

4. Emergency Water Supply

Assistance. Technical assistance and equipment (pipe, pumps, etc.) is provided by the PEMA at the request of the PADER Bureau of Community Environmental Control. This Bureau is also the first point of contact for a local government developing an emergency source of water supply, to assure acceptable water quality.

Emergency Surface Water Allocation Permits. Issued by the PADER Bureau of Water Resources Management.

5. Water Rights/Permits/Restrictions

The Water Rights Act of 1939 (32 P.S.A. SEC 631 et seq., Act of June 24, 1939, No. 365, P.L. 842) requires public water suppliers that utilize surface sources to obtain a permit prior to withdrawal of water. The permits are issued by the PADER. Certain applications may be subject to the "Prior Notification and Consultation" process pursuant to the Great Lakes Charter. (Please refer to Chapter 7 for a discussion of the Charter.)

6. Water Conservation/Public Education

Information. Information on water conservation measures is available from the Water Conservation/Technical Assistance Section of the PADER, County Conservation Districts, and public water suppliers.

7. Key Agencies

Pennsylvania Dept. of Environmental Resources
Bureau of Water Resources Management
(includes Water Conservation/Technical Assistance Section)
P.O. Box 8761
Harrisburg, PA 17110-8761
(717) 541-7800

Pennsylvania Dept. of Environmental Resources
Bureau of Community Environmental Control
P.O. Box 2357
Harrisburg, PA 17120
(717) 787-5017

Pennsylvania Dept. of Environmental Resources
Regional Sanitarian
Meadville Regional Office
1012 Water St.
Meadville, PA 16335
(814) 332-6945

Pennsylvania Emergency Management Agency
Transportation and Safety Building; Room 13151
Harrisburg, PA 17120
(717) 783-8150

Wisconsin

1. Great Lakes Water Levels and Drought Conditions

Agricultural Bulletin. The University of Wisconsin - Extension publishes "Dryline", a weekly bulletin providing drought-specific information and agribusiness, primarily for county extension agents to pass on to farmers.

2. Drought Planning/Drought Task Force

Task Force and Working Group. A Task Force on Drought was created by the governor during the drought of 1988. A more informal working group was also established by the Department of Administration to gather and share information on drought effects and drought-related activities.

Drought Management Plan. A drought management plan for the state has been developed by the Department of Natural Resources.

3. Financial and Technical Assistance

Drought Assistance Guaranteed Loan Program. The Wisconsin Housing and Economic Development Authority administers this program for farmers who lost at least 40% of their crops due to drought. The legislature gave the program $35 million of lending authority in 1988.

Property Tax Credit. A property tax credit, approved in 1988, allowed farmers to claim a refund of up to 10% on property taxes for that year's drought.

Farmers Assistance Program. Five Department of Agriculture, Trade, and Consumer Protection programs assist financially stressed farmers:

1) Farm Crisis Hotline;
2) Farm Credit Advisor Program;
3) Legal Information Services Program;
4) Tuition Assistance Program; and
5) Wisconsin Farm Mediation and Arbitration Program;

Employment Resources. The Department of Labor, through the United Migrant Opportunities Service, administers a program providing emergency assistance to farm workers affected by drought.

4. Emergency Water Supply

Emergency Surface Water Irrigation. During the 1988 drought, the governor signed an executive order giving the Department of Natural Resources the authority to bypass the formal irrigation permit process and issue permits on the spot.

5. Water Rights/Permits/Restrictions

Water Use Permits are reviewed and issued by the Department of Natural Resources.

6. Water Conservation/Public Education

Public Education for Farmers. Programs on managing drought-stressed crops and limited water supplies are provided by University of Wisconsin - Extension staff during periods of drought.

7. Key Agencies

Wisconsin Department of Natural Resources
Director, Bureau of Water Resources
P.O. Box 7921
101 S. Webster, Second Floor
Madison, WI 53702
(608) 266-8634

Wisconsin Department of Administration
Administrator, Division of Energy and Intergovernmental Relations
P.O. Box 7868
101 S. Webster St. Sixth Floor
Madison, WI 53702
(608) 266-8234

Wisconsin Department of Agriculture, Trade, and Consumer Protection
Administrative Assistant
P.O. Box 8911
801 West Badger Road
Madison, WI 53708
(608) 266-9586

University of Wisconsin - Extension
302 Hiram Smith Hall
1545 Observatory Drive
Madison, WI 53706
(608) 262-4522

Department of Labor
United Migrant Opportunities Service
809 W. Greenfield Avenue
Milwaukee, WI 53204
(414) 671-5700 *(or contact satellite offices)*

Wisconsin Housing and Economic Development Authority
Executive Director
P.O. Box 1728
One South Pinckney St., Suite 500
Madison, WI 53701-1728
(608) 266-7884

Chapter 7

MAJOR WATER SUPPLY ISSUES IN THE BASIN

Climate is a highly variable component of nature and has been the basis for research, policymaking and resource management programs in the Great Lakes Basin. Seasonal and annual climate variations in recent years have resulted in extreme events, such as flooding and drought, as well as longer-term fluctuations in streamflows, lake levels and snowpack.

Between November 1985 and October 1986, for example, all of the Great Lakes except Ontario experienced record high water levels, based on data collected since 1860. The lake basins were saturated with moisture, expediting land runoff and exacerbating an already critical problem. By September 1987, high water levels had eased on all the Great Lakes due to a precipitation deficiency that began in late 1986. A major drought beginning in late 1986 and lasting through late 1988 caused Great Lakes water levels to drop further and faster than lake level forecasters had predicted.

Extreme events, whether they involve lake level fluctuations, drought or other natural occurrences, have pronounced impacts on the Great Lakes citizenry and its water-dependent economy and quality of life. The assessment of climate impacts on the Great Lakes Basin must therefore involve a full range of disciplines, including engineering, the environmental sciences and socio-economics, among others.

To provide a sense of the diversity of water supply and coastal zone issues that in some way impact (or are impacted by) drought, a brief review of three current and emerging concerns is offered: global climate change, lake level fluctuations and water diversion.

A. GLOBAL CLIMATE CHANGE AND THE GREAT LAKES REGION

Projections of future interactions between climate, society and the resources of the Great

Lakes Basin must include an element, not experienced by previous generations, known as an enhanced greenhouse effect.

The greenhouse effect is the natural process by which solar radiation reflected from the Earth's surface is trapped by carbon dioxide and other gases in the atmosphere and thereby prevented from radiating back into space.

A continuation or acceleration of the greenhouse effect will promote global climate change — a warming of the Earth's climate due to the absorption of terrestrial radiation by increased concentrations of gases in the atmosphere. There is much speculation as to the effect that global warming may have on the climate of the Great Lakes region. Many scientists believe that current trends may result in major changes in the hydrologic cycle and net basin water supply. These changes would in turn influence the region's environment and economy and likely trigger major changes in water resources planning and management practices.

Numerous studies have been undertaken to estimate possible regional impacts of the greenhouse effect. One of these was a pilot study initiated by Environment Canada in 1984, evaluating the Ontario portion of the Great Lakes Basin.

In 1986, the U.S. Environmental Protection Agency, at the direction of Congress, coordinated several regional studies of the potential effects of a doubling of atmospheric CO_2 on various aspects of society. The Great Lakes Environmental Research Laboratory (NOAA) was responsible for assessing changes in Great Lakes water supplies and lake levels using simulated atmospheric scenarios. The Illinois State Water Survey assessed the impacts of severely reduced water levels (2 to 9 feet) on Lake Michigan.

In these studies, net basin supplies of water were assumed to drop consistently for all lakes and scenarios. Reduced supplies led to lower levels for all of the lakes in all scenarios. A reduction of Lake Michigan by 9 feet was calculated to cost $600 million in Chicago alone to modify harbors, water intakes, and outlets.

Regional economic impacts identified by the Ontario study were largely negative. Economic losses for hydroelectric power and commercial navigation would be experienced. Agriculture would experience wider variations in annual production, and irrigation would probably need to be expanded. Industrial and domestic consumptive uses could cause water use conflicts similar to those experienced in other interstate/international basins where water shortages periodically occur.

According to the Canadian studies, if low lake levels were to prevail as the new "normal levels" due to climatic changes from the greenhouse effect, everyone would lose — including utilities, navigation interests, riparians, recreation interests, agriculture, wetlands, and municipalities.

Six categories of recommendations for addressing global warming concerns were generated from a September 1988 meeting of United States and Canadian federal, state and provincial officials held in Chicago, Illinois. These included the need to: 1) enhance atmospheric research; 2) conduct research on climate impacts for both physical and socio-economic responses; 3) develop data bases and information systems; 4) study coping strategies, focusing specifically on conservation, resource management, adaptation, energy policies, and ecological reserves; 5) assess public policies and develop coordinated strategies for conflict resolution; and 6) educate the public about the impacts of climate change.

While future climate patterns are uncertain, scientist and policymakers agree that now is the time to prepare for climatic change. To this end, they recommend two actions: 1) develop an integrated U.S.-Canada study of the Great Lakes Basin as a regional pilot project for international response to global climate change, and 2) establish a joint planning group to organize and develop the pilot project.

Much more research is needed to resolve the uncertainties in atmospheric modeling and in assessing the impacts of climatic change in the Great Lakes. In addition, more thought must be given to the linkages among the economy, society and the natural environment as these sectors respond to future climatic trends in the Great Lakes.

B. HISTORICAL PERSPECTIVE ON LAKE LEVEL FLUCTUATIONS

Fluctuations in Great Lakes water levels have occurred continually since the Great Lakes were formed some five to six thousand years ago with the retreat of the last glacier. Since continual lake level measurements began in 1860, the Great Lakes have experienced periods of high and low water levels. Such a short period of record (from a hydrological/geologic standpoint) makes prediction of future Great Lakes water levels extremely difficult.

Scientists are still learning about the hydrology, geology and climate of the Great Lakes region, especially patterns that occurred over the last 10,000 years. As they learn, they may be able to predict long-term lake level fluctuations more accurately.

Certainly, there are both positive and negative impacts associated with high and low lake levels. A better understanding of the causes of lake level changes won't ease the negative impacts of high

or low water, but may make it easier for communities and shoreline residents to plan for shoreline use.

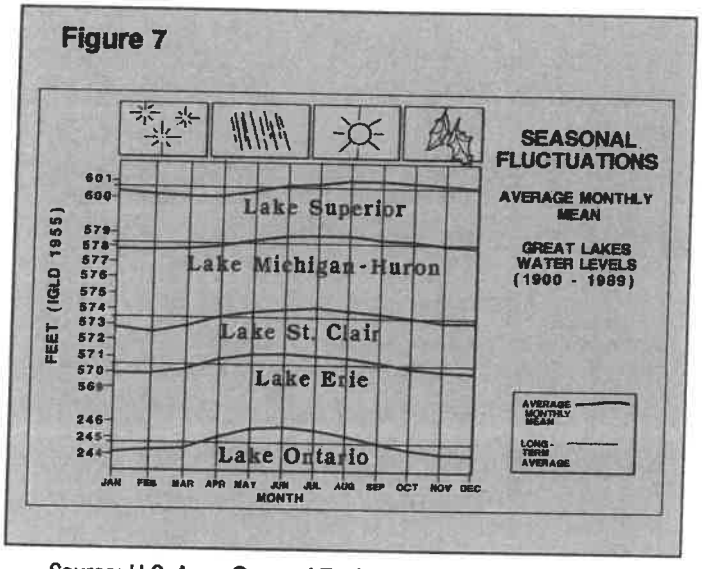
Lake Level Fluctuations

The water level in each of the Great Lakes rises or falls according to the amount of water entering the lake or the amount leaving it. The amount entering a lake includes precipitation falling on the lake, runoff (including snowmelt) from the land within the drainage basin, inflow from connecting channels, diversions of water into the lake and groundwater inflow. The water leaving a lake consists of evaporation from the lake's surface, groundwater outflow, consumptive uses, diversions to another basin, and outflow at the lakes outlet.

Lake level fluctuations are generally described as seasonal, long term or short term.

Seasonal Fluctuations - are those fluctuations occurring over the course of a year that average about 12-18 inches, with lows usually in December through March and highs in June through September. (See Figure 7.)

Figure 7

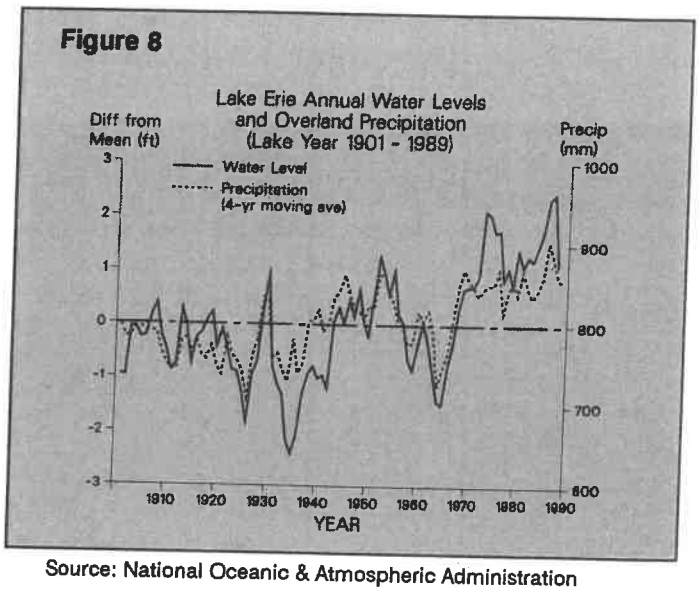


Source: U.S. Army Corps of Engineers

Long-Term Fluctuations - can occur on the order of five to six feet from record highs to record lows and are due to changes in natural factors such as precipitation, runoff, temperature and evaporation over a period of years. (See Figures 8 and 9 for data on unregulated lakes: Michigan, Huron and Erie.)

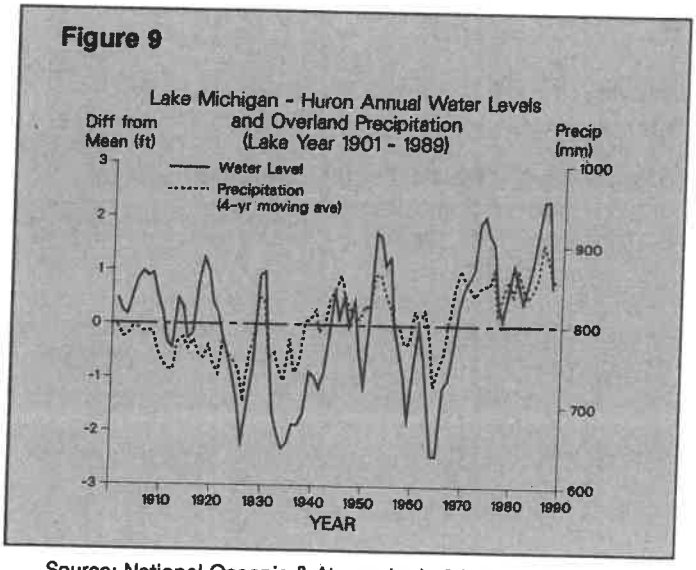
Short-Term Fluctuations - are those fluctuations resulting from strong winds and storms that typically last from a few hours to a few days. An example would be the storm of December 2, 1985 that caused a 16 foot difference in water levels on Lake Erie between Toledo (eight feet lower) and Buffalo (eight feet higher).

Figure 8



Source: National Oceanic & Atmospheric Administration

Figure 9



Source: National Oceanic & Atmospheric Administration

The amount of precipitation is the main cause of long-term fluctuations in water levels on the Great Lakes. From 1900 to present there have been two distinct precipitation patterns in the region. From 1900-1939 the Great Lakes experienced below average precipitation, with a basin-wide annual average of 30.77 inches. (Average annual

precipitation is about 32 inches.) From 1940-1984, precipitation was, for the most part, above average, with an annual average of 32.77 inches. This extra two inches per year, a six percent increase, represents a tremendous amount of water added to the Basin.

Analysis of Great Lakes water level records shows that the record high lake levels set in 1985 and 1986 were the result of a 5-year period of higher than normal precipitation. Beginning in November 1986 and extending through June 1987, precipitation was 25% below the long-term average from the Basin. The 1988 precipitation was only about 25% of the long-term average at the end of June. These low precipitation amounts helped cause the lowering of lake levels in 1988. Great Lakes water levels are also influenced significantly by the amount and timing of runoff. In this regard, land within the Great Lakes Basin can be compared to a sponge. When the sponge is dry (i.e., drought conditions), very little runoff occurs. When the sponge is saturated (i.e., heavy precipitation), runoff is much more substantial.

From the mid-1960s to the present, the Great Lakes Basin has experienced both record low and record high water levels. Human manipulation of the system (e.g., dredging, consumptive use, diversions, shoreline alteration, navigation locks) has had some influence on lake levels and flows, but the influence has been modest in comparison to natural fluctuations. The outflows of Lakes Superior and Ontario, for example, are regulated through use of control structures (locks, dams, compensating works) under regulation plans approved by the International Joint Commission. Such controls can "moderate" water level extremes with the lakes acting as "holding basins" for water, but cannot significantly affect fluctuations in comparison to natural factors. Lake Ontario is the one exception where regulation has a somewhat larger impact on water levels. It prevented record high levels in 1985-86 by keeping the lake 3.5 feet lower than if regulation had not been in effect.

The Great Lakes system is a dynamic one and fluctuations, pronounced or otherwise, will continue to occur. Planning and management practices that fully recognize and accommodate lake level fluctuations are needed at all levels of government. A good understanding of the causes of lake level changes and their economic and environmental impacts on the shoreline and the region in general will help communities and residents of the Basin plan for the future and avoid questionable shoreline development activities.

C. DIVERSIONS TO AND FROM THE GREAT LAKES

A diversion is a man-made transfer of water from one drainage basin to another that can affect the levels and flows of water in each. There are currently five operating diversions on the Great Lakes: Long Lac and Ogoki; Lake Michigan Diversion at Chicago; Welland Canal; and New York State Barge Canal. These diversions either change the natural water supply to the Great Lakes or bypass a natural outlet. Table 8 demonstrates the effect that these five diversions have on Great Lakes water levels. All five diversions are relatively minor in comparison to the tremendous volume of water in the Great Lakes system. For example, on the upper lakes (Superior, Michigan, Huron) approximately three and

Table 8
Effect of Existing Diversions on Mean Great Lakes Water Levels
(in inches)

Diversion	Rate (avg)	Superior	Michigan-Huron	Erie	Ontario
Long Lac/ Ogoki	5,650 cfs	+2.5	+4.5	+3.0	+2.6
Lake Michigan at Chicago	3,200 cfs	-0.8	-2.5	-1.7	-1.2
Welland Canal	9,400 cfs	-0.7	-2.2	-5.3	-
New York State Barge Canal	700 cfs	-	-	-	-
Total		**+1.0**	**-0.2**	**-4.0**	**+1.4**

Source: International Joint Commission and Great Lakes Commission

a half years will pass before one-half of the anticipated effect of a diversion is experienced. The full effect requires 12-15 years.

Long Lac and Ogoki Diversions

Actually two separate diversions, Long Lac and Ogoki are often considered together because they both divert water from James Bay into Lake Superior. These diversions were developed in the 1940s to generate hydroelectric power and to transport pulpwood logs southward.

The Long Lac Diversion connects the headwaters of the Kenogami River with the Aguasabon River, which naturally discharges into Lake Superior. The Ogoki Diversion connects the upper portion of the Ogoki River to Lake Nipigon and from there flows into Lake Superior.

The Ogoki and Long Lac Diversions can be altered so that more or less water is brought into the Great Lakes system. In 1985, when water levels were very high, Ontario took action to store Ogoki waters in Lake Nipigon. After Lake Nipigon developed critically high water levels, Ogoki water was redirected to the Albany River and Hudson Bay. This action continued until December 1985 and its ultimate effect was the lowering of Lake Superior by about 0.4 inches.

Lake Michigan Diversion at Chicago

The Lake Michigan Diversion at Chicago passes water out of Lake Michigan through the Illinois Waterway and on to the Mississippi River. Flow through the Lake Michigan Diversion at Chicago is currently limited by a 1967 Supreme Court decree. Increases in flow out of Lake Michigan must be approved by the Court or legislated by the U.S. Congress.

Welland Canal Diversion

The Welland Diversion takes water from Lake Erie at Port Colborne and diverts it across the Niagara Peninsula to Lake Ontario, bypassing the Niagara River and Falls. The diversion is used primarily for navigation and hydropower, and also supplies water for industrial and municipal use.

New York State Barge Canal

This canal diverts water (primarily for navigation purposes) from the Niagara River to Lake Ontario through several tributaries and the Oswego Canal. The average flow of water through the New York State Barge Canal is quite modest and has little hydrologic impact on any of the Great Lakes. All of the flow is returned to Lake Ontario, with no loss of water to the system.

Proposals are occasionally put forth to divert water from the Great Lakes to arid regions of the United States and Canada. Especially during times of drought outside the Great Lakes region, diversion of Great Lakes water may seem to be an answer to water shortages in other parts of the continent.

Present diversions have limited impact upon the levels and flows of the Great Lakes, but there is well-founded concern that any new out-of-basin diversion will set an undesirable precedent that could ultimately have devastating effects on the economy and environment of the Great Lakes region. While the Great Lakes states and provinces do enjoy plentiful water supplies, the Great Lakes are intensively used. In 1985 the eight Great Lakes Governors and two Great Lakes Premiers responded to these concerns by signing the Great Lakes Charter, which discourages out-of-basin diversion and encourages regional unity in managing the waters of the Great Lakes. The Charter promotes long-term management through the establishment of a Regional Water Use Data Base (maintained by the Great Lakes Commission) and the identification and assessment of current and future demands for withdrawals, consumptive uses and diversions.

Section 1109 of the U.S. Water Resources Development Act of 1986 also recognizes the importance of the Great Lakes to the eight Great Lakes states and two Canadian provinces. To protect Great Lakes water quantity, the Act prohibits any new or increased diversion of Great Lakes water for use outside of the Basin without the approval of the Governor of each of the Great Lakes states.

Appendix 1
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Appendix 2

MODEL REGULATION FOR WATER CONSERVATION

Note: this model regulation and ordinance were developed by the Pennsylvania Department of Environmental Resources for use by communities in Pennsylvania. The overall substance and approach can be adapted for use in other Great Lakes communities.

The adoption of an ordinance, rule, or regulation which restricts nonessential uses of water during periods of drought and other water shortages is essential to the effective implementation of response plans by municipal water purveyors. Such an ordinance, rule, or regulation shall serve to institutionalize a water shortage response plan, identify water uses deemed "nonessential", and provide local law enforcement agencies and water authorities with the necessary authority to impose sanctions on those customers that violate the provisions of a mandatory ban on nonessential water uses. Violators may face sanctions which include surcharges, monetary fines or the curtailment of water service. This document has been prepared for your careful review and use in establishing the necessary legal authority to adequately respond to water shortages.

ORDINANCE #____ OF *(Municipality)*

(or)

AMENDMENT TO *(Rule, Regulation or By-law)* **OF** *(Purveyor Name)*

WATER SHORTAGE RESPONSE

WHEREAS, The *(Board of Supervisors, Board of Commissioners, Council, Board of Authority, Association, Owner or Operator)*, hereinafter referred to as the BOARD, of *(Municipality, Authority, Association, or Mobile Home Park)*, finds and determines that in order to conserve and protect its water supply and to meet the essential water needs of those residents to which public water service is provided, it is necessary to adopt a water shortage response plan and to establish the legal framework to properly implement such a plan, and

WHEREAS, the purpose of this *(Ordinance or Rule or Regulation)* is to protect public health and safety during periods of water shortage,

NOW THEREFORE, be it ordained by the BOARD of _____ *(Municipality, Authority, Association, or Mobile Home Park)*, as follows:

SECTION ONE: WATER SHORTAGE RESPONSE PLAN

The WATER SHORTAGE RESPONSE PLAN OF _____ *(Municipality, Authority, Association, or Mobile Home Park)* thereby adopted and attached hereto. This plan may be modified and updated by BOARD resolution.

SECTION TWO: NONESSENTIAL USES OF WATER

Those uses of water not essential to the protection of public health and safety are deemed nonessential. Nonessential uses of water may be restricted by both voluntary and mandatory measures as prescribed and outlined within the water shortage response plan. A list of nonessential water uses is included in the Plan.

SECTION THREE: MANDATORY WATER USE RESTRICTIONS

If, during a water shortage period, a voluntary ban on nonessential uses of water has not sufficiently reduced the rate of depletion of water supply sources, and those sources have reached a level at which the Response Plan prescribes more severe demand reduction measures, a mandatory restriction of nonessential water uses shall be imposed. Those water service customers found not cooperating with this action shall face a surcharge of $_____ for each day of noncompliance, or the curtailment of water service, whichever is deemed most appropriate.

SECTION FOUR: WATER RATIONING

If a water shortage emergency is declared by the Governor of the Commonwealth of Pennsylvania within an area which includes the service area of the _____ *(Municipality, Authority, Association, or Mobile Home Park)* and both voluntary and mandatory restrictions of nonessential water uses have failed to sufficiently reduce the rate of depletion of all available water supply sources, and if the _____ *(Municipality, Authority, Association, or Mobile Home Park)* plans for water rationing have been reviewed and approved by the Pennsylvania Emergency Management Council, water rationing may be implemented. The _____ *(Municipality, Authority, Association, or Mobile Home Park)* WATER RATIONING PLAN is included in the water shortage response plan.

SECTION FIVE:

Any water service customer(s) may apply to the _____ *(Municipality, Authority, Association, or Mobile Home Park)* for an exemption to the terms of this *(Ordinance or Amendment)* which may be granted by the BOARD upon adequate evidence of inequitable hardship imposed through adherence to the provisions of the Plan.

Adopted this ____ day of _____, 19___.

SUGGESTED LEGAL BASIS FOR RESPONSE ACTIONS AT LOCAL AND/OR REGIONAL LEVELS TO ESTABLISH MANDATORY RESTRICTIONS THAT WOULD FALL SHORT OF LOCAL WATER RATIONING:

Water use restrictions as part of a PUC Tariff pursuant to the Public Utility Code and PUC regulations.

Borough ordinance pursuant to 53 Pa. C.S.A. § 46202 (Borough Code).

Rules, regulations and/or bylaw amendment pursuant to 53 Pa. C.S.A. § 301 (Municipal Authorities Act of 1945).

Lease and/or rental rules and regulations pursuant to 68 P.S. § 398.1 (Mobile Home Park Rights Act).

Multiple municipal ordinances pursuant to appropriate Pennsylvania statutes where service areas cross municipal boundaries.

FOR ASSISTANCE IN DEVELOPING A "WATER SHORTAGE RESPONSE PLAN", CONTACT THE PENNSYLVANIA DEPT. OF ENVIRONMENTAL RESOURCES WATER CONSERVATION/TECHNICAL ASSISTANCE SECTION AT (717) 541-7805

Commonwealth of Pennsylvania
DEPARTMENT OF ENVIRONMENTAL RESOURCES
P.O. Box 8761
Harrisburg, Pennsylvania 17110-8761

ORDINANCE #____ OF *(Municipality)*

WATER CONSERVATION

WHEREAS, the Board of Supervisors of *(Municipality)* hereby finds and determines that in order to conserve and protect its water supply for the greatest public benefit, it is necessary to reduce the demand for water in the manner hereinafter set forth, and

WHEREAS, the purpose of this ordinance is to insure continued availability and service of water to *(Municipality)* residents, now therefore

BE IT ORDAINED BY THE BOARD OF SUPERVISORS OF *(Municipality)* as follows:

SECTION ONE:

No water shall be provided for internal or external use to any residential, commercial, industrial, agricultural, recreational, governmental, or public building or structure of any kind which is constructed or remodeled and in which plumbing, water piping or water fixtures are to be installed, extended or altered in any way, and for which construction a permit is required to be obtained from *(Municipality)* (or would be required but for an exemption from a permit requirement for public or governmental agencies) unless the new, extended or altered plumbing, water piping and other water using fixtures therein conform to the requirements and standards of Section Two of this Ordinance. The provisions of this Ordinance shall apply to any such building or structure for which such a building permit is issued, or would otherwise be required to be issued but for such an exemption, on or after *(Date of Adoption)*.

SECTION TWO: WATER CONSERVATION PERFORMANCE STANDARDS FOR PLUMBING FIXTURES AND FITTINGS

Article 1 - Water Closets and Associated Flushing Mechanisms

The water consumption of water closets operated by flush tanks shall not exceed an average of 1.6 gallons per flush cycle over a range of test pressures from 20 to 80 psig. The fixture shall perform in accordance with the test requirements of the ANSI 122.19.2M Vitreous China Plumbing Fixture Standard.

Article 2 - Urinals and Associated Flushing Mechanisms

Urinal water consumption shall not exceed an average of 1.5 gallons per flush cycle over a range of test pressures from 20 to 80 psig. The fixtures shall perform in accordance with the test requirements of ANSI 122.19.2M.

Article 3 - Showerheads

Showerhead discharge rates shall not exceed 3.0 gallons of water per minute over a range of test pressures from 20 to 80 psig. The fixture shall perform in accordance with the test requirements of ANSI 122.18.1M.

Article 4 - Faucets

Sink and lavatory faucet discharge rates shall not exceed 3.0 gallons of water per minute over a range of text pressures from 20 to 80 psig. The fixture shall perform in accordance with the test requirements of ANSI 112.18.1M.

Article 5 - Pressure Reducing Valves

Where the service water pressure to a building is expected to exceed 60 psig, a water pressure reducing valve with strainer shall be installed just downstream of the building's main valve, so as to be accessible. The valve shall provide for pressure adjustment within the range of 50 to 60 psig. The valve shall conform to the requirements of product standard ASSE 1003. Exemptions to this article are service lines to sill cocks, outside hydrants, and main supply risers to buildings where pressure from mains does not exceed 60 psig at the fixture branches or at individual fixtures.

SECTION THREE: SPECIAL PROVISIONS

Article 1-Special Purpose Equipment

The performance standards of Section Two shall not apply to fixtures and fittings such as emergency showers, aspirator faucets, and blowout fixtures that, in order to perform a specialized function, cannot meet the specified standards.

Article 2 - Exemptions

Any person(s) may apply to the *(Municipality)* for an exemption to the terms of this Ordinance, which may be granted by the Board of Supervisors, upon proof that some other device, system or procedure will save as much or more water as those set forth herein, or that those set forth herein cannot be compiled with, without undue hardship.

SECTION FOUR: OFFICIAL REVIEW AND MODIFICATION

The Board of Supervisors may, from time to time, modify, add to, or remove from the standards and restrictions herein.

SECTION FIVE: PENALTIES

It shall be a misdemeanor for any person to use or apply water within *(Municipality)* contrary to or in violation of the restrictions herein, and upon conviction thereof, such persons shall be punished by being imprisoned in the county jail for not more than _____ days or by fine of not more than _____ or by both such fine and imprisonment.

Adopted this _____ day of _____, 19____

Appendix 3

MEMBERSHIP: TASK FORCE ON DROUGHT MANAGEMENT AND GREAT LAKES WATER LEVELS

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The Great Lakes Commission is an eight-state compact agency that guides, protects and advances the common interests of its membership in areas of regional environmental quality, resource management and economic development.

Established in 1955 by the Great Lakes Basin Compact and founded in state and federal law, the Commission is comprised of state officials, legislators and governors' appointees. Its research, policy and advocacy activities are unique to the region and dedicated to securing a strong economy, clean environment and high quality of life for the Great Lakes region and its citizenry.

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