



# Drought, Water Conservation, and the Cambridge Water System



Photo: Hobbs Brook Reservoir on 10/17/2016



# Overview

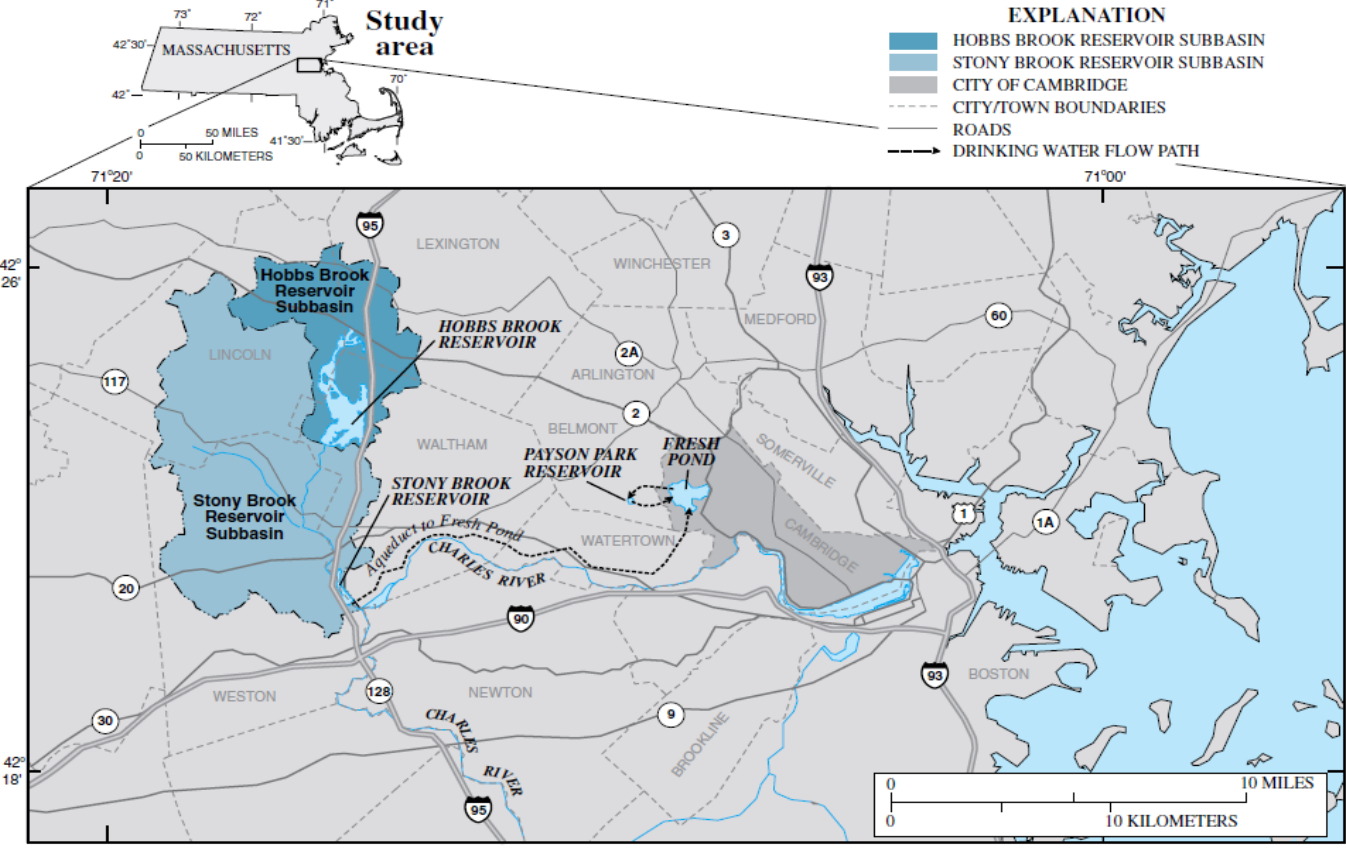
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- Cambridge Water System
- Drought
  - What is drought?
  - What does drought look like in the Cambridge Reservoirs?
  - What conditions led to this drought?
  - Will the drought end?
- Drought and Climate Change
- Impacts
- Actions
- Questions and Resources

# Cambridge Water System

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# Cambridge Water System





# Cambridge Water System

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- Cambridge Reservoir system capacity when full is 8 months (without any precipitation)
- Beneficial aspects
  - Can fill more quickly than other systems
  - Can readily withstand short term precipitation variations (+/- 1year)
- Challenging aspects
  - Cannot withstand long term droughts (+/- 2 years or more)
  - Not a lot of warning for problem conditions/ short term planning horizon
- Reservoir system annual recharge cycle starts in September

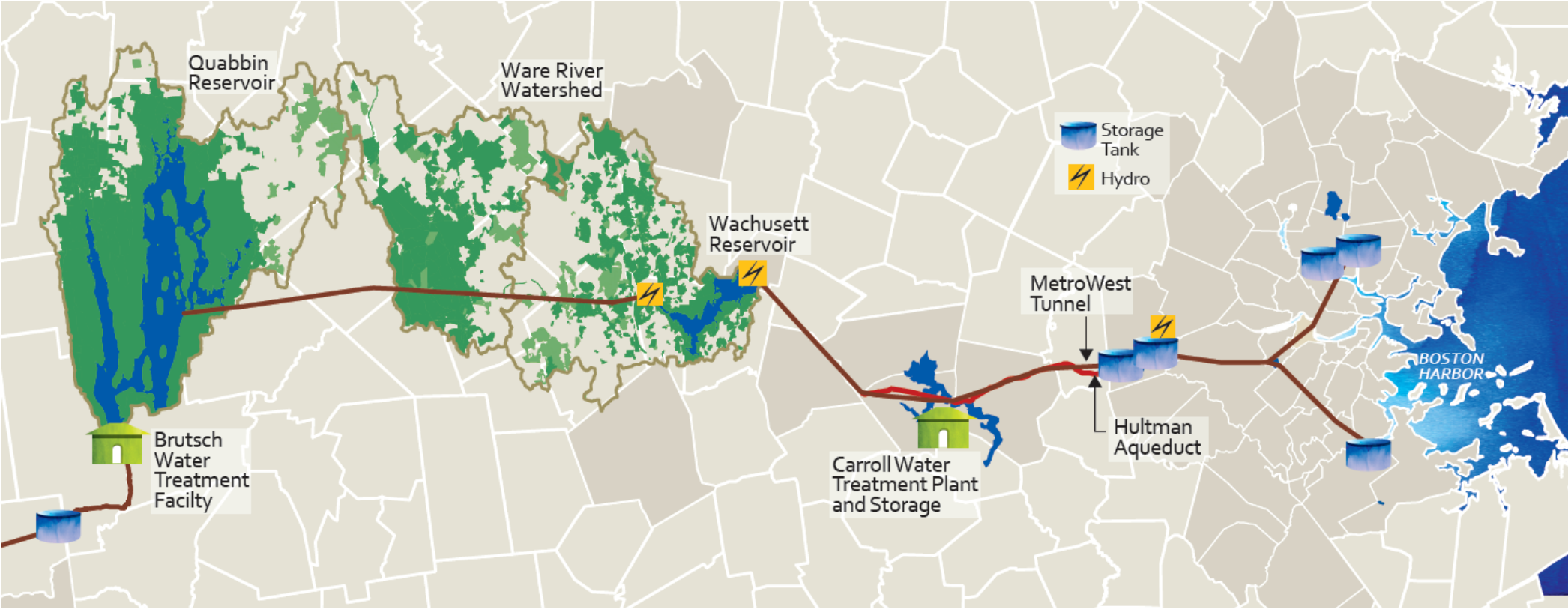
# MWRA Water System

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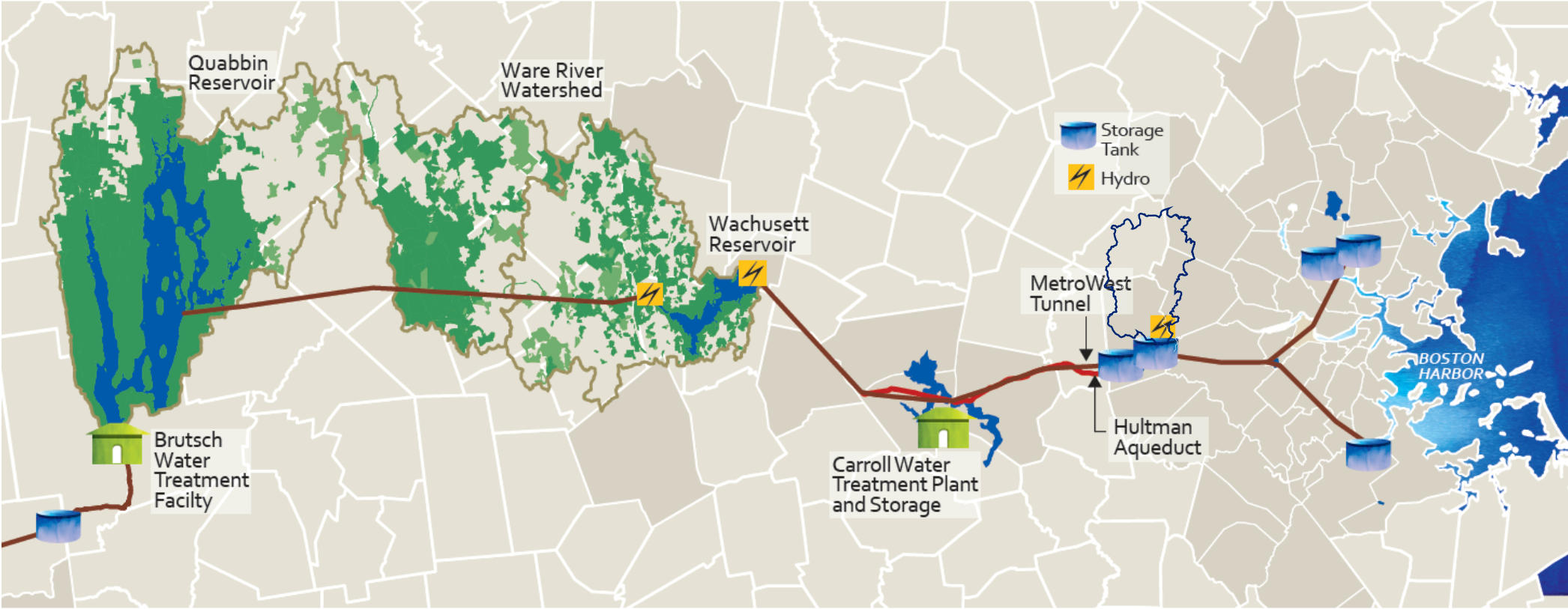
- Cambridge is a full member of Massachusetts Water Resources Authority (MWRA)
  - Permanent connection to MWRA water system
  - Follow MWRA drought management plan vs. state plan
  - Access to water is readily available
    - Used MWRA water earlier this year (2016)
    - Practiced activation and short term use in 2015
    - Used MWRA water in 2014
- MWRA water cost is ~2.0 X our cost



# Map of MWRA System



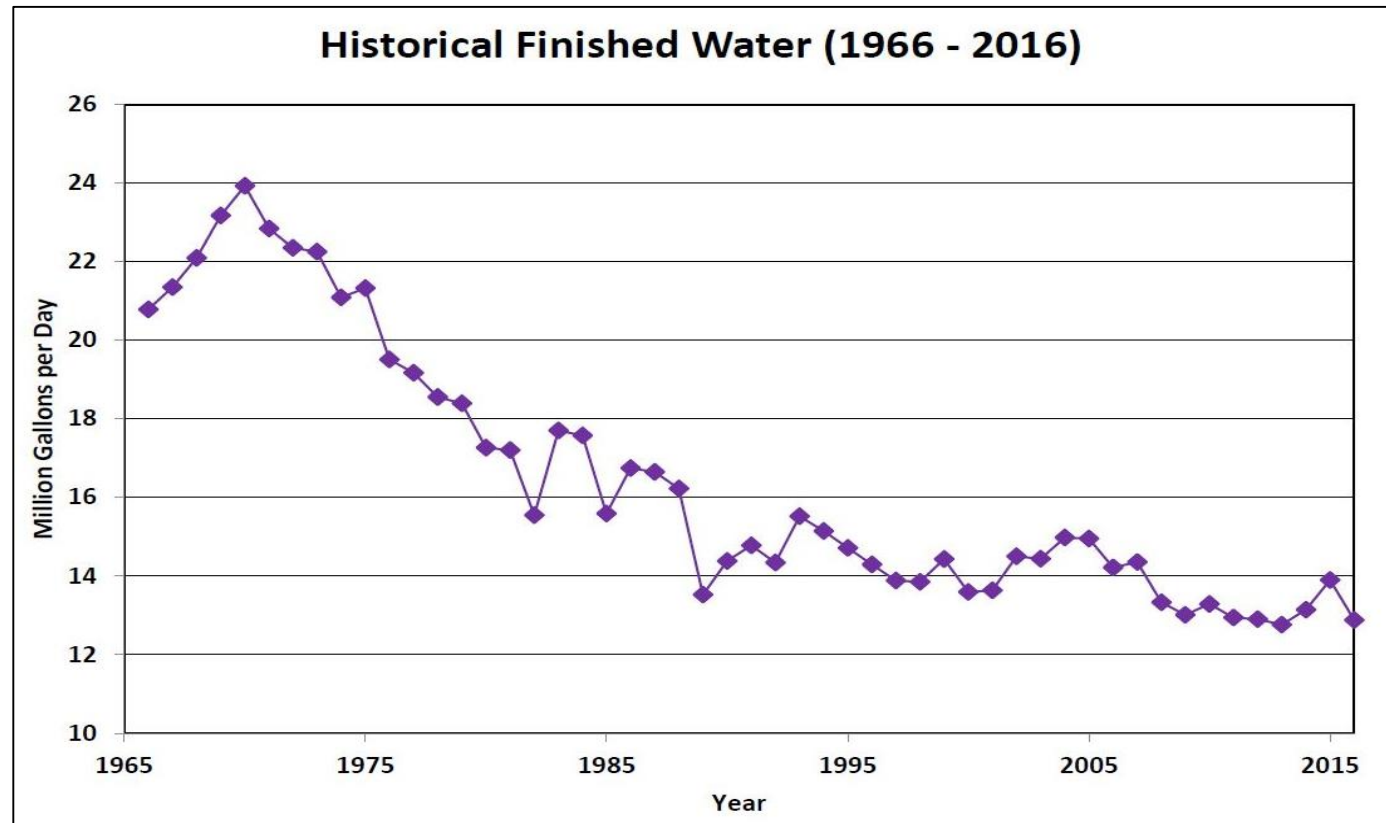
# Comparison





# Cambridge Water Consumption

Cambridge average daily water demand has steadily declined since the early 70s



# Cambridge Water Consumption

Cambridge **residential per capita per day (rgpcd)** use was **46 rgpcd** in 2016, which is significantly below the state goal of 65 rgpcd

**Unaccounted for water (UAW)** was **8.2 %** in 2016, lower than the state goal of 10% or less

Year	Cambridge RGPCD	Cambridge UAW (%)
2010	51	13.3
2011	48	14.3
2012	48	16.7
2013	52	13.3
2014	46	12.4
2015	49	12.2
2016	46	8.2



# Drought

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# What is a drought?

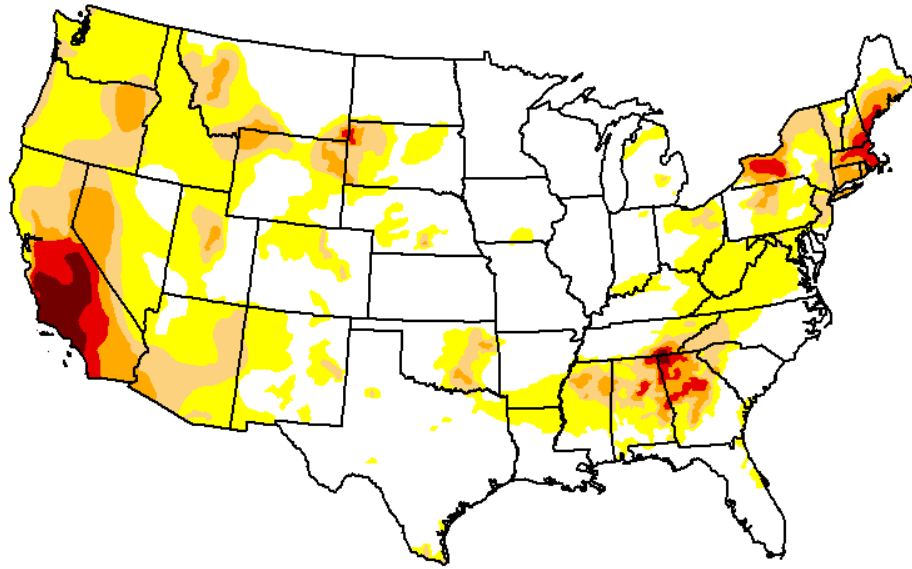
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- Broadly defined, drought is a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. (NOAA)
- Can be thought of as an extended imbalance between precipitation and evaporation. (EPA)
- Four general approaches to measuring drought: meteorological, hydrological, agricultural, and socioeconomic. (National Drought Mitigation Center)

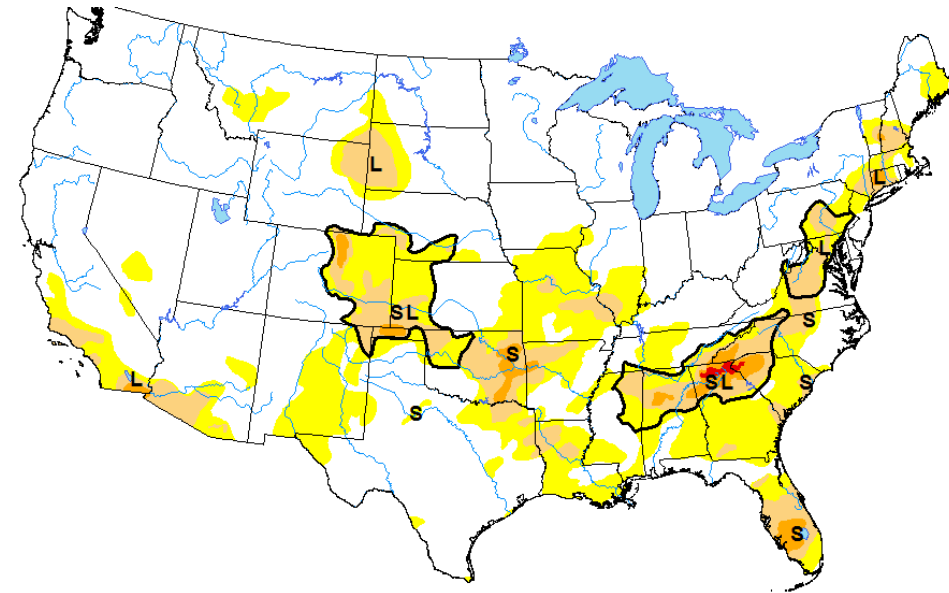


# U.S. Drought Monitor

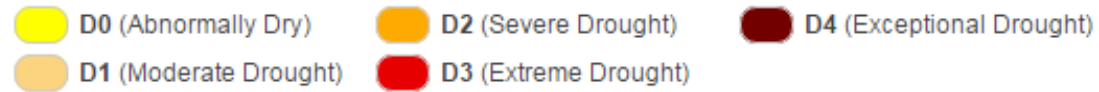
September 27, 2016



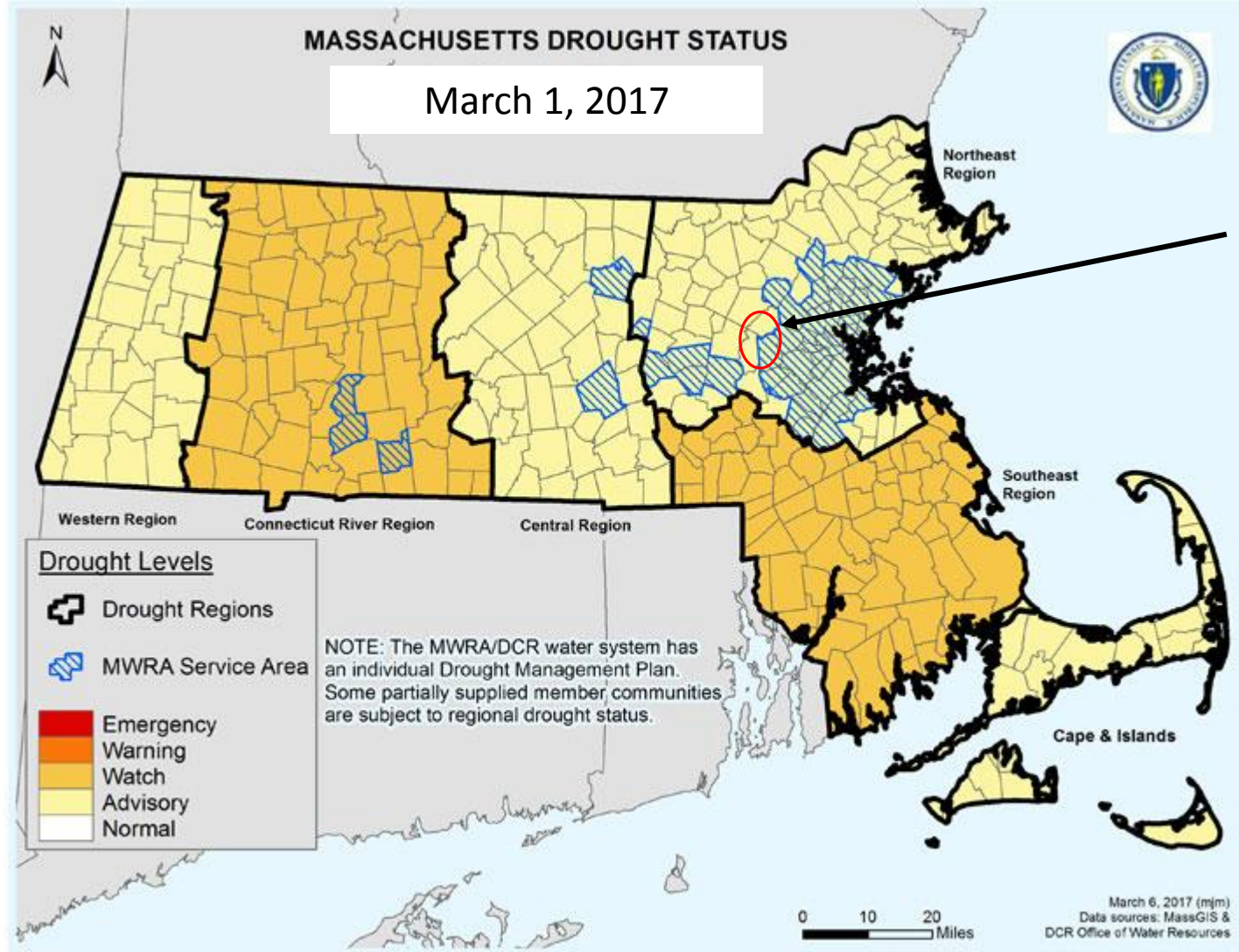
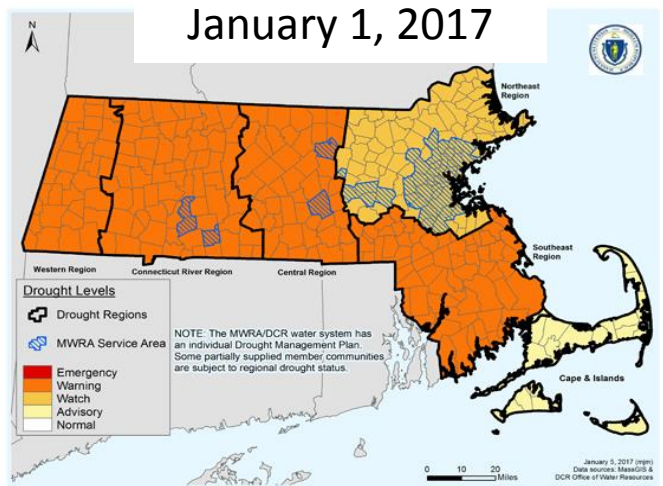
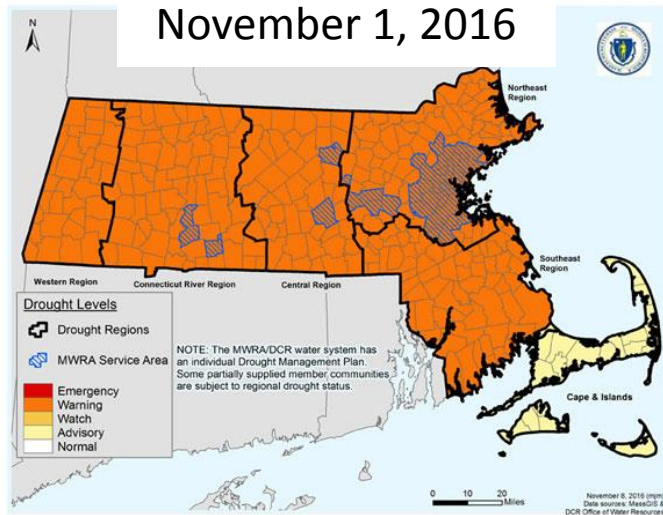
April 4, 2017



Intensity:



# MA Drought Management Task Force



Cambridge Watershed Region

# MWRA Drought Status

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- MWRA Drought Plan is triggered only by the Quabbin Reservoir storage volume
- As of February 1, 2017, MWRA categorized operations as Below Normal
  - Quabbin Reservoir was at 79.1% of its 412 billion gallon capacity
  - Wachusett Reservoir was at 91.2% of its 65 billion gallon capacity
- The MWRA 6 month projections expect a return to Normal Operations

**Current Conditions Status = Below Normal Operations**

<b>Quabbin Level</b>	<b>Normal Operations</b>	<b>Below Normal</b>	<b>Drought Warning</b>	<b>Drought Emergency 1</b>	<b>Drought Emergency 2</b>	<b>Drought Emergency 3</b>
	100% - 80%	80% - 65%	65% - 50%	50% - 30%	38% - 25%	25% - 0%



What does drought look like in the Cambridge reservoirs?

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# Hobbs Brook Reservoir

10/17/16



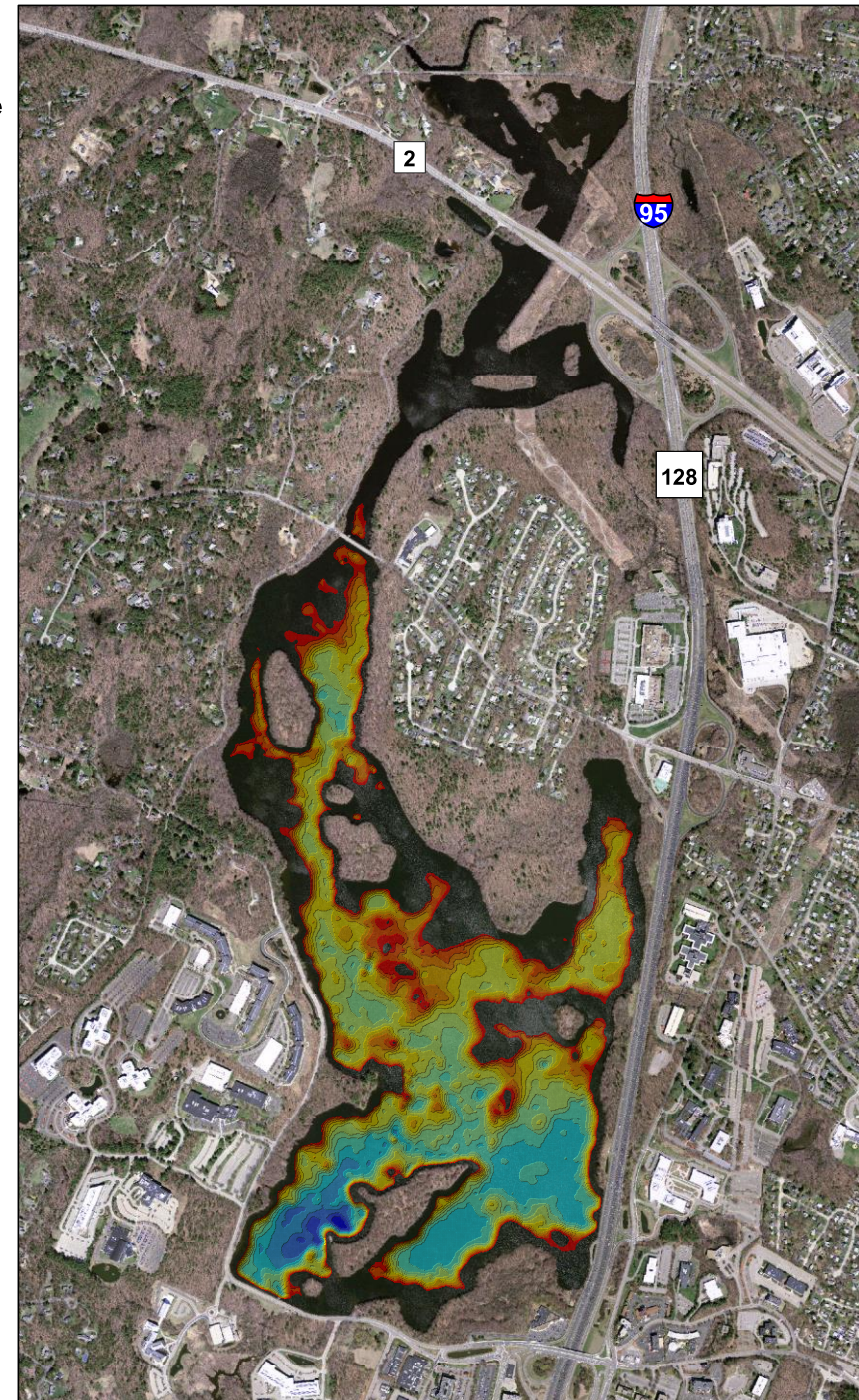
# Hobbs Brook Reservoir Drought Depth

- At height of drought, water levels at HBR dropped to 167 ft CVD
- Average water levels at HBR in the fall (Sept.-Dec.) range from 175.3-177.5 ft CVD

Scenario 1  
-500 MG  
Residual Volume

Water Surface  
Elevation  
~167 CVD

Water Depth (ft)







10/11/2016



10/1/2013

# Stony Brook Reservoir





# Fresh Pond

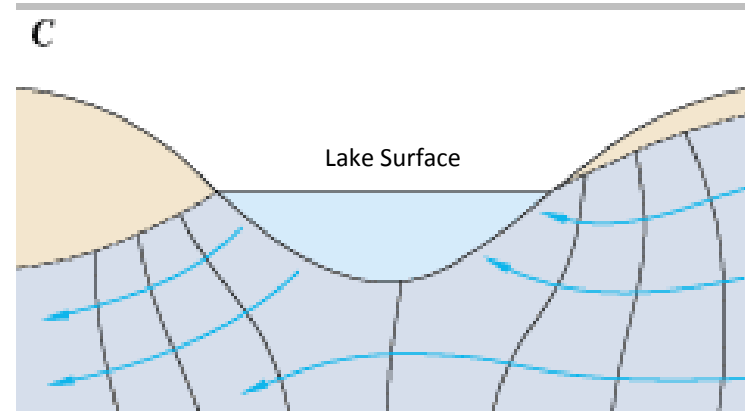
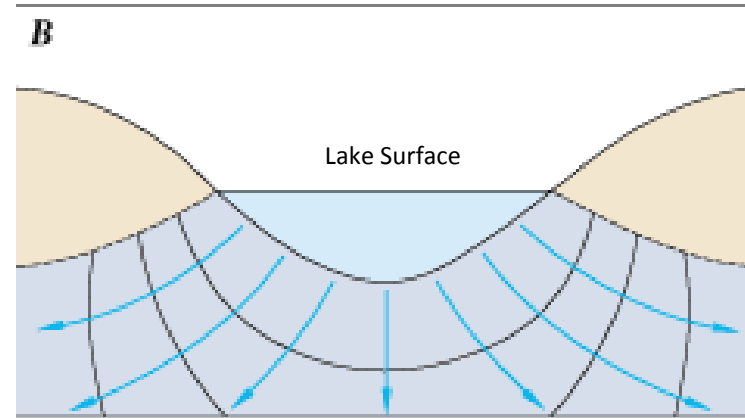
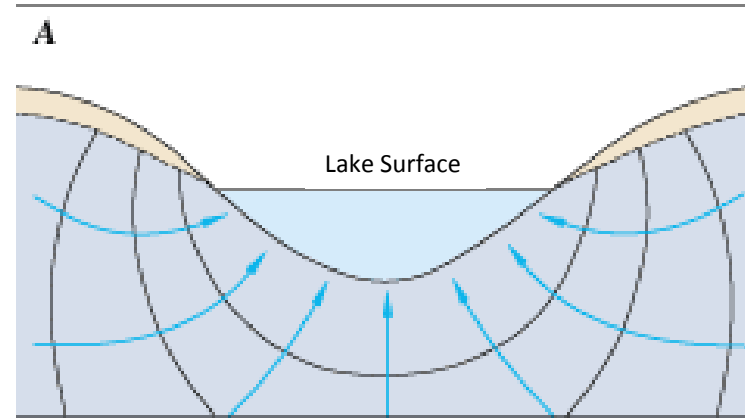
10/12/2016



# Why is Fresh Pond still full if Hobbs Brook Reservoir is so low?

Fresh Pond's water level is intentionally kept high for plant operations and to minimize groundwater inputs

Stony Brook Reservoir levels are also actively managed by increasing flows from Hobbs Brook, releasing water to the Charles River, and transferring water to Fresh Pond

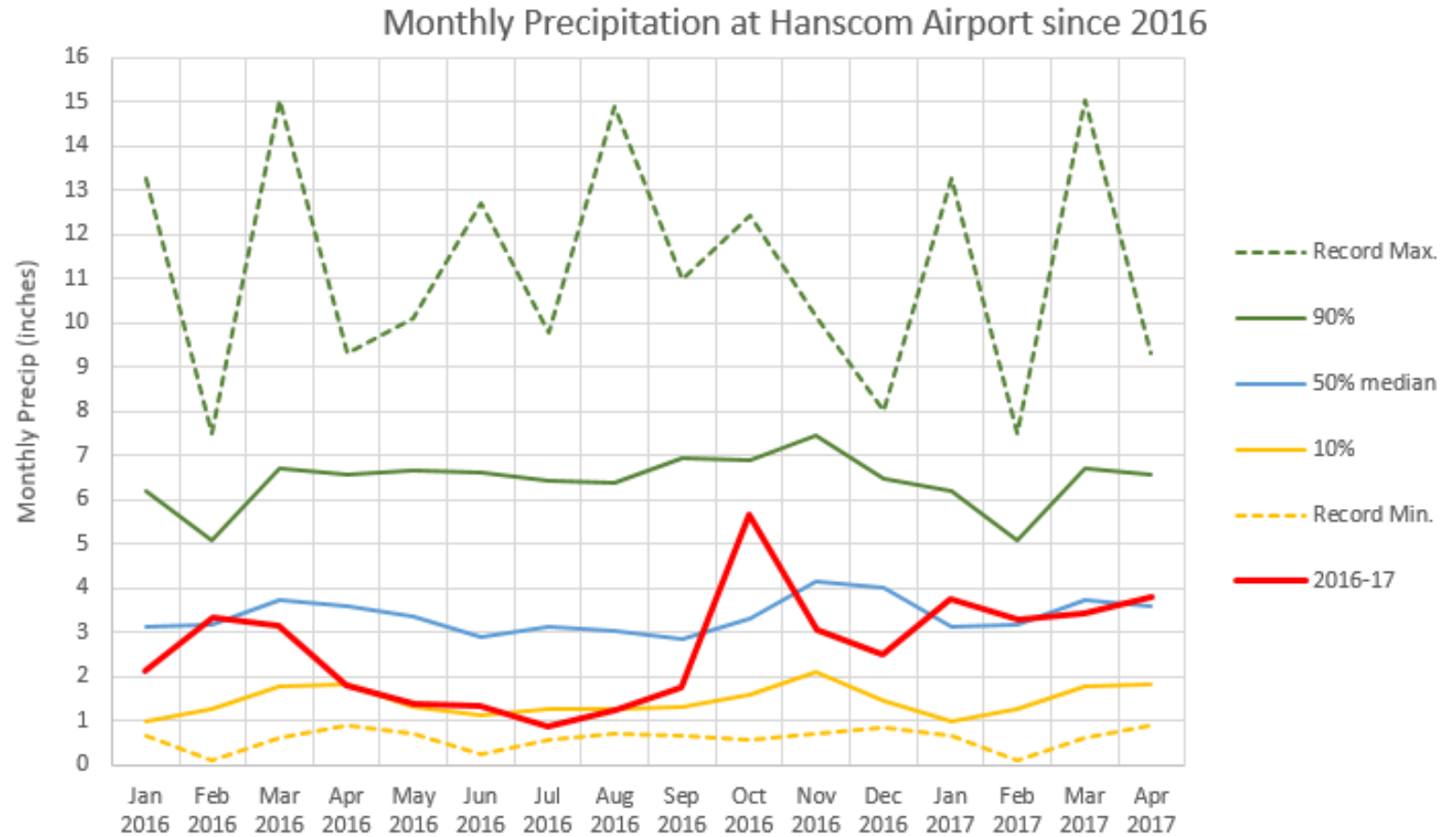


What conditions led to this drought?

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# 2016 Drought: Record Low Precipitation

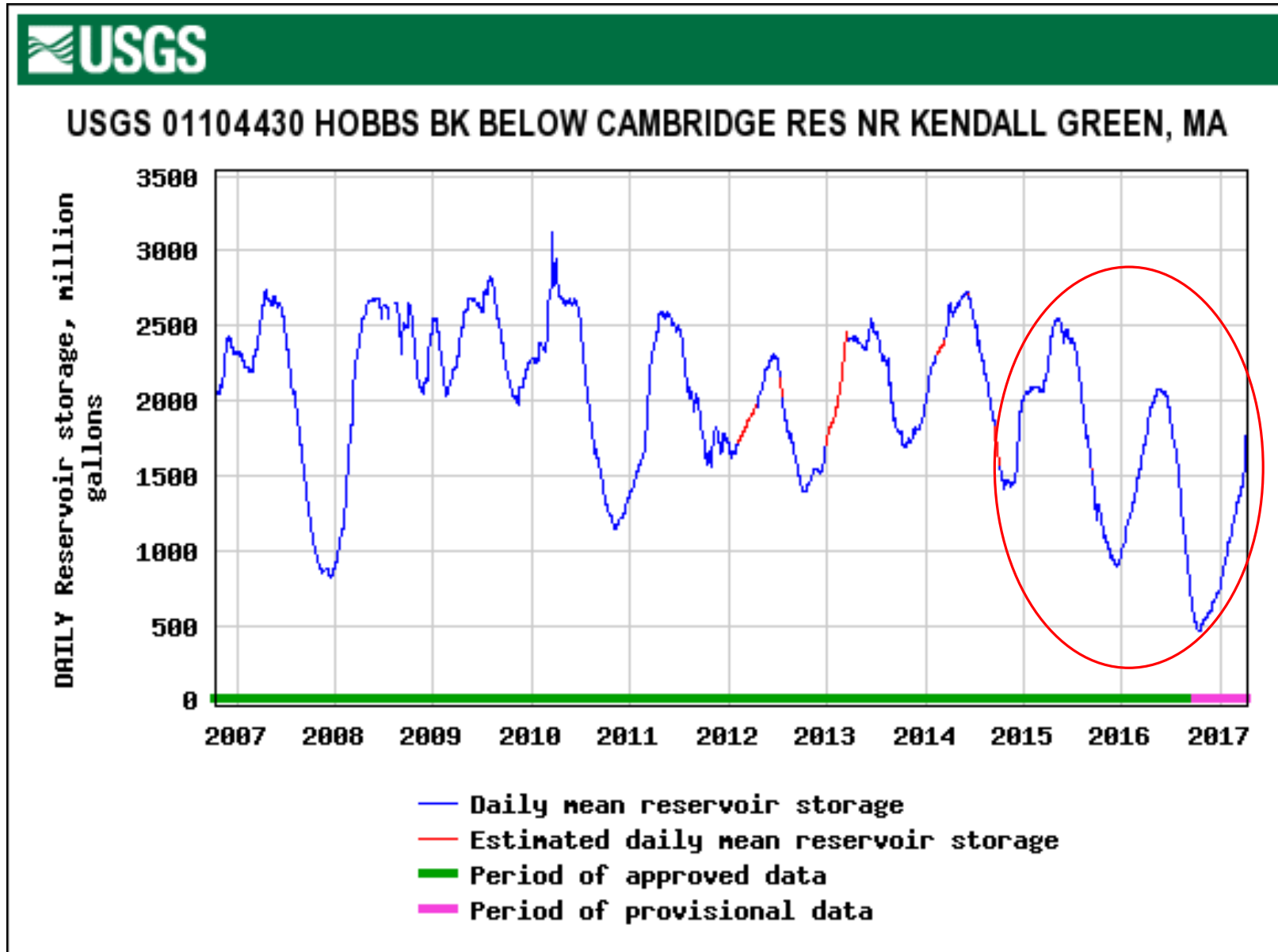
Cumulative precipitation from April 2016 through September 2016 is the lowest on record (1949)



# Historic Performance & 2016 Drought

System ran out of water during droughts in 1960s and 1980s

Typically, the reservoir system gets low towards the end of each summer, but rebounds quickly in winter/spring



# Will the drought end?

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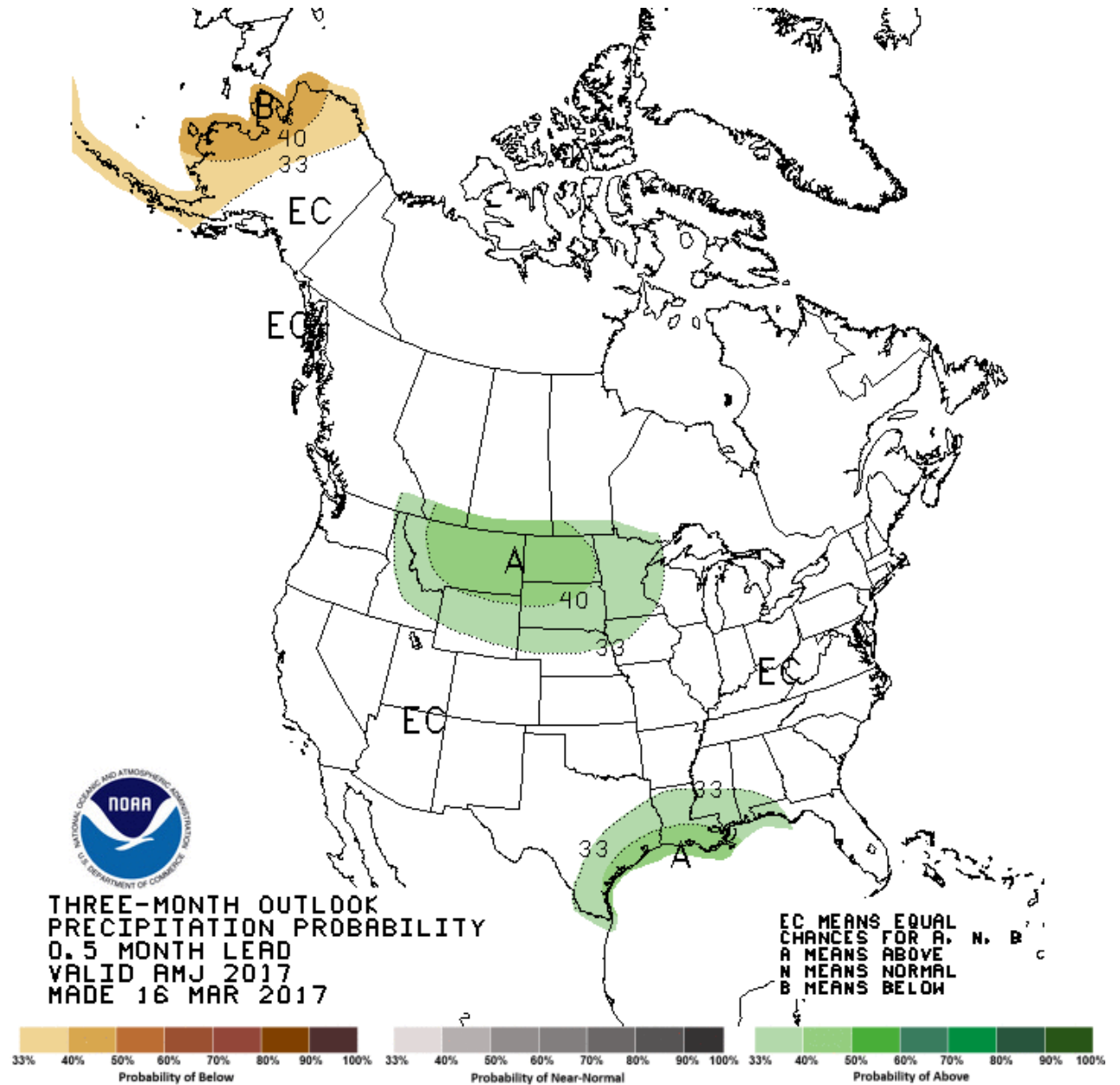
# Precipitation Required for Drought End or Improvement

*The current Palmer Hydrologic Drought Index (PHDI) for Eastern/Central Massachusetts is -3.0 to -3.9 as of January 18, 2017*

Condition	Statistics	1 Month	3 Months	6 Months
<u>Drought End</u> <i>(attain PHDI of -0.5)</i>	Precipitation to End	9 - 12 inches	15 - 18 inches	24 - 36 inches
	% of Normal Precipitation to End	200 - 224%	150 - 175%	100 - 125%
	Probability of Ending	0 - 1%	0 - 3.5%	9 - 18%
<u>Drought Improvement</u> <i>(attain PHDI of -2.0)</i>	Precipitation to Improvement	6 - 9 inches	12 - 15 inches	18 - 28 inches
	% of Normal Precipitation to Improve	175 - 200%	100 - 125%	75 - 100%
	Probability of Improving	0 - 7.6%	20 - 30%	50 - 60%

# NOAA Long Term Precipitation Forecasts

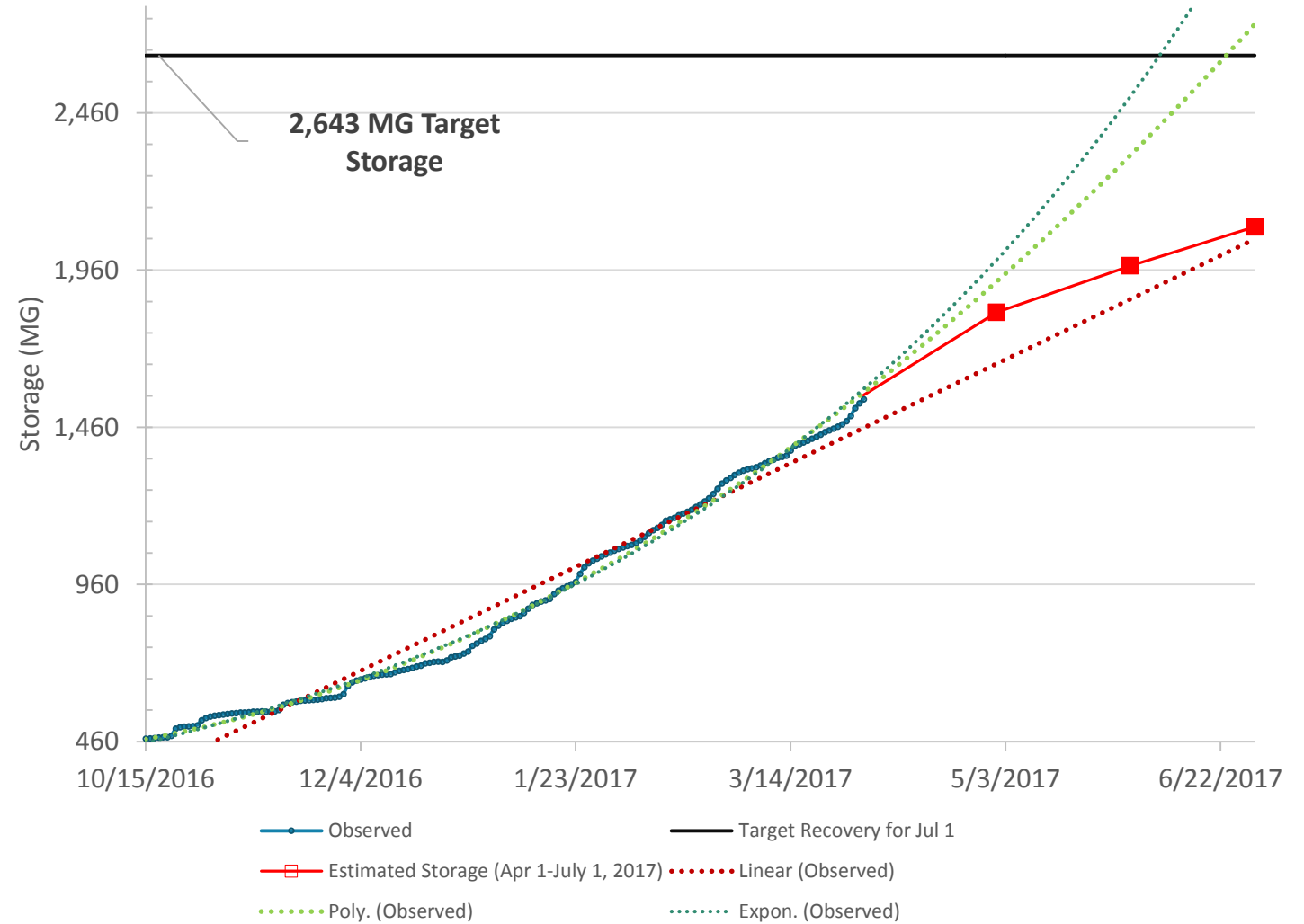
- April – June forecast
  - Equal chance of above or below average precipitation
- 1 year forecast
  - Slight chance above normal precipitation June – Oct 2017
- Would average rainfall be enough to recharge Cambridge Reservoirs?



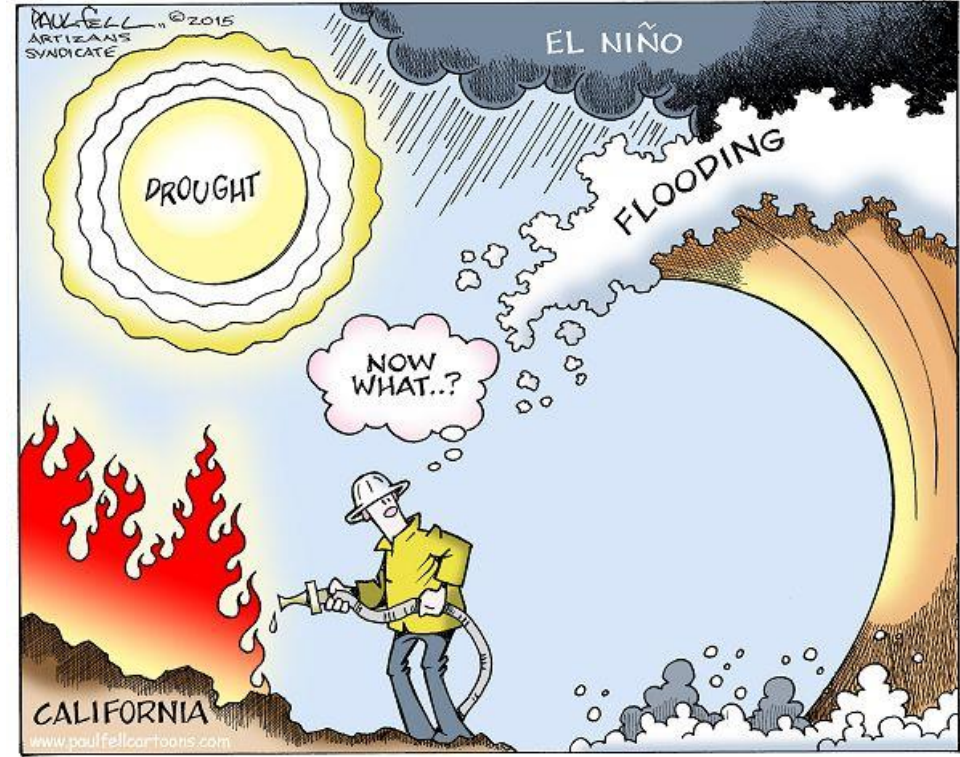
# Projected Reservoir Drought Recovery

- Estimated volume of water in Hobbs Brook Reservoir July 1, 2017 would not meet recharge target
- Drought could continue into the fall

Cambridge Reservoir Projected Storage Recovery



# Drought and Climate Change



# Connection with climate change

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- There is a strong consensus in scientific literature that temperatures will increase in New England, and while timing of precipitation is expected to shift, there is more uncertainty associated with projections of precipitation and hydrology (USACE)
- Increased temperatures may lead to more precipitation falling as rain, earlier snowmelt, and increased evaporation and transpiration, leading to higher risk of drought. (Union of Concerned Scientists)
- Increased temperatures can amplify the effects of drought when it does occur (Center for Climate and Energy Solutions)
- The Cambridge Climate Change Vulnerability Assessment has temperature and precipitation projections consistent with other literature, but focuses on the risk of flooding, not drought, for Fresh Pond (CCVA)



# Drought Impacts

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# Effects on Wildlife

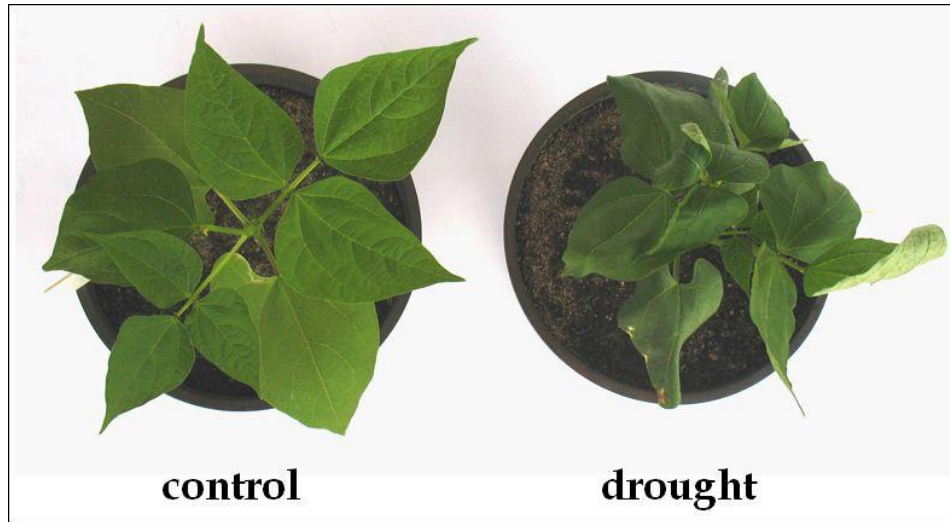
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- Extended drought conditions most severely impact fish
  - Reduce quality of quantity of habitat, trap fish in isolated pools – more vulnerable to predation
  - Stagnant, warmer water contains less dissolved oxygen
  - Small headwater streams evaporate first, eliminating nursery habitat
- Dry conditions exacerbate avian botulism
- Reduced berries cause bears to forage in neighborhoods (MassWildlife)



Hobbs Brook Reservoir, 10/17/16

# Effects on Vegetation



String bean

- Fall foliage

- Lose leaves earlier
- Green leaves change directly to brown (WBUR)

- Short term effects

- Wilting
- Scorch
- Defoliation
- Shrinkage of cell membranes
- Increased synthesis of abscisic acid, leading to closing of stomates
- Root hairs responsible for water uptake die off
- Reduced photosynthesis; reduced growth

- Long-term effects

- Dieback of branches
- Death as the plant's capacity to absorb water is damaged
- Susceptibility to disease and insect infestation (UMass Extension)

# Effect on Citizens

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- Cost
  - Water rates are set through June 30, 2017
- Water quality
  - MWRA and CWD produce very similar water
  - MWRA water is slightly softer and cooler
  - MWRA and CWD treatment and disinfection processes are the same to address the Lead and Copper rule

# Actions

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# CWD Water Conservation Actions

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- August 2016:
  - Strongly encouraged water conservation on water department webpage
- September 2016:
  - Urged outdoor and indoor water conservation – updated water department webpage
  - Reduced municipal outdoor irrigation by 50% or more
  - Turning off municipal irrigation early
  - Urging water conservation through all city social media accounts
  - Posted drought and water conservation link to city webpage
  - Added water conservation note to water bills

# What can you do as a citizen?

- Indoor water use
  - Efficient appliances
  - Wash full loads of dishes
  - Efficient behaviors
- Outdoor water use
  - Improved irrigation techniques
  - Drought-tolerant native plant selection
  - Drought-tolerant landscape design
  - Recycling & reuse of water, such as using rain barrels (MWRA)







Questions?



# Works Cited

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By slide number:

4: [Where Does Our Drinking Water Come From?](#)

7: [The MWRA Water System](#)

12: [NOAA, EPA, NDMC](#)

13: [US Drought Monitor](#)

14: [MA Energy and Environmental Affairs Drought Management](#)

15: [MWRA Water Supply Status](#)

21: [USGS Groundwater and Surface Water Interactions](#)

23: [Daily precipitation record at Hanscom Airforce Base \(USW00014702\)](#)

24: [USGS National Water Information System](#)

26: Calculations by CDM Smith

27: [NOAA Long Term Precipitation Forecasts](#)

28:

30: [Union of Concerned Scientists; Center for Climate and Energy Solutions; USACE; CCVA](#)

32: [MassWildlife October Newsletter](#)

33: [Impact of Drought on Fall Foliage; UMass Extension](#)

37: [Garden and Landscaping Conservation Tips; Water Use Graphic](#)