MASSACHUSETTS DROUGHT MANAGEMENT PLAN

MAY 2013

Massachusetts Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114

Massachusetts Emergency Management Agency
400 Worcester Rd, Box 1496
Framingham, MA 01701

Governor Deval Patrick
Secretary Richard K. Sullivan, Jr., Executive Office of Energy and Environmental Affairs
Secretary Andrea J. Cabral, Esq., Executive Office of Public Safety and Security

May 21, 2013

Massachusetts Drought Management Plan
Table of Contents

	Page
1. Introduction	1
1.1 Background	1
1.2 Purpose	1
2. Roles and Responsibilities	1
2.1 Coordination of the Task Force	1
2.2 Task Force Membership	2
2.3 Task Force Role and Responsibilities	2
2.4 Task Force Recommendations	2
3. Data Collection and Reporting	3
4. Communications	3
4.1 Communicating to the General Public	3
4.2 Communicating to Target Audiences	3
5. Drought Action Levels	5
5.1 Regional Assessment of Drought	5
5.2 Drought Levels	6
6. Drought Severity Indices	6
6.1 Drought Indices	7
6.1.1 Standardized Precipitation Index	7
6.1.2 Crop Moisture Index	7
6.1.3 Keetch-Byram Drought Index	9
6.1.4 Precipitation	9
6.1.5 Groundwater Levels	9
6.1.6 Streamflows	10
6.1.7 Reservoirs	10
6.2 Determination of the End of a Drought	10
7. Drought Response	11
7.1 Local Governments	11
7.2 Executive Office of Energy and Environmental Affairs	12
7.3 Department of Conservation and Recreation – Office of Water Resources	12
7.4 Department of Environmental Protection	12
7.5 Department of Public Utilities	12
7.6 Department of Agricultural Resources and U.S. Department of Agriculture	13

Table of Contents (continued)

	Page
7.7 Department of Conservation and Recreation – Forestry	13
7.8 Department of Fish and Game	13
7.9 Massachusetts Emergency Management Agency (MEMA)	13
7.10 Department of Public Health	14
7.11 State Drought Response Actions	14
7.12 End of Drought Conditions	14
8. Emergency Declarations-Legal Authorities and Powers	14
8.1 Local	16
8.2 State Agencies	16
8.2.1 Department of Environmental Protection	16
8.2.2 Massachusetts Water Resources Authority	17
8.2.3 Department of Public Health	18
8.2.4 Massachusetts Emergency Management Agency	18
8.2.5 Governor Declared State of Emergency	19

List of Appendices

Appendix A - Drought Management Task Force Contact List

Appendix B - Massachusetts Drought Regions; Watersheds and Associated Counties

Appendix C - MWRA Water Supply Communities – Full and Partially Served

Appendix D - Drought Preparedness for Local Governments and Water Suppliers

Appendix E - MassDEP Model Water Use Restriction Bylaw/Ordinance

Appendix F - Massachusetts Drought History Summary

List of Tables

	Page
Table 1. Information Collection Responsibilities	4
Table 2. State Agency Communications	5
Table 3. Drought Indices	8
Table 4. State Drought Action Plan	15

Massachusetts Drought Management Plan

1. Introduction

The Executive Office of Energy and Environmental Affairs (EEA) and the Massachusetts Emergency Management Agency (MEMA) have developed the Massachusetts Drought Management Plan to guide state activities in response to droughts and extended periods of dry weather. This Drought Management Plan outlines the responsibilities of various state and federal agencies, the lines of communication to be used, the general sequence of actions to be followed based on the severity of the situation, and the emergency powers available to local and state government agencies.

1.1 Background

This Plan was initially developed as part of the response to the period of precipitation deficiency from April, 1999 to March, 2000. State and federal agencies met in August 1999 at the Massachusetts Emergency Management Agency Operations Center in Framingham as an ad-hoc Drought Management Task Force (DMTF) and presented information from their respective offices on the water supply status or impacts related to water deficiency. This allowed all members to obtain a clear understanding of the situation and develop recommendations to the Secretary of Energy and Environmental Affairs on the level of drought and to the agencies on drought responses. The group continued to meet, reassessing the situation and developing further plans as the dry weather continued, and agreed that developing a Drought Management Plan with standard procedures would help to facilitate response to the current and future situations. The Drought Management Plan was developed in 2001 as a working document and has been activated several times. This plan has been updated in consultation with the Drought Management Task Force (comprising agencies and organizations that provide technical advice on drought conditions) to reflect the lessons of past experience, and to assure a thorough and responsive approach to managing drought conditions in the future.

1.2 Purpose

The purpose of the Massachusetts Drought Management Plan is to help state and federal agencies and other entities affected by drought to:

- Coordinate activities in response to drought situations;
- Identify responsibilities for information collection needed to assess the impacts caused by dry conditions;
- Establish a consistent basis for evaluating the severity of drought situations;
- Identify the lines of communications to allow the smooth flow of information to decision-makers; and
- Summarize the emergency powers available to government agencies to respond to drought situations.

2. Roles and Responsibilities

The Drought Management Task Force (DMTF) assists in monitoring, coordinating, and managing responses to droughts and recommends actions to minimize impacts to public health, safety, the environment and agriculture. The DMTF assists in collecting and assessing technical information, facilitates coordination and communication among DMTF members, and provides

advice to the Secretary of EEA, the Secretary of Public Safety and Security, and the Governor on the level of drought and agency response.

2.1 Coordination of the Task Force

Coordinating the DMTF is the joint responsibility of EEA and MEMA. Together, they:

- Convene the DMTF;
- Collect and disseminate data on the status of the drought;
- Establish DMTF meeting agendas;
- Facilitate DMTF meetings;
- Prepare DMTF meeting summaries;
- Coordinate communications between government agencies;
- Advise on communications with the general public; and
- Forward recommendations to the appropriate entities.

The DMTF is not intended to infringe upon the statutory or other obligations of its member agencies or of others who are responsible for responding to any particular situation. Both the DMTF and the coordinating agencies serve to facilitate the activities of the DMTF members and ensure there is a coordinated response by state and federal agencies to drought situations.

2.2 Task Force Membership

The Drought Management Task Force consists of officials from state and federal agencies as well as certain professional organizations that have responsibility for areas likely to be affected by drought conditions. In addition, the DMTF includes representatives of agencies that provide data related to assessing the severity of drought conditions, such as representatives from the United States Geologic Survey (USGS), National Weather Service (NWS), and other public health and safety professionals. Finally, the DMTF includes representatives of agencies that have the ability to respond to drought conditions, such as public health officials, public safety officials, and the U.S. Army Corps of Engineers. The contact list for the Task Force is presented in Appendix A.

2.3 Task Force Role and Responsibilities

The role of the DMTF is to facilitate communication and situational awareness, provide a comprehensive assessment of the situation, and develop recommendations on potential responses to drought situations. Therefore, the primary responsibilities of the Task Force are to gather the information necessary to assess the impact of dry conditions and to make recommendations to the Governor's Office, the Secretary of Energy and Environmental Affairs, the Secretary of Public Safety and Security, or others as needed. In the event of a severe drought, the DMTF makes recommendations for declaring emergencies and for developing and implementing emergency responses. Each of these responsibilities is discussed below.

2.4 Task Force Recommendations

The DMTF provides advice to the Secretary of EEA regarding the severity of the drought conditions. In cases approaching a drought emergency, the DMTF also provides advice to the Governor's Office and the Secretary of Public Safety and Security. Implementation of the DMTF recommended response actions is the responsibility of the appropriate agency or entity based on its jurisdiction or expertise. MEMA and EEA forward recommendations through the

appropriate chain(s) of command and follow up with the responsible agencies to help ensure the successful implementation of Task Force recommendations.

3. Data Collection and Reporting

Monitoring trends and collecting pertinent information is vital to making timely and accurate decisions. This Drought Management Plan describes which agencies or organizations can be relied upon to provide information for use in assessing the severity of drought conditions and impacts to the public health, economic viability and natural environment of the Commonwealth. When persistent dry conditions occur, agencies are responsible for collecting specific information for use by the DMTF (Table 1).

DCR's Office of Water Resources staff compiles these data into the Current Water Conditions in Massachusetts Report, a monthly report summarizing current water resource conditions. This report includes groundwater data, surface water data, reservoir data, precipitation data, and streamflow conditions as well as reports on fire danger and agricultural conditions.

4. Communications

Establishing clear lines of communication with the public and decision-makers to ensure they have accurate information on which to base decisions is a key component to managing droughts. This Plan outlines a general communications framework for agencies to follow.

4.1 Communicating to the General Public

It is extremely important that accurate and timely information about the current status of drought conditions and the resultant impacts are communicated to the public. EEA will communicate drought-related advice from the DMTF to state agencies. EEA's press office will be the primary vehicle through which information will be made available to the media and the general public. EEA will partner with other agencies or offices (such as MEMA, the Department of Public Health, or the Governor's Office) when jointly released public announcements are needed to bring attention to the situation or to communicate specific response actions.

Consistent messaging is the key to effective communications. If other agencies or groups determine that communication to the general public about drought response is necessary, it is recommended that they coordinate with EEA on how best to accomplish this.

4.2 Communicating to Target Audiences

In general, state agencies will be responsible for communicating with their particular constituents (Table 2). Although this Drought Management Plan is intended to facilitate coordination between state agencies, it is understood that local governments and associations play a key role in communications with their constituents, such as local water suppliers or Boards of Health.

Table 1. Information Collection Responsibilities

Information	Agency or Organization
Summary of state groundwater levels, surface water levels, streamflow conditions	Department of Conservation and Recreation (DCR) United States Geological Survey (USGS)
Summary of extended forecast (3-month intervals); summary of historical comparisons	National Weather Service (NWS)
Summary of precipitation data	DCR Office of Water Resources National Weather Service
List of communities with mandatory water bans and declared water emergencies	Department of Environmental Protection (MassDEP)
Other drinking water quality, water pressure or public health concerns associated with drinking water supplies	Department of Environmental Protection Department of Public Health Massachusetts Water Works Association (MWWA)
Quabbin and Wachusett reservoir levels	DCR and Massachusetts Water Resources Authority (MWRA)
Status of other major reservoirs throughout state	Department of Conservation and Recreation
Status of MWRA communities' water supplies	Massachusetts Water Resources Authority
Update of forest fire conditions	DCR Bureau of Forest Fire Control
Update of crop, soil, and agriculture conditions and impacts	Department of Agricultural Resources (DAR) United States Department of Agriculture (USDA) Farm Services
Summary of public utility issues	Department of Public Utilities (DPU)
Summary of public health issues	Department of Public Health (DPH) Massachusetts Association of Health Boards (MAHB)
Status of U.S. Army Corps of Engineers water resources	United States Army Corps of Engineers (USACE)
Drought Indices	Department of Conservation and Recreation
Impacts to ecosystems, flora, and fauna	Department of Fish and Game (DFG)
Other	As reported

Table 2. State Agency Communications

Entity Receiving Communications	Agency Providing Communications
General Public	EEA (DPH, MEMA, and Governor's Office as applicable) MWRA for MWRA service area
Public Water Suppliers	Department of Environmental Protection Department of Public Utilities
MWRA Community Water Suppliers	Massachusetts Water Resources Authority
Local Boards of Health	Department of Public Health Department of Environmental Protection
Foresters	Department of Conservation and Recreation
Farmers	Department Agricultural Resources
Other Large Water Users (including industrial and golf courses)	Department of Environmental Protection
Local Fire Departments	DCR Bureau of Forest Fire Control Department of Fire Services

5. Drought Action Levels

Unlike many other emergency situations, drought severity of droughts develops over time and, therefore, allows for a graduated implementation of appropriate measures. The Drought Management Plan defines action levels with appropriate levels of response, given the severity of the situation.

5.1 Regional Assessment of Drought

Although Massachusetts is relatively small, it has a number of distinct regions that experience significantly different weather patterns and react differently to the amounts of precipitation they receive. Therefore, the DMTF assesses drought conditions on a regional basis, rather than using a single statewide assessment.

The DCR precipitation index divides the state into six regions: Western, Central, Connecticut River Valley, Northeast, Southeast, and Cape and Islands (see Appendix B). Because drought conditions may vary due to precipitation patterns, these regions may be adjusted based on the conditions in any particular drought situation. For example, the DMTF may advise that a drought be defined on a watershed basis, if drought indices indicate that an entire watershed is affected but that watershed straddles a region that would otherwise not be considered to be affected by drought. In addition, areas served by water supplies outside of their regions (most notably the Massachusetts Water Resources Authority (MWRA) water communities) have their drought conditions, as applied to their water supplies only, assessed by the capacities of their systems, rather than by the regional indices. For all other purposes, regional indices are used to assess drought conditions of areas served by water supplies outside of these regions. A regional approach allows customization of drought actions and conservation measures to address

particular situations in each region. Because the regions differ in population, density, water demand, topography, and runoff characteristics, different responses may be needed.

5.2 Drought Levels

Five levels of drought have been developed to characterize drought severity:

- Normal
- Advisory
- Watch
- Warning
- Emergency

These drought levels are based on the conditions of natural resources and are intended to provide information on the current status of water resources. The levels provide a basic framework from which to take actions to assess, communicate, and respond to drought conditions. They begin with a normal situation where data are routinely collected and distributed, move to heightened vigilance with increased data collection during an advisory, to increased assessment and proactive education during a watch. Water restrictions might be appropriate at the watch or warning stage, depending on the capacity of each individual water supply system. A warning level indicates a severe situation and the possibility that a drought emergency may be necessary. A drought emergency is one in which mandatory water restrictions or use of emergency supplies is necessary.

The action levels specified in this document are a general plan of action to coordinate statewide response to drought situations. However, numerous individual agencies have particular responsibilities that they are responsible for implementing on an ongoing basis. In addition, individual communities have a range of actions they can take to manage their systems during droughts. Drought levels are also defined in community drought management plans. These local drought indices should factor in both water resource conditions and system specific responses to those conditions at the local level. Because local drought management plans are system specific, the terminology for drought action levels may differ. Also, actions taken based on assessment of local conditions may not progress through the same levels outlined above.

6. Drought Severity Indices

As dry conditions can have a range of different impacts, a number of drought indices are available to assess these various impacts. The Commonwealth uses a multi-index system that takes advantage of several of these indices to determine the severity of a given drought or extended period of dry conditions.

Drought level is determined monthly based on the number of indices which have reached a given drought level. In practice, the drought level designation has been based upon the condition in which the majority of the drought indices occur. That is, a majority of the indices would need to be triggered in a region in order for a drought designation for that region to move to a more severe level. Drought levels are declared on a regional basis for each of six regions in Massachusetts: Northeast, Southeast, Central, Connecticut River, Western, Cape Cod and

Islands. County by county or watershed-specific determinations may also be made. A map and list of the regions, and the counties included in the regions is included in Appendix B.

Once a drought level of warning and emergency have been reached for the precipitation index, conditions must improve to those of the previous level before a determination is made to reduce the warning or emergency.

6.1 Drought Indices

A determination of drought level is based on seven indices: Standardized Precipitation Index, Crop Moisture Index, Keetch-Byram Drought Index, Precipitation, Groundwater levels, Streamflow levels, and Index Reservoir levels. In the 2001 Drought Management Plan, the Palmer Drought Severity Index was included as an index, however it was found to be non-responsive to drought conditions in 1999 and 2001-2002. Thus, the Palmer Drought Index was replaced with the Standardized Precipitation Index. The 2001 Drought Management Plan also used a daily Fire Danger Index; this was replaced with the Keetch-Byram Drought Index in 2010 on the recommendation of the DCR Bureau of Forest Fire Control. The KBDI gives a longer-term indication of drought conditions related to the severity of forest fire behavior (fuel moisture), that affect potential fire spread and the resources needed to extinguish fires. The KBDI is less subject to daily fluctuations than the daily fire danger rating. A detailed description of each index is provided below. Thresholds for each of the drought indices at different levels of drought are specified in Table 3.

6.1.1 Standardized Precipitation Index – The Standardized Precipitation Index (SPI) reflects soil moisture and precipitation conditions; calculated monthly using Massachusetts Rainfall Database at DCR, Office of Water Resources. SPI values are calculated for "look-back" periods of 1 month, 3 months, 6 months, and 12 months. The SPI values for the time periods are equivalent to the precipitation total's number of standard deviations from the normal for that time period. Drought thresholds for look-back periods of 3-month, 6-month, and 12-months are specified in Table 3. Additional information regarding the SPI method can be found online at http://www.drought.unl.edu/whatis/indices.htm#spi.

6.1.2 Crop Moisture Index – The Crop Moisture Index (CMI) reflects short-term soil moisture conditions as used for agriculture; available from the National Climate Data Center. The crop moisture index was developed by Palmer (Palmer, W.C., 1968. Keeping track of crop moisture conditions, nationwide: The new Crop Moisture Index. Weatherwise 21:156–161) to assess short-term crop water conditions and needs across major crop-producing regions. It is based on the concept of abnormal evapotranspiration deficit, calculated as the difference between computed actual evapotranspiration (ET) and computed potential evapotranspiration (i.e., expected or appropriate ET). Actual evapotranspiration is based on the temperature and precipitation that occurs during the week and computed soil moisture in both the topsoil and subsoil layers. The maps are issued weekly and can be found on-line at: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/cmi.gif.

.

Table 3. Drought Indices

Drought Level	Standardized Precipitation Index	Crop Moisture Index*	Keetch-Byram Drought Index*	Precipitation	Groundwater	Streamflow	Reservoir***
Normal	3-month > -1.5 **or** 6-month > -1.0 **or** 12-month > -1.0	0.0 to -1.0 slightly dry	< 200	1 month below normal	2 consecutive months below normal**	1 month below normal**	Reservoir levels at or near normal for the time of year
Advisory	3-month = -1.5 to -2.0 **or** 6-month = -1.0 to -1.5 **or** 12-month = -1.0 to –1.5	-1.0 to -1.9 abnormally dry	200-400	2 month cumulative below 65% of normal	3 consecutive months below normal**	At least 2 out of 3 consecutive months below normal**	Small index Reservoirs below normal
Watch	3-month < -2.0 **or** 6-month = -1.5 to -3.0 **or** 12-month = -1.5 to -2.0	-2.0 to –2.9 excessively dry	400-600	1 of the following criteria met: 3 month cum. < 65% **or** 6 month cum. < 70% **or** 12 month cum. < 70%	4-5 consecutive months below normal**	At least 4 out of 5 consecutive months below normal**	Medium index Reservoirs below normal
Warning	6-month < -3.0 **or** 12-month = -2.0 to -2.5	< -2.9 severely dry	600-800	1 of the following criteria met: 3 month cum. < 65% and 6 month cum. <65%, **or** 6 month cum. <65% and 12 month cum. <65%, **or** 3 month cum. <65% and 12 month cum. <65%	6-7 consecutive months below normal**	At least 6 out of 7 consecutive months below normal**	Large index reservoirs below normal
Emergency	12-month < -2.5	<-2.9 severely dry	600-800	Same criteria as Warning and previous month was Warning or Emergency	>8 months below normal**	>7 months below normal**	Continuation of previous month's conditions

* The Crop Moisture Index is subject to frequent change. The drought level for this indicator is determined based on the repeated or extended occurrence at a given level.

** Below normal for groundwater and streamflow are defined as being within the lowest 25th percentile of the period of record.

*** Water suppliers should be consulted to determine if below normal reservoir conditions are due to operational issues.

6.1.3. Keetch-Byram Drought Index – The Keetch-Byram Drought Index (KBDI) is designed specifically for fire potential assessment (Keetch, John J; Byram, George. 1968. A drought index for forest fire control. Res. Paper SE-38. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 32pp. [Revised 1988]). It is a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers. It is a continuous index, relating to the flammability of organic material in the ground.

The KBDI attempts to measure the amount of precipitation necessary to return the soil to full field capacity. It is a closed system ranging from 0 to 800 units and represents a moisture regime from 0 to 8 inches of water through the soil layer. At 8 inches of water, the KBDI assumes saturation. Zero is the point of no moisture deficiency and 800 is the maximum drought that is possible. At any point along the scale, the index number indicates the amount of net rainfall that is required to reduce the index to zero, or saturation.

The inputs for KBDI are weather station latitude, mean annual precipitation, maximum dry bulb temperature, and the last 24 hours of rainfall. Reduction in drought occurs only when rainfall exceeds 0.20 inch (called net rainfall). The computational steps involve reducing the drought index by the net rain amount and increasing the drought index by a drought factor.

- KBDI = 0 - 200: Soil moisture and large class fuel moistures are high and do not contribute much to fire intensity. Typical of spring dormant season following winter precipitation.
- KBDI = 200 - 400: Typical of late spring, early growing season. Lower litter and duff layers are drying and beginning to contribute to fire intensity.
- KBDI = 400 - 600: Typical of late summer, early fall. Lower litter and duff layers actively contribute to fire intensity and will burn actively.
- KBDI = 600 - 800: Often associated with more severe drought with increased wildfire occurrence. Intense, deep burning fires with significant downwind spotting can be expected. Live fuels can also be expected to burn actively at these levels.

(The text above is from U.S. Forest Service, Wildland Fire Assessment System, http://www.wfas.net/index.php/keetch-byram-index-moisture--drought-49). The KBDI is reported weekly from 13 Massachusetts fire districts by the DCR Bureau of Fire Control. This data is not available on-line.

6.1.4 Precipitation – The Precipitation Index is a comparison of measured precipitation amounts (in inches) to historic normal precipitation. Cumulative amounts for 3-, 6-, and 12-month periods are factored into the drought determination. This data is available from the DCR, Office of Water Resources. DCR publishes a monthly Water Conditions Report and Precipitation Composite Report, available on-line at: http://www.mass.gov/dcr/watersupply/rainfall/.

6.1.5 Groundwater Levels – The Groundwater Level Indix is based on the number of consecutive months groundwater levels are below normal (lowest 25% of period of record for the respective months). The U.S. Geological Survey (USGS) monitors groundwater levels in a

network of monitoring wells throughout Massachusetts. Groundwater conditions maps showing areas of above normal, normal and below normal (monthly conditions compared to monthly normals) are provided by the USGS on a monthly basis. Also, DCR provides a table specifying whether each Massachusetts Drought Region experienced normal, above-normal, or below normal ground water levels each month and includes this information in a monthly report, Current Water Conditions in Massachusetts (available at http://www.mass.gov/dcr/watersupply/rainfall/index.htm).

6.1.6 Streamflows – The Streamflow Index is based on the number of consecutive months that streamflow levels are below normal (lowest 25% of period of record for the respective months). The USGS monitors streamflow in a network of gages throughout Massachusetts. Streamflow conditions maps showing areas of above normal, normal and below normal (monthly conditions compared to monthly normals) are provided by the USGS on a monthly basis. In addition, USGS provides a table that describes the cumulative monthly streamflow condition as normal, above-normal, or below normal. USGS monthly reports can be found online at: http://ma.water.usgs.gov/current_cond/cwrc_statements.htm.

6.1.7 Reservoirs – The Reservoir Index is based on the water levels of small, medium and large index reservoirs across the state. The reservoir level relative to normal conditions for each month of the year will be considered. As part of its monthly conditions report, DCR, Office of Water Resources maintains a list of index water supply reservoirs and the percentage at which they are at capacity as well as non-water supply index reservoir levels, as available. Reservoir data are summarized in the DCR monthly Water Conditions Reports, available on-line at: http://www.mass.gov/dcr/watersupply/rainfall/. A reservoir level is considered below normal for the month when it reaches less than one standard deviation below its normal (average) for the month for the period of record.

6.2 Determination of the End of a Drought

Determinations regarding the end of a drought or reduction of the drought level focus on two key drought indicators: precipitation and groundwater levels. These two factors have the greatest long-term impact on streamflow, water supply, reservoir levels, soil moisture and potential for forest fires. Precipitation is a key factor because it is the overall cause of improving conditions. Groundwater levels respond slowly to improving conditions, so they are good indicators of long-term recovery to normal conditions.

Recommendations to the Secretary of EEA or the Governor's Office for a drought action level can occur in one of three ways after the first month it has been reached. If conditions reach the criteria for the next drought level, the DMTF will recommend that the severity of the drought action level be increased. If conditions persist but do not reach the next level, the DMTF will recommend that the drought action level be held constant. If conditions improve, the DMTF will recommend that the severity of the drought action level be reduced based on either site-specific information or on progress toward returning to normal.

A drought emergency will end when the conditions that led to the specific emergency have abated. For example, a critically low reservoir will need to have made a significant recovery, or groundwater wells will need to have returned to normal operating capacities. If an emergency

has been declared based on environmental impacts, the emergency will end when these conditions have abated.

Drought warnings, watches and advisories can be reduced based on: 1) normal levels of precipitation, and 2) groundwater levels within the "normal" range. Normal levels of precipitation are those described in Table 4, less severe than the Advisory level criteria. USGS defines normal as groundwater levels that are in the range of 25th-74th percentile of the period of record. Therefore, groundwater levels within the normal range can include a situation when groundwater levels are lower than an average condition.

In order to return to a normal status, groundwater levels must be in the normal range and/or one of two precipitation measures must be met. The precipitation measures are: 1) three months of precipitation that is cumulatively above normal, and 2) long-term cumulative precipitation above normal. The period for long-term cumulative precipitation ranges from 4 to 12 months, depending on the time of year. Precipitation falling during the fall and spring is ideal for groundwater recharge and, therefore, will result in the quickest return to normal conditions. Because the same levels of cumulative precipitation can differ in their abilities to reduce drought conditions, the decision to reduce a drought level will depend on the professional judgment of the Secretary of EEA with input from his agencies and the DMTF.

As part of this interpretation of the short and long-term measures, is the need to discount the effect of short-duration large storms such as hurricanes when considering precipitation. While these storms may return long-term precipitation levels to normal and may fill reservoirs, they often do little to replenish groundwater levels necessary for long-term water resource protection. Their review will also take into account other data as reported from appropriate agencies and organizations (as described in Section 3 of this Plan).

A majority of the indices are not used to determine an end of a drought because many of the indices will tend to return to normal at some point during the year. For example, the Crop Moisture Index returns to normal at the end of the growing season. The Fire Danger season ends with snowfall. In addition, the end of a drought is easily defined by rainfall and groundwater levels, which have the most significant impact on the other indices.

7. Drought Response

7.1 Local Governments

Local governments or waters suppliers, either independently or in conjunction with MassDEP and DPU, are responsible for the management of their systems to ensure that they can provide water sufficiently to meet public health and safety needs. Though this drought plan is intended to coordinate the state and federal agencies as they work with local governments and others to assess and respond to dry conditions and droughts, the agencies recognize the fundamental role that local governments play. Key to this function is ensuring that local suppliers have up-to-date emergency response plans that include plans for responding to droughts and identifying existing and potential emergency water supplies. It also includes ensuring that the public and elected officials at the local level are educated on the need to impose water restrictions and other measures early so that serious deficits, pressure problems or water quality issues are avoided to

the greatest extent possible. Appendix E outlines the major elements that water suppliers should have in place to ensure their readiness for drought situations.

When dry conditions occur, actions by local government and water suppliers can range from requesting voluntary reductions in water use to declarations of local water emergencies (either under local bylaw or through petition to the MassDEP) based on the status of their local water supplies. These local decisions are made independently of the state responses outlined below. In addition, it is anticipated that state drought status levels and communication to water suppliers about such levels will prompt local action by communities. It should also be noted that regardless of drought conditions, many water suppliers with Water Management Act permits are required to institute non-essential outdoor water use restrictions as a result of their permit conditions.

7.2 Executive Office of Energy and Environmental Affairs

As a state Cabinet-level office, the Executive Office of Energy and Environmental Affairs (EEA) oversees both environmental and energy agencies, including MassDEP, DCR, DFG and DAR. During a drought, EEA serves as Co-Chair of the DMTF, convening DMTF members and considering their technical input in making a decision about the geographical extent and severity of drought conditions. Typically, EEA handles all coordination with the media during less severe droughts. During more severe droughts and in special circumstances, EEA coordinates communications with other agencies or offices (such as MEMA, the Department of Public Health, or the Governor's Office).

7.3 Department of Conservation and Recreation – Office of Water Resources

Every month, DCR's Office of Water Resources prepares a report entitled, Current Water Conditions in Massachusetts. The report describes precipitation trends, dry periods, high or low river flow conditions, and ground water levels, and reviews the current water year. In addition, DCR manages the state's Rainfall Program, a network of approximately 150 precipitation observation stations, operated by volunteers throughout Massachusetts, and a precipitation database for research and analysis, uses its precipitation data to calculate a composite of precipitation conditions statewide and in the six drought regions. During a drought, DCR staff continues to prepare the Current Water Conditions Report and plays a key internal coordination role, assisting in DMTF meeting preparation and acting as a liaison between the DMTF Co-Chairs and the agencies responsible for data collection and analyses.

7.4 Department of Environmental Protection

MassDEP has the authority to declare water emergencies for communities facing public health or safety threats as a result of the status of their water supply systems, whether caused by drought conditions or for other reasons. Such local-based response is perhaps the most important element in managing public water supplies during drought situations as almost all water supplies are locally or regionally controlled. The MassDEP's authority to declare local emergencies is outlined in detail in section 8.2.1 of this plan.

7.5 Department of Public Utilities

DPU's Water Division oversees investor-owned water utilities or every person, partnership, association or corporation, other than a municipal corporation, and other than a landlord

supplying his tenant, engaged in the distribution and sale of water in the Commonwealth through its pipes or mains. This excludes municipally-owned water systems, water and fire districts, and homeowner associations that provide water service. DPU would oversee a water company seeking alleviate the effects of a long-term drought or frequently occurring droughts by purchasing or taking by eminent domain waters or lands for collecting, storing, holding, purifying, and preserving water within its franchise territory. Also, DPU is able to grant a water company the authority to acquire and hold real estate beyond amounts limited by the company's charter or special laws if DPU finds that such additional real estate is necessary or convenient for the company to carry out the purposes of its organization and the acquisition and holding will not be contrary to the public interest.

7.6 Department of Agricultural Resources and U.S. Department of Agriculture

Crop losses can pose severe financial impacts on farmers, aquaculturists, and other agricultural businesses. The Department of Agricultural Resources is responsible for recommending to the Governor, through the Secretary of Energy and Environmental Affairs, an emergency declaration or other needed steps based on either actual or predicted impacts to agricultural products. This declaration is often made in anticipation of crop failures so that the Commonwealth will be eligible to receive federal disaster assistance from the U.S. Department of Agriculture. The Department of Agricultural Resources is also responsible for communicating with USDA to determine the types and timing of federal assistance that may be available and ensure that the state applies for such assistance as needed. If the assistance is available to individual farms, the Department works to ensure that these farmers are aware of the aid that is available to them.

7.7 Department of Conservation and Recreation - Forestry

Risk of fires in wild land, rural areas, state forests and parks are linked to dry conditions. In addition, a drought can impact the availability of water for fire suppression. Assessment of fire risk and management of fire control resources is an on-going activity of the Bureau of Forest Fire Control under the Department of Conservation and Recreation. It is the responsibility of DCR Director of Forestry to manage state fire suppression resources and to coordinate with other local, state, federal agencies and other states to coordinate the appropriate resources given the situation.

7.8 Department of Fish and Game

Dry conditions can lead to impacts to fisheries and wildlife, including reducing habitat, fish kills, displacement of certain populations of animals, or increased human-wildlife interactions that include mortality or injury, population losses, and inability to find sufficient refugia. Drought can result in impacts to individual organisms but can also impact populations. The Department of Fish and Game's Division of Fisheries and Wildlife serves as first responder to fish kills through a formal interagency Memorandum of Understanding between DFW, MassDEP, DAR, and the Office of Law Enforcement, as well as through the collection and analysis of reports of human-wildlife interactions such as sightings, property damage, and public health and safety threats. Responses to these reports may include education and information through various communication methods, technical assistance, site visits, referral to licensed problem-animal control agents, and, in certain instances, response from the interagency large-animal response team. Responses to drought also include identifying impacts to specific fisheries and wildlife populations as they are developing so that DFG and other agencies, such as local governments or

MassDEP, can implement measures to reduce the impacts to these resources. In some cases, population impacts may require regulatory changes to hunting seasons, permits, bag limits, species listing, or site-specific habitat management actions, or the regulatory review of projects that might impact the habitat of state-listed rare species.

7.9 Massachusetts Emergency Management Agency (MEMA)

Dry conditions can have severe impacts on public water supply providers, farmers and other water users. MEMA serves as a Co-Chair of the DMTF and is responsible for coordination of Federal, State, local, voluntary and private resources during an emergency. MEMA's network includes public health and safety officers, emergency management, fire, police, public works and transportation officials, non-profit and volunteer agencies, private businesses and industry and the Federal Emergency Management Agency. MEMA's coordination effort includes rapid deployment of appropriate resources to sustain public health and safety.

MEMA is responsible for maintaining the Massachusetts Comprehensive Emergency Management Plan (CEMP). The Massachusetts CEMP establishes the fundamental policies, basic program strategies, assumptions and mechanisms through which the Commonwealth will mobilize resources and conduct activities and support local government efforts through response and recovery. The Massachusetts Drought Management Plan is an addendum to the CEMP.

7.10 Department of Public Health

Dry conditions can impact the availability of water and the quality of water. Low water pressures can result in bacteria problems in water distribution systems. Low water levels in surface water supplies can also result in water quality problems. The Department of Public Health (DPH) in conjunction with MassDEP monitors drinking water quality in communities. DPH also provides notification to communities on necessary steps to purify drinking water.

7.11 State Drought Response Actions

As dry conditions persist, agencies direct their drought responses to regions of the state based on the regional assessment of drought levels. Responses by the agencies (Table 4) range from collection and sharing of information during normal conditions; to increased coordination and communications during drought advisories, watches, and warnings; to declaration of a State of Emergency by the Governor during a drought emergency. These actions are not intended to limit or inhibit the discretion of the agencies as they undertake certain activities. Also, some actions may be triggered by particular drought indices and do not rely on the triggering of a majority of the Drought Management Plan indices. The definition of each drought level was provided in the Section 5 of this Plan.

7.12 End of Drought Conditions

Once a drought has ended, as defined in Section 6.2, relevant agencies and organizations should communicate this information to their target audiences, described in Section 4.2. This message should not only include an update on the current conditions, but should communicate the need for general conservation measures and emergency planning as part of good water resource management practice.

Table 4. State Drought Action Plan

Drought Level	Response/Actions
Normal Conditions	(1) DCR collects basic weather and hydrological data and produces the monthly Current Water Conditions in Massachusetts Report. (2) MassDEP encourages communities to adopt local bylaws that provide for drought related contingency plans.
Drought Advisory	(1) DCR distributes monthly summary of dry conditions (Current Water Conditions in Massachusetts Report) to DMTF. (2) MassDEP communicates with municipalities and Massachusetts Water Works Association about dry conditions. (3) EEA/MEMA contact members of DMTF and call a meeting to discuss drought. (4) DMTF recommends to the Secretary of EEA that a Drought Advisory be issued. (5) EEA, in coordination with the Governor's Press Office, develops draft news release as necessary. (6) EEA/MassDEP/DCR/DPH begin to coordinate on a regular basis to exchange information regarding status of drinking water supplies. (7) EEA/DAR/DFG/MassDEP/DCR begin to coordinate on a regular basis to exchange information regarding the status of agriculture, fisheries, wildlife impacts (8) Agencies expand data collection and monitoring. Forward Current Water Conditions in Massachusetts Report to drought DMTF coordinators.
Drought Watch	(1) DMTF coordinates assessment and recommendations. (2) Intensified monitoring and appraisal of drought situation through information gathering of state agencies. (3) MassDEP offers technical assistance to communities on managing systems, including assistance on use of emergency connections and supplies. (4) MassDEP ensures that towns know how to request a declaration of drought emergency. (5) DAR/DFG provide more detailed assessment of environmental/agricultural impacts of worsening conditions. (6) DMTF recommends to the Secretary of EEA that a Drought Watch be issued. (7) EEA prepares memorandum on status of situation for Governor's Office, Secretary of Energy and Environmental Affairs, Secretary of Public Safety and Security, and other applicable agencies. (8) EEA, in coordination with the Governor's Office, develops media strategy, including draft news release as necessary, to communicate information on drought. (9) DMTF coordinators consider utilizing Mass 2-1-1 and mass notification systems to advise the public of current conditions and general conservation measures. (10) DMTF initiates contact and planning efforts with federal agencies.
Drought Warning	(1) DMTF coordinates assessment and recommendations. (2) State agencies intensify monitoring and appraisal of drought situation through information gathering. (3) DMTF recommends to the Secretary of EEA that a Drought Warning be issued. (4) EEA, in coordination with the Governor's Office, implements press strategy to keep media and public informed about the situation. (5) DMTF develops measures to reduce water use and protect public and vital health, economic, and environmental interests. Fully implements and promotes public information and technical assistance. (6) DMTF collect information on availability and use of emergency sources of water. (7) DPH works closely with local boards to assess public health threats and take actions as needed. (8) MEMA/EEA initiate contact and planning with New England states and New York regarding situation and to alleviate drought impacts. (9) MEMA prepares Governor Proclamation of a State of Emergency. (10) EEA recommends to Governor on communications strategy. (11) MEMA/EEA/DAR develop recommendations for special legislation and/or funding. (12) MEMA/DAR begin process to utilize appropriate federal assistance options.
Drought Emergency	(1) MEMA/MassDEP: Finalize Governor Proclamation of a drought emergency to utilize state emergency authorities and powers to restrict water uses and implement measures to provide emergency water supplies. (2) DMTF continues to coordinate response of state, local and federal agencies. (3) MEMA/DAR/MassDEP: Work to secure emergency funding and/or legislation. (4) MEMA/DAR: Secure federal assistance.

8. Emergency Declarations-Legal Authorities and Powers

The following section discusses the local, state, and federal authorities and powers related to drought situations. This section provides a general summary of the laws applicable to drought issues. However, the appropriate legal staff should be consulted in advance of the use of any of these powers by a state agency.

8.1 Local

Municipal governments are critically important to managing drought situations and assessing the impact of drought situations. Municipal governments that own, operate or oversee a public water supply are responsible for putting in place either voluntary or mandatory water use restrictions. State level response to droughts is premised on the assumption that local authorities are taking all necessary action to manage drought situations and to protect public health and the environment.

Municipalities are authorized to adopt and implement bylaws in appropriate circumstances. For example, they may regulate public water supply pipes or to manage their prudential affairs and preserve peace and good order under their police powers, pursuant to G.L. c. 40, § 21, and c. 41, § 69B. Municipalities, which have established water supply or distributing systems, may regulate through such bylaws the use of water from the municipal system. Further, when MassDEP determines that an emergency exists in the case of a drought or disaster, a municipality may, following appropriate notice, regulate or otherwise restrain the use of water on public or private property (regardless of whether the supply source is public or private) pursuant to G.L. c. 40, § 41A. Municipalities, particularly those that experience chronic water shortages, are encouraged to promulgate bylaws to address necessary rules for responding to an actual or threatened drought condition. A model water use restriction bylaw is provided in Appendix E.

In the event of a declared emergency, a municipality may, generally, raise, appropriate, and expend money for the purposes of maintaining, distributing and providing at reasonable rates a sufficient supply of the common necessities of life, which includes water.

8.2 State Agencies

8.2.1 Department of Environmental Protection

MassDEP's authority for addressing water supply shortage emergencies is derived from the Water Management Act, M.G.L. c. 21G, §§ 15-17 and from M.G.L. c. 111, § 160, related to ensuring the provision of safe drinking water.

Any operator of a public water system, such as a municipality, water company or other public agency, may petition MassDEP to declare a state of water emergency. M.G.L. c. 21, § 15 (1998). In declaring such a state, MassDEP must find that "there exists or impends a water supply shortage of a dimension which endangers the public health, safety or welfare." Id. MassDEP must limit the applicability of the state of water emergency to the petitioning municipality or to the area served by the petitioning public water supplier, whichever the case. Id.

In declaring a state of water emergency, MassDEP may require the municipality or water supplier to submit a plan, which must be approved by MassDEP, designed to address and resolve

the emergency. This plan may include provisions for shutting off water on public or private property, and MassDEP may further require the following: (1) an approved water resources management plan; (2) a leak detection program; (3) a program for auditing water use; (4) a program for overall system rehabilitation; (5) conservation programs for public and private buildings; (6) bans or restrictions on certain water uses; (7) a moratorium on the issuance of building permits; (8) a plan for establishing priority for distribution of water among competing uses; and, (9) drought management or contingency plans.

Once a state of water emergency is declared, MassDEP has significant authority to address the emergency. MassDEP may take by eminent domain the right to use any land for the time necessary to use water on the land for addressing the emergency. M.G.L. c. 21, § 16 (1998). In the case of a water emergency affecting the MWRA system, DCR, rather than MassDEP, has such eminent domain authority. Id. This eminent domain authority seems narrower than that which the Governor may exercise following a declaration of a state of emergency under the Massachusetts Civil Defense Act (M.G.L. Chapter 639, CDA. Further, any such taking by eminent domain must be approved by the municipality in which the proposed taking will occur.

During a state of water emergency, MassDEP may issue orders, applicable within or outside the affected area of the water emergency, to: (1) establish priorities for the distribution of any water or quantity of water use; (2) permit any person engaged in the operation of a water supply system to reduce or increase by a specified amount or to cease the distribution of that water; to distribute a specified amount of water to certain users as specified by the department; or to share any water with other water supply systems; (3) direct any person to reduce, by a specified volume, the withdrawal or use of any water; or to cease the withdrawal or use of any water; (4) require the implementation of specific water conservation measures; and, (5) mandate the denial, for the duration of the state of water emergency, of all applications for withdrawal permits within the areas of the Commonwealth to which the state of water emergency applies.

MassDEP is also granted broad powers to protect the public health through the oversight of water supplies as provided in M.G.L. c. 111, § 160. This section gives the Department the ability to "…make rules and regulations and issue such orders as in its opinion may be necessary to prevent the pollution and to secure the sanitary protection of all such waters used as sources of water supply and to ensure the delivery of a fit and pure water supply to all consumers." The statute also provides MassDEP the ability to "make such orders relative thereto (complaints about water supplies) as it may deem necessary for the protection of the public health and to restrain the use of such waters to the extent as in its opinion such use will tend to adversely affect the public health."

Violation of orders, rules or regulations under this section are punishable by either fines of up to $25,000 per day for each day a violation occurs or by imprisonment for not more than one year, or both; or by a civil penalty up to $25,000 per day for each day a violation occurs.

8.2.2 Massachusetts Water Resources Authority

The MWRA, which serves the water needs of many municipalities in the metropolitan Boston area, is generally authorized to develop programs, procedures and regulations for water conservation, leak detection and repair. M.G.L. c. 92 App., § 1-8(m) (1998). Such programs

and regulations may also provide for "water use limitations in the time of drought or other emergency." Id. With respect to water emergencies, MWRA and its communities have the power to provide connection and supply to adjoining communities under an order from MassDEP with appropriate compensation to MWRA. Section 8 (d). This is parallel to MassDEP's powers under c. 21G, but doesn't go beyond them. Further, in an emergency situation, MWRA is authorized to incur expenses in excess of those shown in its annual budget. M.G.L. c. 92 App., § 1-8(b) (1998).

The MWRA has developed a drought management plan for its system that is tailored to the capacity of its system. The MWRA has daily on-line tracking of its system, including reservoir levels and system demand, as well as sophisticated modeling ability to predict the ability of the MWRA system to meet short and long-term demands. The MWRA drought management plan should be referred to for more details.

MWRA is charged with promoting water conservation, protecting the adequacy of a pure water supply and improving environmental quality under M.G.L. c. 92 § 8(e) and has general authority to promote leak detection and water conservation through its regulations, charges and other programs under Section 8(m). Section 8(m) specifically includes water use limitations in time of drought or other emergency.

8.2.3 Department of Public Health

The Department of Public Health (DPH) has broad authority over matters affecting public health and is mandated to "take cognizance of the interests of life, health, comfort and convenience among the citizens of the commonwealth." M.G.L. c.111 § 5. DPH is specifically mandated to "conduct sanitary investigations and investigations as to the causes of disease…" M.G.L. c. 111 § 5. With regard to water quality, MassDEP is required to report to DPH any violations of MassDEP regulations relating to drinking water quality standards and, based upon that report or upon its own investigation, DPH may order the appropriate party to cease violating the water quality standards and take whatever steps are necessary to purify the water. If any such order of DPH conflicts with any order of MassDEP, the order of DPH takes precedence. M.G.L. c. 111 § 160B. MassDEP regulations require MassDEP to report to DPH all violations of MassDEP drinking water regulations and to consult with DPH with regard to enforcement actions taken to obtain compliance with MassDEP drinking water regulations 310 CMR 22.03(4).

In addition, pursuant to M.G.L. c. 111 §127A, DPH has promulgated State Sanitary Code Chapter II, entitled Minimum Standards of Fitness for Human Habitation, which requires all owners of residential dwellings to provide a potable water supply. 105 CMR 410.180. Local boards of health have primary authority to enforce the sanitary code requirements, but DPH may enforce these regulations if the local board of health fails to act.

8.2.4 Massachusetts Emergency Management Agency

MEMA is responsible for direction and control of all state emergency operations as outlined in Chapter 639, Acts of 1950. The Massachusetts Comprehensive Emergency Management Plan (CEMP) is the framework for managing preparedness, response, recovery and mitigation actions at all levels of government in the Commonwealth. Utilizing the CEMP, MEMA coordinates state, federal, and private resources with regard to planning, response and recovery activities.

The Drought Management Plan is an example of such coordination between EEA and MEMA. Should a declaration of a state of emergency be warranted as a result of drought conditions, the CEMP would be the framework for response and recovery actions.

Executive Order 144, issued in 1978 to facilitate planning for, and operations during disasters and emergencies, requires state agencies to designate liaison officers to MEMA for the purposes of coordinating resources, training and operations. The Massachusetts Emergency Management Team (MEMT) consists of these representatives who are authorized to deploy the resources which their organizations can provide to local governments during emergencies or disasters. A list of the agencies and their responsibilities is available in the CEMP.

8.2.5 Governor-Declared State of Emergency

The Commonwealth has several established mechanisms for responding to drought conditions. The legislature has placed the primary statutory-based drought management tools at the disposal of the Governor and the MassDEP.

Chapter 639 of the Acts of 1950, as amended by Chapter 425 of the Acts of 1958, (the "Civil Defense Act" or "CDA") allows the Governor to proclaim a state of emergency to address certain situations, which may occur in all or in a part of the Commonwealth. When it may be reasonably anticipated that the health, safety or property of the citizens will be endangered, the Governor may declare the existence of such an emergency situation due to a shortage of water resulting from an absence of rainfall or from the occurrence of a disaster or catastrophe of natural causes. Section 5 of Chapter 639 of the Acts of 1950, as amended. A proclamation of such a state of emergency provides the Governor with expansive power, authority and discretion to address and resolve the declared emergency.

During a state emergency, section 5(a) of the CDA provides the Governor the authority to employ every agency and the members of every department towards protection of the lives and property of the citizens and to enforce the law. Under section 5(b) of the CDA, the Governor may, in the event of a disaster or shortage that makes such action necessary for the protection of the public, take possession of land and many types of personal property, permanently or temporarily. The owner of any such property taken, however, is entitled to just compensation for its value. Section 7 of the CDA provides the Governor with the authority "to exercise any and all authority over persons and property, necessary or expedient for meeting the state of emergency," including for example, policing, protecting or preserving all property, public or private. This broad authority should provide the Governor the power to take necessary steps, such as restraining the use of water on private property, to address an actual or threatened drought.

In addressing threatened disaster or danger of drought to civil defense, pursuant to section 4 of the CDA, the Governor has the authority to cooperate with federal authorities and other states, propose a comprehensive plan and program, conduct studies and surveys, ascertain the capabilities of the Commonwealth, and delegate any such administrative authority provided to him under the Civil Defense Act. Pursuant to Section 8 of the CDA, the Governor may exercise, in advance, any powers conferred under the CDA as requires preparation <u>in anticipation</u> of a declaration of an emergency, including issuing executive orders or promulgating regulations.

The violation of any such executive order or regulation shall be punished by imprisonment for not more than one year or by a fine not to exceed $5,000, or both.

APPENDIX A
Drought Management Task Force Contact List

STATE CONTACTS

Executive Office of Energy and Environmental Affairs
Kathleen Baskin
Director of Water Policy
(617) 626-1012
kathleen.baskin@state.ma.us

Massachusetts Emergency Management Agency
Kurt Schwartz
Undersecretary for Homeland Security &
Director of MEMA
(508) 820-2010
kurt.schwartz@state.ma.us

Peter Judge
Public Information Officer
(508) 820-2002
peter.judge@state.ma.us

Paul Holloway
Planning Manager
(508) 820-1421
paul.holloway@state.ma.us

Allen Phillips
Operations Manager
(508) 820-1426
allen.phillips@state.ma.us

Department of Conservation and Recreation
Jonathan Yeo
Director of Water Supply Protection
(617) 626-4987
jonathan.yeo@state.ma.us

Anne Carroll
Director, Office of Water Resources
(617) 626-1395
anne.carroll@state.ma.us

Dave Celino
Chief Fire Warden
(617) 626-4981
david.celino@state.ma.us

Scott Bassett
Fire Warden
(508) 497-0147
scott.bassett@state.ma.us

Bill Gode
Director Flood Control Management
(617) 727-0488
william.gode@state.ma.us

Bruce Hansen
Geologist
(617) 626-1388
bruce.hansen@state.ma.us

Linda Hutchins
Hydrologist
(617) 626-1384
linda.hutchins@state.ma.us

Mike Misslin
Acting Chief Engineer
(617) 626-4927 (office)
(617) 828-1649 (cell)
mike.misslin@state.ma.us

Department of Environmental Protection
Paul Blain
Drinking Water Program
(617) 292-5948
paul.blain@state.ma.us

Duane LeVangie
Director, Water Management Program
(617) 292-5706
duane.levangie@state.ma.us

Tom Maguire
Wetlands
(617) 292-5602
thomas.maguire@state.ma.us

Department of Fish and Game
Todd Richards
Fisheries Biologist
(508) 389-6336
todd.richards@state.ma.us

Laila Parker
Watershed Ecologist
(617) 626-1533
laila.parker@state.ma.us

Department of Agricultural Resources
Gerard Kennedy
(617) 626-1773
gerard.kennedy@state.ma.us

Department of Public Health
Mike Celona
(617) 624-5757
mike.celona@state.ma.us

Department of Public Utilities
Paul Osborne
(617) 305-3500
paul.osborne@state.ma.us

Department of Fire Services
Edmund Walker
(978) 567-3114
edmund.walker@state.ma.us

Massachusetts Water Resources Authority
John Gregoire
(508) 424-3608 (office)
(617)799-8855 (cell)
john.gregoire@mwra.state.ma.us

FEDERAL CONTACTS

U.S. Army Corps of Engineers
Jack Keenan, Chief, Reservoir Control Center
(978) 318-8310
jack.a.keenen@usace.army.mil

U.S. Geological Survey
Roy Socolow
(508) 490-5059
rsocolow@usgs.gov

National Weather Service
Nicole Belk, Service Hydrologist
(508) 823-2262
nicole.belk@noaa.gov

Farm Services Agency
Thomas Smiarowski
USDA
(413) 253-4500
thomas.smiarowski@ma.usda.gov

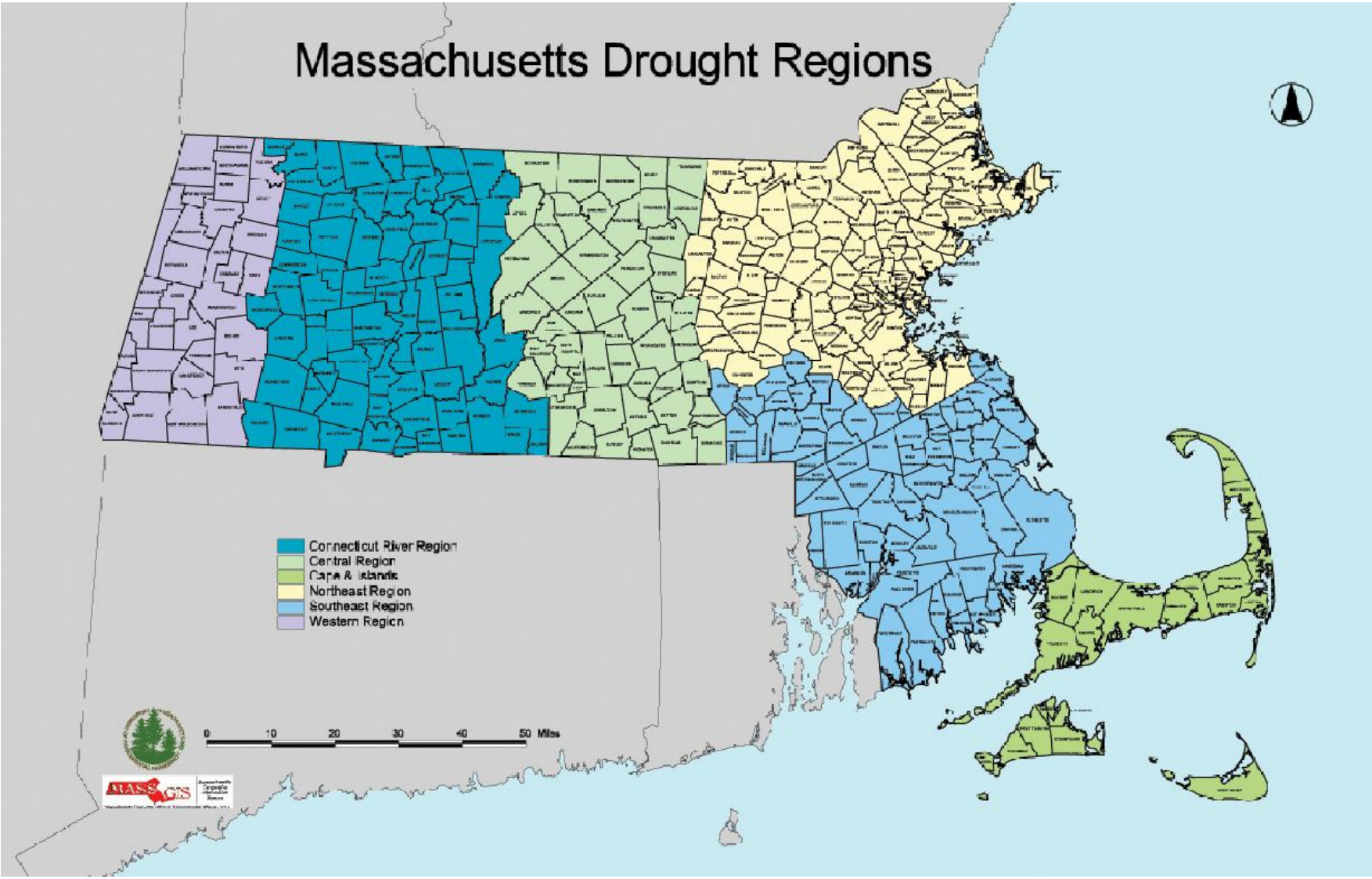
OTHER CONTACTS

Massachusetts Association of Health Boards
Marcia Benes
(508) 643-0234
benes@mahb.org

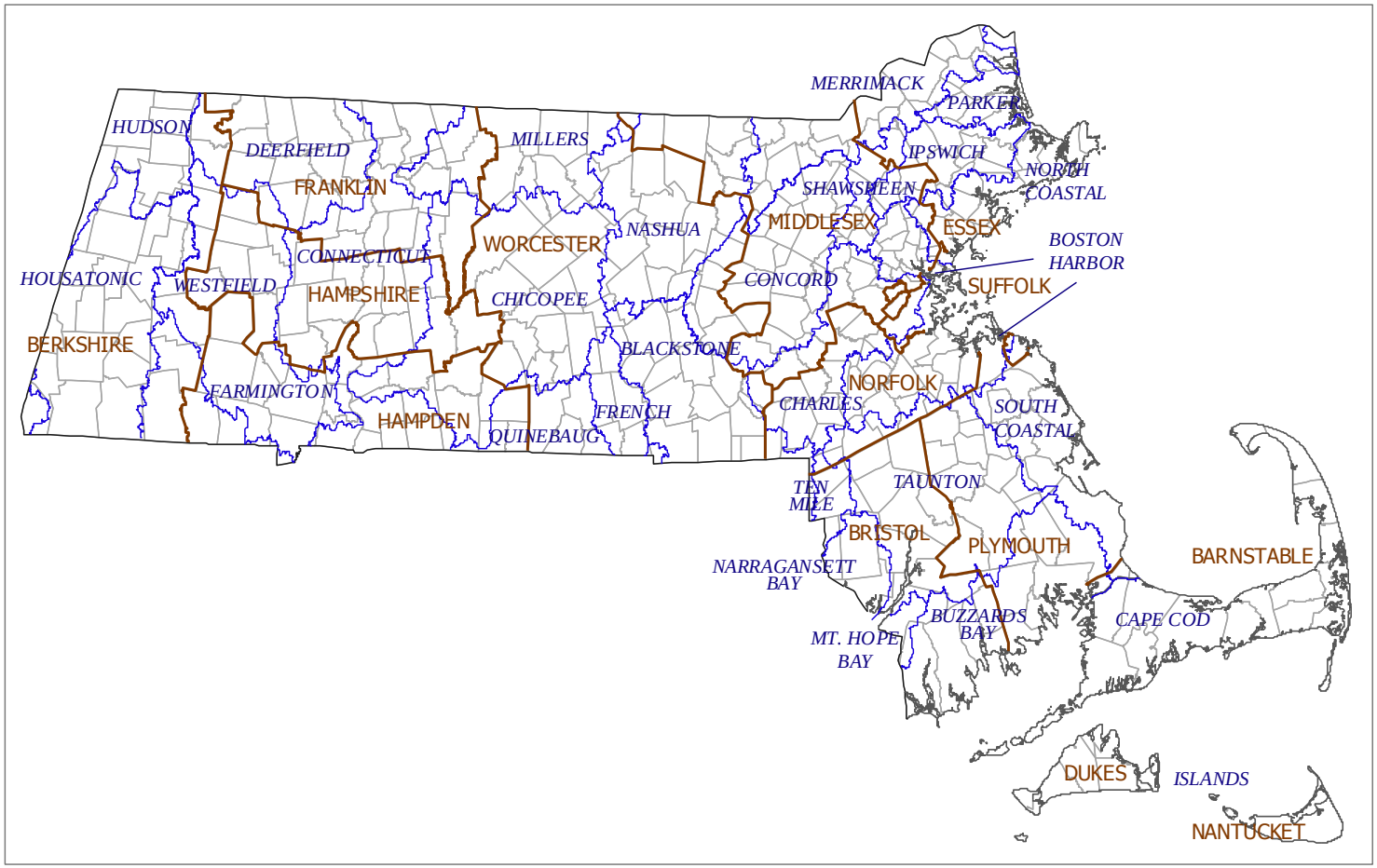
Massachusetts Water Works Association
Jennifer Pederson, Executive Director
PO Box 1064
Acton, MA 01720
(978) 263-1388
mwwa@verizon.net

MWRA Water Supply Citizens Advisory Committee (WSCAC)
Lexi Dewey, Executive Director
(413) 213-0454
wscac@rcn.com

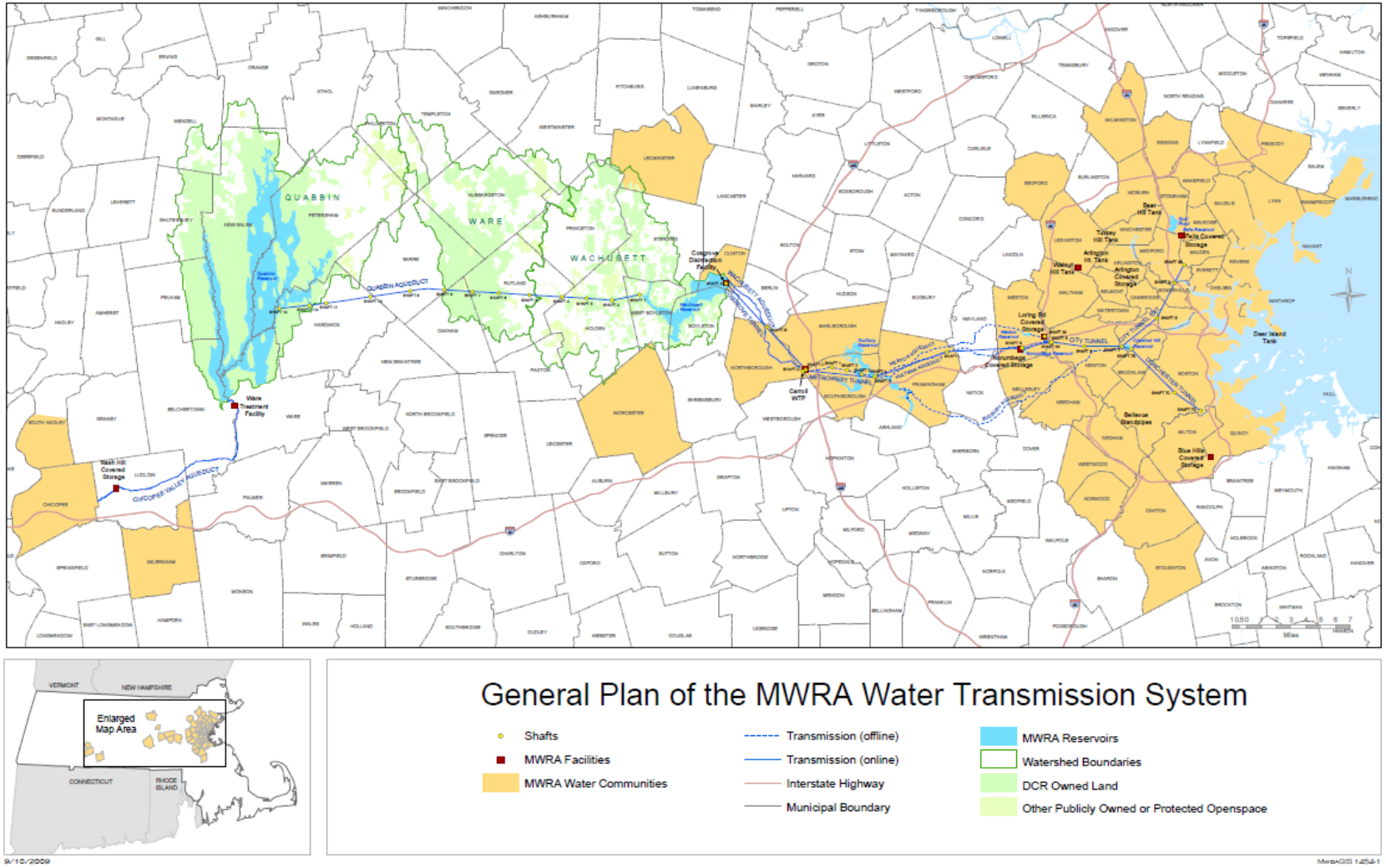
APPENDIX B


Massachusetts Drought Regions
Connecticut River Region
Central Region
Cape & Islands
Northeast Region
Southeast Region
Western Region
0
10
20
30
40
50 Miles

WATERSHEDS AND ASSOCIATED COUNTIES



APPENDIX C
MWRA WATER SUPPLY COMMUNITIES – FULL AND PARTIALLY SERVED



Note: The MWRA/DCR water system has an individual Drought Management Plan.

LIST OF MWRA WATER SUPPLY COMMUNITIES
FULL AND PARTIALLY SERVED

Metro System
Arlington
Belmont
Boston (BWSC)
Brookline
Canton (Partial)
Chelsea
Dedham-Westwood Water District (Partial)
Everett
Framingham
Leominster (Partial)
Lexington (Bedford, Partial)
Lynn (Lynn Water and Sewer District, Partial)
Lynnfield Water District
Malden

Aqueduct
Marblehead
Marlborough (Partial)
District #1
Medford
Melrose
Milton
Nahant
Needham (Partial)
Newton
Northborough (Partial)
Norwood
Peabody (Partial)
Quincy
Reading
Revere
Saugus
Somerville
Southborough
Stoneham
Stoughton (Partial)
Swampscott
Wakefield (Partial)
Waltham
Watertown
Wellesley (Partial)
Weston
Wilmington (Partial)
Winchester (Partial)
Winthrop
Woburn (Partial)

Chicopee Valley

Chicopee
South Hadley Fire

Wilbraham

Others

Cambridge (Partial)
Clinton
Worcester (Partial)

Appendix D
Drought Preparedness for Local Governments and Water Suppliers

Contingency plans for drought circumstances are a critical component of any water supply management program in order to establish what levels of dry or drought conditions are likely to lead to a water supply emergency and what actions will be taken to prevent the emergency and/or respond should one occur. According to the American Water Works Association "A well conceived drought management plan can take the "crisis" out of the situation . . .[and] can lessen any public perception that the utility's actions are ill considered or arbitrary. . . a drought management plan can enhance public acceptance of the actions to be taken in response to a water supply emergency."

This guidance focuses on four key elements that local governments and water suppliers should have in place to address dry conditions. These are:

- development of drought plans
- development of emergency response plans
- passage of water restriction by-laws;
- identifying emergency water connections and water supplies

Each is briefly discussed below, followed by Appendix E, which includes a copy of the DEP model bylaw for water restrictions.

Drought Management Planning

While severe droughts can result in dire emergency situations, they are generally slow developing and therefore provide the opportunity to take actions to minimize their impacts on water supplies and the environment. Identifying drought indicators and drought triggers is essential to developing an effective drought management plan. Drought indicators are used to assess the status of water supplies and the status of the impact of water withdrawals on the environment.

The drought indicators for particular water supply systems will depend on the specific conditions of the system, such as the capacity of storage and treatment facilities, storage tank elevation, reservoir storage, streamflow levels, groundwater levels and precipitation. They will also depend on the location and sensitivity of environmental resources. Drought triggers act as benchmarks that provide warning signals of impending or ongoing water shortage.

The purpose of developing triggers is to link them with specific response actions to plan for dry conditions and mitigate drought impacts. A key response action is the ability to restrict water use restrictions. Water use restrictions can move from limited and voluntary actions to more extensive mandatory restrictions depending on the drought stage triggers. The development of a drought plan with both clear triggers and clear responses provides communities and water users with predictable responses to dry conditions and droughts.

Local governments need to enact a water restriction by-law in order to have the ability to impose mandatory water restrictions without receiving an emergency declaration from the Department of Environmental Protection. Water use restrictions should be tailored to the

needs of the community or water district, but should include a variety of levels or stages so that the appropriate response is available based on the severity of the situation.

The following example provides four different stages. As part of a drought management plan, each of these stages would be implemented based on pre-established triggers. Please note that an odd/even day water use restriction is not included because this type of restriction may actually encourage users to water more often than necessary.

Stage I. Voluntary conservation

Stage II Off peak watering only. *Off-peak watering may not reduce overall demand, but can reduce peak demands.*

And/or

Outside water use is limited to between *** and *** (name particular hours). *Such a restriction is useful when the system generally has sufficient water quantity, but is has system limitation in meeting peak demands.*
.

Stage III. Outside water usage is limited to 1 day per week.

And/or

Outside water use restricted to hand held hose for flower or vegetable garden watering only. No lawn watering, car washing (excluding commercial car washing), or pool filling, allowed.

Stage IV. Mandatory ban on outside water use. All outside use of water is forbidden and subject to penalties in accordance with law for violation of this restriction

The American Water Works Association has developed a manual entitled *Drought Management Planning* to assist suppliers in developing drought management plans. To obtain a copy contact the American Water Works Association 1-800-926-7337 and refer to ISBN # 0-89867-627-4.

Emergency Response Planning

Communities should also develop emergency response plans that cover a broader range of emergencies beyond droughts. These plans provide the framework for responses when water supply situations become critical. The Department of Environmental Protection has put out the **Handbook for Water Supply Emergencies** that outlines the key components of such an emergency plan. These plans develop specific procedures for various levels of emergency, include lists of key phone numbers and contact information for local, state and federal emergency response officials. The Handbook also contains an emergency response checklist and guidelines for preparing news releases to communicate with the public.

Water Restriction Bylaws
All communities responsible for operating public water supply systems should have a water restriction bylaw in place. These bylaws give the appropriate person or board the power to declare water restrictions as necessary. These powers are important to allow a community to have a predictable plan to reduce water use as drought conditions develop. If communities do not have these powers, they can only institute such restrictions by requesting a declaration of emergency from the Department of Environmental Protection. However, waiting for an emergency situation to occur means the town will have missed opportunities to reduce non-essential water uses early, and therefore missing the opportunity to prolong the sufficiency of local supplies and forestalling more drastic measures such as emergency hook-ups or providing bottled water to meet local needs

Emergency Supplies and Emergency Connections
In order to assure that a community is fully prepared for drought conditions and for other emergencies they should have emergency connections to other supplies and/or have plans to access contingency water supplies. Such efforts should include connections to nearby public water supplies, identification of emergency sources of water, and contingency contracts to purchase water by tanker truck or bottled water. Contingencies should include identification of non-potable water sources that can be used for fire protection or for use in conjunction with boil orders. By having these contingencies in place communities can ensure that they can protect public health and safety during the most severe droughts or emergency.

APPENDIX E
MASSDEP MODEL WATER USE RESTRICTION BYLAW/ORDINANCE

DEP STRONGLY ADVISES YOU TOCONSULT WITH YOUR TOWN OR CITY COUNSEL TO ENSURE ADOPTION OF AN APPROPRIATE, ENFORCEABLE AND LEGALLY VALID BY-LAW THAT WILL MEET YOURMUNICIPAL AND/OR DISTRICT NEEDS.

The terms "town" and "bylaw" used throughout this document are intended also to refer to cities and ordinances, respectively. References to Boards of Water Commissioners throughout this model bylaw should be edited by particular cities and towns or water districts or boards to accurately describe the municipal department or water district or board having authority and responsibility for the operation and maintenance of the public water supply.

DEP MODEL OUTDOOR WATER USE BY-LAW/ORDINANCE

Section 1 Authority
This By-law is adopted by the Town [or Water District][1] under its police powers pursuant to the Home Rule Amendment of the Massachusetts Constitution, Article LXXXIX, to protect public health and welfare and pursuant to its powers under M.G.L. c.40, §§21 et seq. and implements the Town's authority to regulate water use pursuant to M.G.L. c. 41, §69B. This by-law also implements the Town's [or Water District's] authority under M.G.L. c. 40, §41A, conditioned upon a declaration of water supply emergency issued by the Department of Environmental Protection under G.L. c. 21G, §15-17. This by-law is also intended to implement other water conservation requirements of M.G.L. c. 21G, the "Massachusetts Water Management Act" and its regulations promulgated at 310 CMR 36.00.

Section 2 Purpose
The purpose of this by-law is to protect, preserve and maintain the public health, safety, welfare and the environment whenever there is in force a "State of Water Supply Conservation" or a "State of Water Supply Emergency" by ensuring an adequate supply of water for drinking and fire protection and to protect the quality and quantity of water in local aquatic habitats such as ponds, rivers and wetlands. This purpose will be accomplished by providing for the imposition and enforcement of any duly implemented restrictions, requirements, provisions or conditions on water use imposed by the Town [or Water District] in accordance with this by-law and/or by the Department of Environmental Protection under its state law authorities.

Section 3 Applicability
All Town [or District] residents that are customers of the public water supply system [and private well users (see footnote 3)] shall be subject to this by-law. This by-law shall be in effect year round.

Section 4 Definitions
Agriculture shall mean farming in all its branches as defined at M.G.L. c. 128, § 1A.[1]

Automatic sprinkler system shall mean any system for watering vegetation other than a hand-held hose or a bucket.

---

1 If the public water supplier in the city or town is an independently authorized entity having its own legislative authority that authority should be cited in this section rather than the municipal statutory authorities. See also, M.G.L. c. 40N "Model Water and Sewer Reorganization Act". The citation to M.G.L. c. 40, § 41A ("Restraint of Use of Water During Emergency") should, however, be retained for both municipal authorities and districts. Both municipal entities and independent entities will be referred herein as "the Town or Water District".
1 This statutory definition includes cultivation of the soil, dairying and the production, cultivation, growing and harvesting of agricultural, aquacultural, floricultural or horticultural commodities as well as forest harvesting, raising livestock inclusive of bees and fur-bearing animals and forestry, lumbering, preparation for market, delivery to storage or market or to carriers to market incidental to an agricultural operation.

Nonessential outdoor water use shall mean those uses that are not required:

1. for health or safety reasons;
2. by regulation;
3. for the production of food and fiber;
4. for the maintenance of livestock; or
5. to meet the core functions of a business (for example, irrigation by golf courses as necessary to maintain tees and greens, and limited fairway watering, or irrigation by plant nurseries or agricultural operations as necessary to maintain stock or establish new plantings, wash equipment to prevent damage and/or maintain performance, pest management and plant cooling).

Nonessential outdoor water uses that are subject to mandatory restrictions include:

- irrigation of lawns via sprinklers or automatic irrigation systems;
- washing of vehicles, except in a commercial car wash or as necessary for operator safety or to prevent damage and/or maintain performance of agricultural or construction vehicles or equipment; and
- washing of exterior building surfaces, parking lots, driveways or sidewalks, except as necessary to apply paint, preservatives, stucco, pavement or cement.

Exceptions to nonessential outdoor water uses are:

- irrigation of public parks and recreation fields outside the hours of 9 AM to 5 PM and;
- irrigation of lawns, gardens, flowers and ornamental plants by means of a hand-held hose outside the hours of 9 AM to 5 PM and;
- Irrigation outside the hours of 9 AM to 5 PM with harvested and stored stormwater runoff.

The following outdoor water uses are subject to review and approval by The Town [or District], through its Board of Water Commissioners [or Selectmen or Water District Commissioners] or their designee:

- irrigation to establish replanted or resodded lawn or plantings during the months of May and September;
- irrigation of newly planted lawns (seeded or sodded) in the current calendar year for homes or businesses newly constructed in the previous twelve months;
- Filling of privately owned outdoor pools

Person shall mean any individual, corporation, trust, partnership, association, agency or authority, or other entity and any officer, employee, group or agent of such persons.

State of Water Supply Emergency shall mean a State of Water Supply Emergency declared by the Department of Environmental Protection under M.G.L. c.21G, §15-17.

State of Water Supply Conservation shall mean a State of Water Supply Conservation declared by the Town [or Water District] pursuant to Section 5 of this by-law.

Water Customers shall mean all persons using the public water supply irrespective of that person's responsibility for billing purposes for use of the water.

Water Users shall mean all persons using water within the Town.[2]

Section 5 Declaration of a State of Water Supply Conservation

The Town [or District], through its Board of Water Commissioners [or Selectmen or Water District Commissioners] or their designee authorized to act as such, may declare a State of Water Supply

2 The inclusion of water users is intended to provide the option to capture the use of private wells for nonessential outdoor water use. If you do not intend to include private well users, strike the "water users" definition and replace the term "water users" with "water customers" wherever applicable.

Conservation upon a determination that conservation measures are appropriate to ensure an adequate supply of water for drinking and fire protection, to protect the quality and quantity of water in local aquatic habitats such as ponds, rivers and wetlands and to ensure compliance with the Water Management Act. Upon notification to the public that a declaration of a State of Water Supply Conservation has been declared, no person shall violate any provision, restriction, requirement or condition of the declaration. The Water Commissioners may designate the [Water Department Superintendant, Town Manager, DPW Director] to declare a State of Water Supply Conservation at any time that conditions warrant. Public notice of a State of Water Conservation shall be given under Section 8 of this by-law before it may be enforced.

Section 6 Declaration of a State of Water Supply Emergency
Upon notification to the public that a declaration of a State of Water Supply Emergency has been issued by the Department of Environmental Protection, no person shall violate any provision, restriction, requirement, condition of any order approved or issued by the Department for the purpose of bringing about an end to the State of Water Supply Emergency.

Section 7 Restricted Water Uses
A declaration of a State of Water Supply Conservation and/or a State of Water Supply Emergency shall include one or more of the following restrictions, conditions, or requirements limiting nonessential outdoor water use by water customers (and water users[2]) as necessary to control the volume of water pumped each day, except as provided as acceptable in Section 4. The applicable restrictions, conditions or requirements shall be included in the public notice required under Section 8.

a) Nonessential outdoor water use days: Nonessential outdoor water use is permitted only on the days per week specified in the State of Water Supply Emergency or State of Water Supply Conservation and public notice thereof. During a State of Water Supply Emergency or State of Water Supply Conservation, nonessential outdoor water use is restricted to two days or fewer per week.

b) Nonessential outdoor water use hours: nonessential outdoor water use is permitted only during the hourly periods specified in the declaration of a State of Water Supply Emergency or State of Water Supply Conservation and public notice thereof. At a minimum, nonessential outdoor water use is prohibited during the hours from 9AM to 5PM.

c) Nonessential outdoor water use method restriction: nonessential outdoor water use is restricted to a bucket or hand-held hose controlled by a nozzle.

d) Nonessential outdoor water use ban: Nonessential outdoor water use is prohibited at all times.

e) Automatic sprinkler system ban: The use of automatic sprinkler systems is prohibited.

Section 8 Public Notification of a State of Water Supply Conservation or State of Water Supply Emergency; Notification of DEP

a) Public Notification of a State of Water Supply Conservation – Notice to the public of all provisions, including all restrictions, requirements and conditions imposed by the Town [Water District] as part of a State of Water Supply Conservation shall be made as soon as possible, but no later than 48 hours following the declaration of a State Water Supply Conservation by publication in a newspaper of general circulation within the Town and by signage on major roadways or intersections. The Town [Water District] may also notify the public using other means determined to be appropriate (cable TV, reverse 911, email, etc.). Notification may also include email, Web sites, public service announcements on local media or other such means reasonably calculated to reach and inform all Water Users.

b) Public Notification of a State of Water Supply Emergency – Notice to the public of all provisions, including all restrictions, requirements and conditions imposed by a State of Water Supply Emergency declared by the Department shall be made by publication in a newspaper of general circulation with the Town and by signage on major roadways or intersections. The Town [Water District] may also notify the public using other means determined to be appropriate (cable TV, reverse 911, email, etc.). This notice shall be provided as soon as possible, but no later than 48 hours after the public water system receives notice of the Department's declaration of a State of Water Supply Emergency. Notification may also include email, Web sites, public service announcements on local media or other such means reasonably calculated to reach and inform all Water Users of the State of Water Supply Emergency.

c) Any restriction imposed under Section 5 or Section 6 or in the Department's State of Water Supply Emergency or Order shall not be effective until notification to the public is provided. Submittal of MassDEP's form "Notification of Water Use Restriction" shall be provided to the Massachusetts Department of Environmental Protection within 14 days of the effective date of the restrictions, per MassDEP regulations (310 CMR 22.15(8)).

Section 9 Termination of a State of Water Supply Conservation; Notice
A State of Water Supply Conservation may be terminated by a majority vote of the Board of Water Commissioners or by decision of their designee upon a determination by either or both of them that the conditions requiring the State of Water Supply Conservation no longer exist. Public notification of the termination of a State of Water Supply Conservation shall be given in the same manner as is required in Section 8a) for notice of its imposition.

Section 10 Termination of a State of Water Supply Emergency; Notice
Upon notification to the Town [or Water Commissioners or their designee or to the Water District] that the declaration of a State of Water Supply Emergency has been terminated by the Department of Environmental Protection, the public will be notified of the termination in the same manner as is required in Section 8b) for notice of its imposition.

Section 11 Penalties
The Town [or Water District] through its Water Commissioners or their designee including the water superintendent, building inspector and/or local police may enforce this by-law. Any person violating this by-law shall be liable to the Town in the amounts listed below:

1) First violation: Warning
2) Second violation: $____
3) Third violation: $____
4) Fourth and subsequent violations: $_____

Each day of violation shall constitute a separate offense. Fines shall be recovered by complaint before the District Court, or by non-criminal disposition in accordance with section 21D of chapter 40 of the general laws. For purposes of non-criminal disposition, the enforcing person shall be any police officer of the town or the water superintendent or the superintendent's designee. If a State of Water Supply Emergency has been declared the Water Commissioners may, in accordance with G.L. c. 40, s. 41A, shut off the water at the meter or the curb stop.

Section 12 Severability
The invalidity of any portion or provision of this by-law shall not invalidate any other portion or provision thereof.

Section 13 Controls on In-Ground Irrigation Systems[3]
Subsection 13.1 Registration and Installation

3 This section is intended to govern automatic irrigation systems and may be passed as part of a water use restriction bylaw or separately. It is included here for convenience.

a) All new and existing in-ground irrigation systems shall be registered with the Town's Board of Water Commissioners in such form and manner as they shall determine. A fee may be charged for this registration. Registration fees shall be set by the Board of Water Commissioners.[4] The Board may require inspection of the irrigation system.

b) All in-ground irrigation systems shall be equipped with a timing device that can be set to make the system conform to the Town's [or District's] nonessential outdoor water use restrictions. During a State of Water Supply Emergency or State of Water Supply Conservation the timing device must be set to conform to the daily and hourly nonessential outdoor water use restrictions.

c) All in-ground irrigation systems shall be plumbed so that a shutoff valve is located outside the building and situated so that it may be shut off if found to be in violation of this by-law. For the purposes of this section only, Police Officers of the Town and/or Agents of the Board of Water Commissioners may enter upon any property to enforce this section.

Subsection 13.2 Soil Moisture-Sensor Devices

a) All in-ground irrigation systems installed in the Town [or District] after the date of effect of this bylaw shall be equipped with a soil moisture-sensor device, approved by the Board of Water Commissioners, to prevent the system from starting automatically when not needed. Proof of this installation shall be provided to the Board of Water Commissioners at the time of registration.

b) Any service or repair to an existing in-ground irrigation system shall include the installation of an approved moisture-sensor device, if the same is not already installed and in good working condition. Proof of this installation shall be provided to the Board of Water Commissioners at the time of installation.

c) The Board of Water Commissioners shall maintain a list, available to the public, of approved soil moisture-sensor devices.

Subsection 13.3 Backflow Prevention

a) All in-ground irrigation systems connected to the municipal water system in the Town [or District] shall be protected from backflow events by the installation of a backflow prevention device approved by the Board of Water Commissioners. Each backflow prevention device shall be registered with the Board of Water Commissioners. [A fee may be charged for this registration. Registration fees shall be set by the Board of Water Commissioners.]

b) The Board of Water Commissioners shall maintain a list, available to the Public, of approved backflow prevention devices. Refer to Table 22-1 in 310 CMR 22.22 for the recommended backflow protection for irrigation systems.

c) Each backflow prevention device shall be installed in accordance with 310 CMR 22.22 and the manufacturer's instructions. Each device shall be tested upon its installation and annually thereafter. A Massachusetts Certified Backflow Device Tester shall perform all testing. Copies of results of all testing shall be filed with the Board of Water Commissioners or Water Department.

4 Be sure that fees charged avoid characterization as a tax under the principles of Emerson College vs. City of Boston, 391 Mass. 415, 424-426 (1984) by ensuring services provided (inspection, etc.) support the fee and that fees paid are used to pay for those services.

Appendix F
Massachusetts Drought History Summary

In the course of developing the Massachusetts Drought Management Plan, extensive data sets were analyzed, including historic rainfall data from the DCR Rainfall Database, ground water and streamflow data from the US Geological Survey cooperative monitoring program in Massachusetts, and Standardized Precipitation Index (SPI) data generated from the DCR Rainfall data base. Long-term data for the other indices (Crop Moisture Index, Keetch-Byram Fire Danger Index, and reservoir levels) were not widely available for the longer historic period. The following is a summary of historic droughts in Massachusetts based on analysis of the precipitation data sources used in development of the Drought Management Plan. The Massachusetts Drought Management Plan specifies five drought levels: Normal, Advisory, Watch, Warning and Emergency. Because drought Advisories can occur relatively frequently and are not particularly severe unless they develop further, description of historic droughts in this appendix is limited to drought Watches, Warnings, and Emergencies. A description of the frequency and occurrence of these events is provided on a statewide basis, using the Standardized Precipitation Index alone. In actual practice, application of the Drought Management Plan requires thresholds for several indices to be exceeded for a drought designation at the various levels to be appropriate. Data associated with the analysis are available in an Excel file by contacting the Massachusetts Water Resources Commission.

Drought Scales

Drought Parameters

Degrees of Drought are specified in the Massachusetts Drought Management Plan based on both their severity (low levels of precipitation) and duration. Because historic data were not available for all indices used in the current Drought Management Plan, the analysis provided herein is limited to precipitation data only. In Massachusetts, this data set begins in 1848 with a station in Amherst, within the Connecticut River region. Because of the complexity of the Massachusetts Drought Management Plan, and the need to meet a majority of drought parameters to result in a drought recommendation at any given level, this Drought History summary will likely over-estimate the frequency and severity of drought events because of its reliance on only precipitation as a single index.

Spatial Scale

For summary purposes, this analysis of drought history in Massachusetts is limited to a statewide analysis. The statewide scale is a composite of six regions of the state: West, Connecticut River, Central, Northeast, Southeast, and Cape Cod and the Islands. Regional composite precipitation values are based on monthly values from six stations, and three stations in the smaller regions (Cape Cod/Islands and West). Analyses of the six separate regions could also be conducted with our precipitation data set. Because the statewide analysis will result in a muting of more extensive local drought impacts, this Drought History summary will likely underestimate the spatial frequency of droughts (i.e., droughts may occur more frequently in individual regions than depicted in the statewide analysis).

Time Scale

In accordance with the Massachusetts Drought Management Plan, drought declarations are made on a monthly basis. The precipitation index relies on composite data using 1-month, 3-month, 6-month and 12-month look-back periods. The SPI analysis is valuable in that it results in the calculation of averages (normal conditions) and standard deviations for each of these statistics for each month. Thus, a precipitation value that is 1 standard deviation below normal is not terribly unusual, while a precipitation value that is 3 standard deviations below normal is very unusual and indicative of a drought. The Drought Management Plan levels were essentially calibrated to the degrees of historic drought experienced in Massachusetts.

Massachusetts Precipitation Characteristics

Average annual precipitation in Massachusetts is 44 inches per year, with approximately 3 to 4 inch average amounts for each month of the year. Regional monthly precipitation ranges from zero to 17 inches. Statewide annual precipitation ranges from 30 to 61 inches. Thus, in the driest calendar year (generally 1965), the statewide precipitation total of 30 inches was 68 percent of average.

Drought Occurrence and Frequency in Massachusetts

The attached graph indicates incidents of drought levels' occurrence in Massachusetts using the SPI parameter alone. On a monthly basis, the state would have been in a Drought Watch to Emergency condition 11 percent of the time between 1850 and 2012.

Drought Emergency

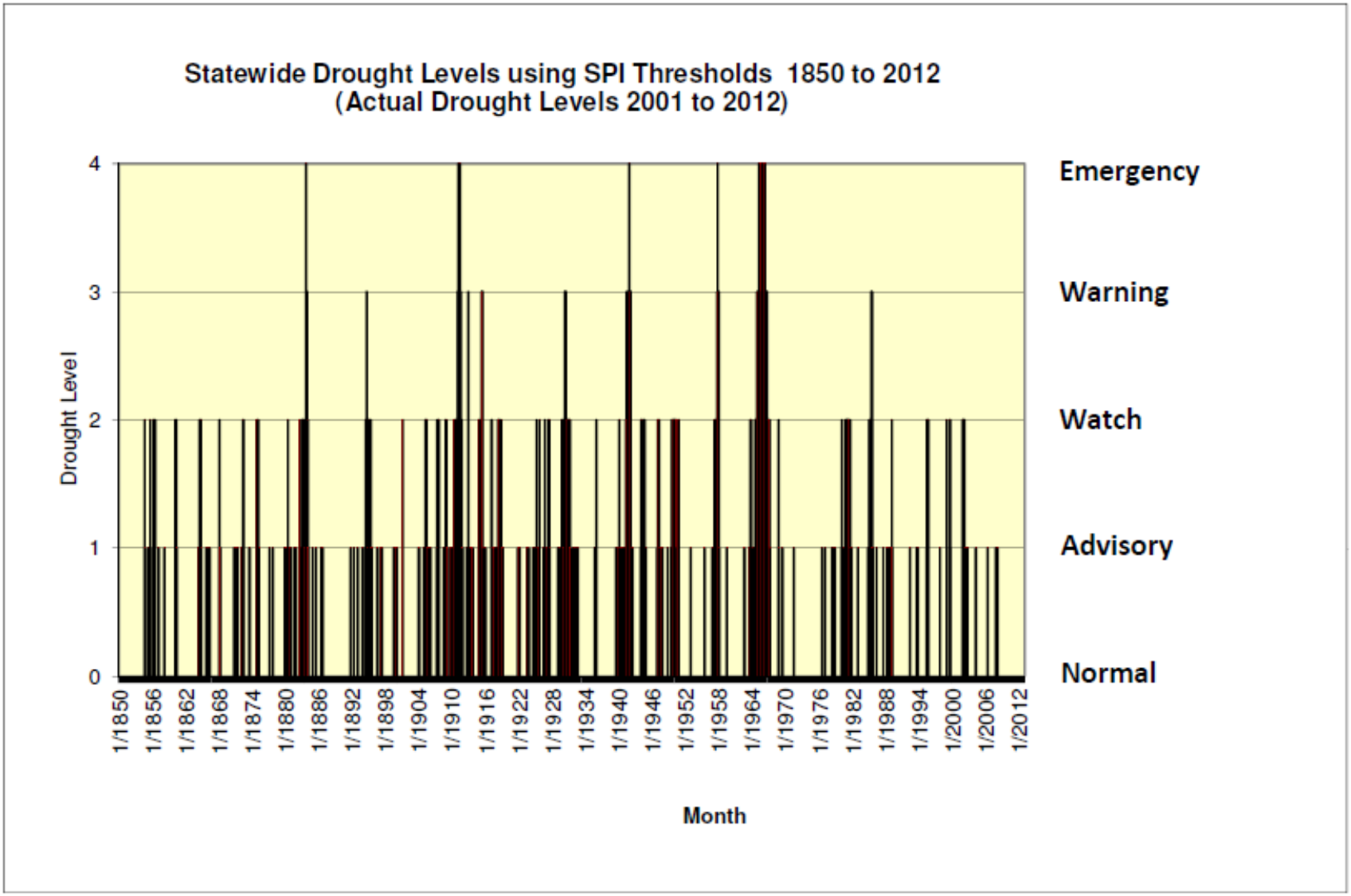
As expected, drought Emergency level would have been reached infrequently, with 5 events occurring in the period between 1850 and 2012: in 1883, 1911, 1941, 1957, and 1965-1966. The 1965-1966 drought period is viewed as the most severe drought to have occurred in modern times in Massachusetts given the period of record for precipitation data because of its long duration. On a monthly basis over the 162-year period of record, there is a one percent chance of being in a drought Emergency.

Drought Warning

Drought Warning levels not associated with drought Emergencies would have occurred in 1894, 1915, 1930, and 1985. On a monthly basis over the 162-year period of record, there is a two percent chance of being in a drought Warning level.

Drought Watch

Drought Watches not associated with higher levels of drought generally would have occurred in three to four years per decade between 1850 and 1950. The drought Emergency dominated the 1960s. There were no drought Watches or above in the 1970s. In the 1980s, there was a lengthy drought Watch level of precipitation between 1980 and 1981, followed by a drought Warning in 1985. A frequency of drought Watches at a rate of three years per decade resumed in the 1990s (1995, 1998, 1999). In the 2000s, Drought Watches occurred in 2001 and 2002. The overall frequency of being in a drought Watch is 8 percent on a monthly basis over the 162-year period of record.


Statewide Drought Levels using SPI Thresholds 1850 to 2012
(Actual Drought Levels 2001 to 2012)
Drought Level
4
3
2
1
0
Emergency
Warning
Watch
Advisory
Normal
1/1850
1/1856
1/1862
1/1868
1/1874
1/1880
1/1886
1/1892
1/1898
1/1904
1/1910
1/1916
1/1922
1/1928
1/1934
1/1940
1/1946
1/1952
1/1958
1/1964
1/1970
1/1976
1/1982
1/1988
1/1994
1/2000
1/2006
1/2012
Month