# J9.11 THE DEVELOPMENT OF A DROUGHT MANAGEMENT PLAN FOR RHODE ISLAND; INCLUDING AN ANALYSIS OF LOCAL DROUGHT CHARACTERISTICS

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## 1. INTRODUCTION

A drought is defined as a period of abnormally dry weather sufficiently long enough to cause a serious hydrological imbalance ( AMS 2000). Drought is a relative term and is typically defined in terms of precipitation deficit over a period of time. Rhode Island has experienced three short term drought episodes during the 1990s, the last of which occurred in 1999. These episodes impacted the population in various ways including increased water restrictions, watering bans, loss of water pressure to some privately owned well systems, and losses to agricultural interests.

Following the short term period of drought during the summer of 1999, the State of Rhode Island set forth on a course to establish a Drought Management Plan, following a similar format and borrowing on the work presented in the *Working Draft - Massachusetts Drought Management Plan* (MAEOEA and MEMA 2000). The Rhode Island plan incorporates a variety of interests including state and local agencies, local universities, water conservation interests, as well as local water suppliers. The National Weather Service Office in Taunton has been a key member of this diverse group and has worked with this task force in developing the drought classification scheme used in their plan.

The task force has adopted a classification scheme modeled after the National Weather Service's Watch/Warning program. The scheme uses a series of indices, including Palmer Drought and Crop Moisture indices, rainfall and stream flow departures, and stream flow and ground water departures to best determine the current drought status.

A Drought Management Steering Committee was assembled to monitor, coordinate, and manage response to drought situations. The purpose of the Steering Committee is to facilitate communication and make recommendations to the appropriate entities to ensure drought impacts to public health, safety, and environment are minimized. It is through the Committee by which all Drought Advisories, Watches, and Warnings are issued, based upon the classification scheme.

This paper will review this classification scheme employed in the plan and will briefly reference the droughts of 1965-67, 1981, 1985, and 1999 as examples.

## 2. DATA SOURCES

The data used to analyze four major drought episodes since 1960 included monthly rainfall, and historical Palmer Drought and Crop Moisture Indices when available. One, three, and six month running averages of rainfall were calculated for the time period of each drought, starting with the preceding late fall and early winter months. Snowfall and temperature averages were also calculated for these time periods. Historical Palmer Drought Indices were obtained from the National Climatic Data Center (NCDC). Crop Moisture indices were only gathered for the 1999 episode due to availability of the data.

## 3. RHODE ISLAND DROUGHT CHARACTERISTICS

An action was taken by the National Weather Service Forecast Office, in Taunton, MA, to review several of the more significant drought episodes since 1960 as a means to demonstrate the utility of the Drought Classification Scheme, as well as to examine precursor conditions leading up to these episodes.

The State of Rhode Island is often considered a "water rich" state. Under normal conditions, regions across the state annually receive between 40 and 50 inches of precipitation. However, Rhode Island can experience extended periods of dry weather, from single season events to multi-year events such as that experienced in the mid-1960s.

Winter precipitation allows ground water and stream systems to recharge prior to the "green-up" period in April and early May. Drought episodes in Rhode Island usually commence just after the green up time frame, reaching their greatest intensity during the mid-summer and early fall. The amount of preceding fall and winter precipitation is critical to the evolution of the drought episode.

In each of the four major episodes, three month running average precipitation during the preceding fall and winter months was below normal to much below normal (defined as less than 90 and 75 percent of normal precipitation, respectively). Similarly, the winter snowfall was below to much below normal, with just one exception during the winter of 1998-99. However, the 1998-99 winter featured heavy snows early in January, with the remainder of the winter experiencing much below normal snowfall.

The occurrence of continued below to much below normal precipitation through spring lead to the most severe drought episodes, including the 1965-67 and 1981.

The 1985 and 1999 droughts did experience above normal precipitation during the spring, but it was not sufficient enough to replenish the deficit from the lack of winter rainfall and snowfall. Also, each of the four major drought episodes had at least one month during the winter where the monthly percent of normal precipitation was less than 50 percent.

In all but the 1965-67 extended drought period, the summer precipitation averaged above normal in all cases. In spite of this, the drought was already well under way, but this helped to bring a more rapid end to the drought during the proceeding fall months. The 1965-67 drought episode was extreme in the sense that it persisted for 3 summers, including long periods of below normal precipitation through the winter, spring and summer months. Graphics pertaining to precipitation, snowfall, and temperature departures are availableat http://www.nws.noaa.gov/er/box/RIdrought_plan.htm

## 4. THE RHODE ISLAND DROUGHT MANAGEMENT PLAN

In light of the relationships between precipitation departures, runoff, ground water and stream flow, and the complexities of addressing impacts on water systems and interests of varying size and capacity, the Drought Steering Committee developed a classification scheme which provides a means for determining appropriate state and local agency response. This scheme is discussed in the following sections.

### 4.1. DROUGHT INDICES

Several indices are used to monitor and assess the severity of a drought, or drought level. The drought level is determined by the number of indices which have reached a given level, and are declared on a regional basis. The indices used in this determination are as follows:

*Palmer Drought Index* - reflects soil moisture and weather conditions

*Crop Moisture Index* - reflects short-term soil moisture conditions as used for agriculture

*Fire Danger* - shows how favorable conditions are for brush fires. Data factored into the index include weather conditions and available fuel. This is a short-term index, which can change daily. The duration of the index is used to determine relative drought levels.

*Precipitation* - a comparison of measured precipitation amounts to 30-year averages. Cumulative amounts for 3, 6, and 12-month periods are factored into the drought determination.

*Ground-water levels* - drought level determination is based upon the number of consecutive months ground-water levels are below normal (lowest 25 percent of period of record).

*Stream flow* - drought level determination is based upon the number of consecutive months streamflow levels are below normal (lowest 25 percent of period of record).

*Reservoirs* - drought level determination is based upon the level of small, medium, and large index reservoirs across Rhode Island. The reservoir level relative to normal conditions are considered.

### 4.2 DROUGHT LEVELS

Unlike many other emergency situations, drought severity develops over time and therefore presents the opportunity to develop and implement appropriate measures before the situation worsens. In order for the Drought Management Steering Committee to assess the severity of a drought, five levels of drought have been identified: Normal, Advisory, Watch, Warning, and Emergency. The levels provide a basic framework from which to take actions to assess, communicate, and respond to drought conditions. Although Rhode Island encompasses a relatively small geographic area, the state has a number of distinct regions that can experience significantly different weather patterns. There is also considerable variation in population density, water demand, topography, and runoff. Therefore, assessments of drought conditions are undertaken on a regional basis in the first two stages of drought, rather than using a single statewide value. These regions are typically divided into North, South, and East but may be adjusted based upon the conditions in any particular drought situation. The purpose for a regional approach is to allow smaller entities to customize drought actions and conservation measures as needed to address their own situation. In the latter three stages of drought, assessments of conditions and recommended actions are conducted on a statewide basis. A description of each drought level, its associated actions, and index descriptors follow.

#### 4.2.1. NORMAL CONDITIONS

When the state is not in a drought condition, as defined inTable 1, basic weather and hydrological data is collected to help monitor the situation. Communities are encouraged to adopt local bylaws that provide for drought related contingency plans.

Table 1. Indices associated with normal conditions.

| Index | Value |
|---|---|
| Palmer Drought Index | -1.0 to -1.99 (slightly dry) |
| Crop Moisture Index | 0.0 to -1.0 (slightly dry) |
| Fire Danger | Low |
| Precipitation | One month below normal |
| Ground Water | Two consecutive months below normal |
| Stream flow | One month below normal |

| | |
|---|---|
| Reservoir Level | At or near normal for time of year |

### 4.2.2. DROUGHT ADVISORY

During an advisory (Table 2), increased data collection occurs in this phase, and more frequent stream flow measurements are taken. The Steering Committee begins to coordinate on a routine basis. Voluntary conservation measures are recommended and general press announcements are developed.

Table 2. Indices associated with a drought advisory

| Index | Value |
|---|---|
| Palmer Drought Index | -2.0 to -2.99 (abnormally dry) |
| Crop Moisture Index | -1.0 to -1.9 (abnormally dry) |
| Fire Danger | Moderate |
| Precipitation | Two month cumulative below 65 percent of normal |
| Ground Water | Three consecutive months below normal |
| Stream flow | At least two out of three consecutive months below normal |
| Reservoir Level | Small index reservoirs below normal |

### 4.2.3. DROUGHT WATCH

As the situation worsens and reaches watch criteria (Table 3), intensified monitoring and appraisal of drought conditions occurs through information gathering of state agencies. The Steering Committee prepares a memorandum on drought status for the Governor, and increases public information distribution regarding current conditions and general conservation measures, including voluntary reduction of water use for residential and commercial users. Contact is initiated with federal agencies and drought mitigation efforts are begun.

Table 3. Indices associated with a drought watch

| Index | Value |
|---|---|
| Palmer Drought Index | -3.0 to -3.99 (excessively dry) |
| Crop Moisture Index | -2.0 to -2.9 (excessively dry) |
| Fire Danger | High |
| Precipitation | Meet one of following criteria: 3 month cumulative below 65 percent, or 6 or 12 month cumulative below 70 percent |
| Ground Water | Four to five consecutive months below normal |
| Stream flow | At least four out of five consecutive months below normal |
| Reservoir Level | Medium index reservoirs below normal |

### 4.2.4. DROUGHT WARNING

A level of drought warning (Table 4) indicates a severe situation and the possibility that a drought emergency may be necessary. Mandatory measures are developed to reduce water use and protect public and vital health, economic, and environmental interests. A press strategy is implemented to keep the media and public informed about the situation. Contact is initiated with other New England states to alleviate drought impacts. The Steering Committee is responsible for preparing a "Governor Proclamation of a Drought Emergency" in regards to a potential drought emergency.

Table 4. Indices associated with a drought warning.

| Index | Value |
|---|---|
| Palmer Drought Index | -4.0 and below (severely dry) |
| Crop Moisture Index | -2.9 and below (severely dry) |
| Fire Danger | Very High |
| Precipitation | Two out of three of the following criteria met: three month and six month cumulative below 65 percent, or six month and twelve month cumulative below 65 percent, or three and twelve month cumulative below 65 percent |
| Ground Water | Six to seven consecutive months below normal |
| Stream flow | At least six out of seven consecutive months below normal |
| Reservoir Level | Large index reservoirs below normal |

### 4.2.5. DROUGHT EMERGENCY

Under a drought emergency (Table 5), mandatory water restrictions are necessary and the Steering Committee continues to coordinate response of state, local, and federal agencies. The Governor Proclamation of a drought emergency is finalized to utilize state emergency authorities and powers to restrict water uses. Federal assistance is secured, including emergency funding or legislation.

Table 5. Indices associated with a drought emergency.

| Index | Value |
|---|---|
| Palmer Drought Index | -4.0 and below (severely dry) |
| Crop Moisture Index | -2.9 and below (severely dry) |
| Fire Danger | Extreme |
| Precipitation | Same as Warning, and previous month was Warning or Emergency |
| Ground Water | Eight or more consecutive months below normal |
| Stream flow | Seven or more consecutive months below normal |
| Reservoir Level | Continuation of previous month's conditions |

### 4.3 DETERMINATION OF THE END OF A DROUGHT

In order to determine the end of a drought, two key factors are examined - precipitation and ground-water levels. These two factors have the greatest long-term impact on stream flow, water supply, reservoir levels, soil moisture, and the potential for brush and forest fires. The drought condition can only be revised to a less severe condition when normal conditions have been reached. Normal conditions are determined when ground-water levels have reached normal or above normal, and there is no rainfall deficit for the year beginning October 1st. A majority of the indices are not considered since some of them 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, and the Fire Danger season ends with snowfall.

## 5. SUMMARY

Rhode Island has experienced three short term drought episodes during the 1990s, the last of which occurred in 1999. These episodes impacted the population in various ways including increased water restrictions, watering bans, loss of water pressure to some privately owned well systems, and losses to agricultural interests. The Rhode Island Drought Management Plan was developed in response to the 1999 drought and provides a means to step up public awareness and to initiate actions to address the evolving drought episode.

As future droughts impact the region, the plan and its components should be reviewed to ensure the actions and classification meet the observed impact.

## 6. REFERENCES


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