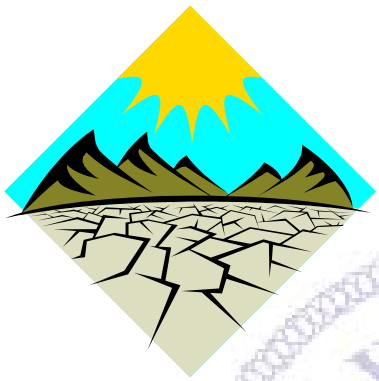
Dennis Water District Drought Management Plan



DRAFT

November 8, 2010

Dennis Water District
80 Old Bass River Road
S. Dennis, MA 02660

Comprehensive Environmental, Inc.
225 Cedar Hill Street
Marlborough, MA 01752

November 8, 2010

David Larkowski
Superintendent
Dennis Water District
80 Old Bass River Road
S. Dennis, MA 02660

RE: DROUGHT MANAGEMENT PLAN

Dear Mr. Larkowski:

In accordance with Comprehensive Environmental Inc.'s (CEI) agreement with the Dennis Water District dated September 16, 2010 this document provides a Draft Copy of the Drought Management Plan for the District.

Please contact us at 508-281-5160 if you should have any questions.

Sincerely,

COMPREHENSIVE ENVIRONMENTAL INC

Kristen M. Berger, P.E.
Project Manager

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National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC), *Meteorological Data Hyannis Station* (LAT 41:39, LONG -70:18), 2010.

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Section 1.0
Purpose and Goals

1.1 Purpose

The hydrologic cycle or water cycle involves condensation, infiltration, runoff, evaporation and precipitation as shown in Figure 1-1.

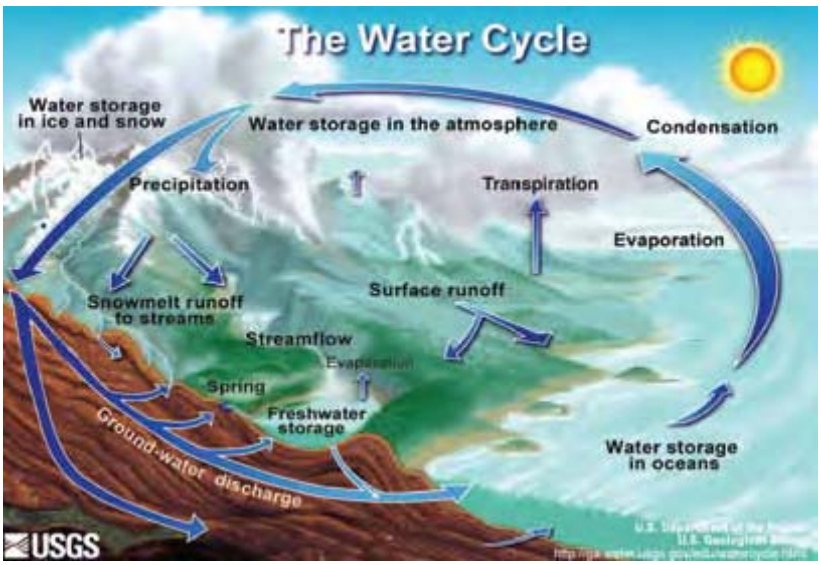

Figure 1-1
The Hydrologic Cycle
Source: U.S.G.S National Atlas of the United States: water use in the United States. Reston, VA: U.S. Department of the Interior.

Factors such as temperature, global winds, and ground permeability affect water distribution and water distribution changes over time. These changes in water distribution can cause drought that last months and years. Droughts are the result of long periods between rainfalls and higher than normal air temperatures that dry out soils and vegetation. Droughts can cause compromised quantity and quality of potable water, compromised food and nutrition, diminished living conditions, and increased disease incidence. It is important for water suppliers to prepare in advance of drought to protect public health and environmental resources.

The purpose of the Dennis Water District Drought Management Plan is to provide the District with a tool for monitoring of potential drought conditions and develop standard operating procedures to respond to drought conditions.

In support of water management efforts, the District has developed this drought management plan in accordance with the standards set forth by the Commonwealth of Massachusetts, Executive Office of Environmental Affairs (EOEA) and Massachusetts Emergency Management Agency (MEMA) in the *Massachusetts Drought Management Plan* dated 2001. The American Water Works Association *Drought Management Handbook* was also utilized in the development of this plan.

Massachusetts is a relatively water rich state with regular precipitation and stable surface water and groundwater supplies. There are times when short and longer term drought conditions can occur. These droughts can last for months or years. The state experienced a multi-year drought event from 1999 to 2002. The state issued a drought advisory in December 2001 and then a drought watch in March 2002. Cape Cod experienced below normal precipitation and groundwater levels.

This plan is intended to help the District in determining when drought conditions occur for the District's specific system and location. Drought management by the District compliments the efforts taken by the state on a regional level. Implementation of a drought plan customized to the District is necessary since the conditions and effects of drought are site specific.

1.2 Goals

The goals of the drought management plan are to:

1. Provide guidelines for monitoring of system specific drought related conditions;
2. Establish benchmarks for normal and dry conditions;
3. Provide guidelines for assessment of various system specific drought conditions;
4. Develop standard operating procedures to respond to drought conditions.

The American Water Works Association *Drought Management Handbook* focuses on four key elements that local governments and water suppliers should have in place to address dry conditions as shown in Table 1-1. The District currently has all four key elements in place.

Table 1-1
Key Elements to Address Dry Conditions

AWWA Key Element	Key Element Completed by the Dennis Water District
Development of Drought Management Plan	
Development of Emergency Response Plan	
Passage of Water Restriction By-Laws	
Identified Emergency Water Connections and Water Supplies	

Section 2.0
System Overview

2.1 System Overview

The Dennis Water District supplies water to the Town of Dennis, Massachusetts located on Cape Cod. This water system is considered a Medium Size Community Water System. An overview of system information is provided in Table 2-1.

Table 2-1
Overview of System Information

Public Water System Name	Dennis Water District	
Public Water System ID	4075000	
Main Office	Dennis Water District 80 Old Bass River Road S. Dennis, MA 02660 508-398-3351	
Basic description and location of system facilities	The Dennis Water District has: • 2 Pressure Zones • 22 Groundwater Supply Wells and Pumping Stations • 13 Chemical Feed Facilities • 2 Fe & Mn Removal Water Treatment Facilities • 4 Water Storage Tanks • 1 Booster Pumping Station • 230 miles Distribution Main • 3,660 valves • 1,585 hydrants	
Location/Town	Dennis, MA in Barnstable County	
Population served and service connections from MADEP Drinking Water Program records.	14,000 people winter 65,000 people summer	14,049 connections

2.2 Sources of Supply

The District supplies water to 2 pressure zones using 22 groundwater supply wells each with a dedicated pumping station. The wells and corresponding flow rates are presented in Table 2-2. The combined supply is 16 million gallons per day (mgd). The current maximum day demand is 10.5 mgd. This allows the District to rotate well pumping which helps the wells to recover after pumping. All of the wells draw water from the Cape Cod Aquifer, Monomoy Lens. The District owns most of the Zone 1 area of each of the wells. The District monitors the activities within the Zone 1 to protect the water supplies.

Table 2-2
Groundwater Supplies

Well No.	Flow (gpm)	Fe/Mn Removal Treatment	Location
North Side Pressure Zone			
4	250	Yes	Old Bass River Rd
6	150	No	Old Bass River Rd
9	600	Yes	Grassy Pond Drive
11	550	Yes	Old Bass River Rd
14	450	No	Bakers Pond Rd
18	700	No	Hokum Rock Rd
19	700	Yes	Setucket Rd
20	700	Yes	Setucket Rd
22	700	No	Old Bass River Rd
23	700	No	Old Chatham Rd
Total	5,300		
South Side Pressure Zone			
M/S	700	No	80 Old Bass River Rd
1	350	No	Old Chatham Rd
2	250	No	Old Chatham Rd
3	300	No	Old Chatham Rd
5	450	No	Route 134
7	450	Yes	Airline Rd
8	300	Yes	Airline Rd
10	700	No	Airline Rd
12	700	No	Old Chatham Rd
15	700	Yes	Bakers Pond Rd
16	450	Yes	Timber Lane
21	700	Yes	Route 134
Total	6,050		

gpm = gallons per minute
Fe/Mn = Iron/Manganese

The Cape Cod aquifer is comprised mainly of fine to coarse sand and gravel Glacial-lake clay, silt and very fine to fine sand. The following is an excerpt from the USGS Groundwater Atlas of the United States: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont, HA 730-M.

> The Cape Cod glacial aquifer is recharged by the part of the water from precipitation that is not returned to the atmosphere by evapotranspiration or that does not run off directly to streams or other surface-water bodies. Because of the permeable nature of the soils on the cape, an estimated 45 percent of the average annual precipitation of 40 inches rapidly soaks into the soil and becomes ground-water recharge. An estimated 55 percent of the precipitation is evapotranspired, and less than 1 percent runs off directly to streams, ponds and lakes, or saltwater bodies.

As described above, the Cape Cod aquifer recharges regularly from precipitation in the form of rain, ice and snow. This allows the aquifer to rebound quickly if short term droughts occur. The Cape Cod aquifer is not designated as a stressed basin by the Massachusetts Department of Environmental Protection (MADEP).

2.3 Sources of Storage

The District has four (4) water storage tanks with a total capacity of 10.5 million gallons (MG). The following table provides a summary of each tank.

Table 2-3
Water Storage Facilities

	South Side		North Side	
	Route 134 Tank	Route 28 Tank	Hokum Rock Tank	Old Bass River Rd Tank
Type	Steel Standpipe	Steel Elevated	Steel Standpipe	Steel Standpipe
Volume	6 MG	0.5 MG	2.7 MG	1.35 MG
Height	135 ft	170.5 ft	107 ft	90 ft
Diameter	87 ft	50 ft	66 ft	50 ft
Overflow El	199 ft	199 ft	244.5 ft	244.5 ft
Date Constr.	1968	1955	1996	1964

These storage facilities discharge water to the distribution system using gravity flow and are filled by the well pumping stations. The tanks within each pressure zone have the same overflow elevation allowing the water level in these tanks to set the pressure and float with the

distribution system. As the water demand in the system increases the water level in the tanks drops. When the water level in the tanks lowers to a certain elevation, select supply pumps initiate to re-fill the tanks. The total volume of these facilities is not usable. In order for the water to be usable it must be stored above an elevation that corresponds to a minimum pressure requirement at service elevations throughout the system. Figure 2-1 shows a typical system's tanks filling and emptying and corresponding pump operation.

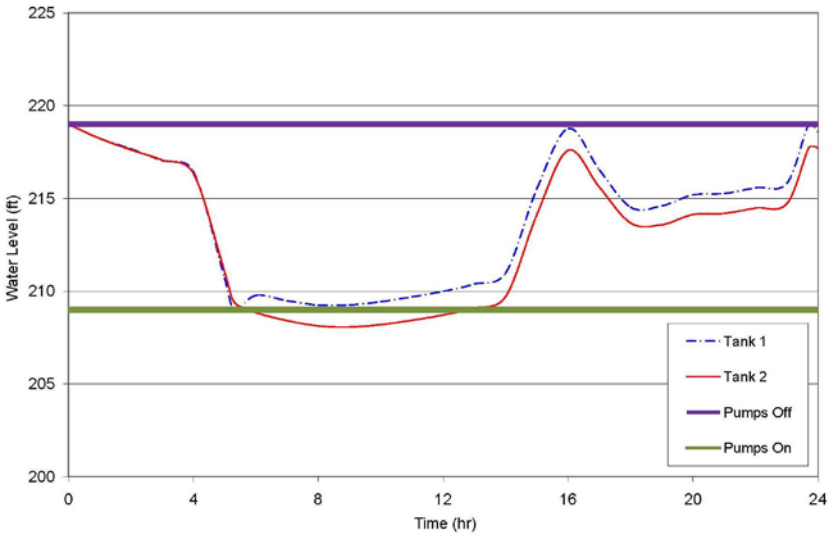

Figure 2-1
Typical Water Storage Tank Level and Pump Operation

Water system storage is has the following key functions: (1) equalization storage to meet peak hour demands, (2) fire flow storage to meet fire flow requirements, and (3) emergency storage to meet short term demands. Equalization storage is the volume of water required to meet the peak hour water demands during the maximum day demand period. This water must be supplied to all services at greater than a pressure of 35 psi for domestic demands, as established by the Massachusetts DEP Guidelines and Policies for Public Water Systems. Fire flow storage is that volume of water required to fight a fire within the area serviced by the distribution system. Emergency storage is the volume of water available to handle short term crises, such as a pump failure or a water main break, beyond the fire flow storage volume and equalization storage volume. The minimum service pressure required during fire and emergency conditions is 20 psi, as established by the Massachusetts DEP Guidelines and Policies for Public Water Systems.

The District has storage capacity to meet the equalization, fire and emergency storage requirements, which permits the District to rest the supply wells and allow them to recover after pumping. Adequate system storage will help the District in times of drought.

The Rte. 134 booster pumps are used to pump the lower portion of the Rte 134 water storage tank into the distribution system since this portion of water in the tank is un-usable under gravity conditions. There are two booster pumps with a capacity of 3,000 gpm. The pumps would be manually initiated for use. The entire storage volume would only be needed during emergency conditions.

2.4 Emergency Supplies and Connections

The District has 22 groundwater wells within the two pressure zones with a combined supply of 16 mgd. The District has some supply redundancy within the system. The District's water storage tanks contain volume for emergency use. The District also has the ability to withdraw all of the water from the Route 134 water storage tank using the 3,000 gpm booster pumping station. This would provide the District with an additional 900,000 Gallons that would not be available through gravity conditions.

The District has emergency interconnections with nearby water systems including the Town of Brewster, Town of Yarmouth and Town of Harwich.

1. The interconnections with Harwich are located on:
    a. Great Western Road,
    b. Depot Street and Center Street intersection, and
    c. Route 28.
2. The interconnection with Brewster is located on:
    a. Whiffletree Lane.
3. The interconnections with Yarmouth are located on:
    a. Route 6A,
    b. South Yarmouth Road, and
    c. Mayfair Road.

The District must work with these water suppliers for permission to use water in emergencies. Additionally, they hydraulics of the other water systems must be considered. Table 2-4 provides a summary of the water storage tank overflows within each water system. Note that to supply water to the North Side Pressure Zone, the District would need to pump water into the zone. If water is taken from Yarmouth, this water also is required to be pumped.

Prior to opening these interconnections, proper procedures must be taken. Hydrants on both sides of the connection must be flushed. Interconnection piping must be disinfected.

Table 2-4
Water System Hydraulics

System	Storage Tank Overflows
Dennis Water District North Side	Tank Overflow 244 feet
Dennis Water District South Side	Tank Overflow 199 feet
Brewster Water Department	Tank Overflow 218 feet
Yarmouth Water Department	Tank Overflow 189 feet
Harwich Water Department	Tank Overflow 211 feet

If necessary, the District can purchase water from one of the MADEP approved bulk water haulers. A MADEP emergency declaration order is required before the use of bulk water may be approved by MADEP.

2.5 Water Demand and Water Management Act

The Massachusetts Water Management Act (WMA) allows MADEP to regulate the quantity of water withdrawn from surface and groundwater supplies, with the goal to ensure adequate water supplies for current and future water needs. The Dennis Water District is authorized to withdraw 1,189,000,000 gallons per year (3.26 mgd on average) as issued in its WMA Permit. In 2009, the District withdrew 886,950,000 gallons (2.43 mgd on average which is 302,050,000 gallons (0.83 mgd) less than the authorized or permitted amount.

The EOEA and WRC *Water Conservation Standards* set the standard for unaccounted for water as meeting or demonstrating "steady progress toward meeting 10% unaccounted-for water (UAW) as soon as practicable." The standard for residential water use is to "meet or

demonstrate steady progress toward meeting residential water use of 65 gallons per capita per day (gpcd) including both indoor and outdoor use as soon as practicable." These standards are in agreement with the goals set by the WMA. The Dennis Water District is not in a stressed basin, so at present these are goals and not WMA permit requirements. However, the District does meet the residential water use goal. In 2009 the District's residential per capita usage was 54 gpcd which includes indoor and outdoor residential water use. The District is actively working to reduce the UAW to less than 10%. In 2009, the UAW was 12%.

Section 3.0
Precipitation and Monitoring

3.1 Historical Precipitation

The District monitors precipitation at the Main Office located at 80 Old Bass River Road, South Dennis, MA. The District has local precipitation data from 1980 to the present. The data can be used to identify historical periods of dry conditions which will help the District in monitoring for future dry conditions.

Historical meteorological data is also monitored by the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC). The NOAA meteorological station closest to the Dennis Water District service area and with the most comprehensive data set is the Hyannis station (LAT 41:39, LONG -70:18) located at the Hyannis Barnstable Municipal Airport. As part of this project, daily precipitation data was obtained from the NCDC for this station for the periods from 1960 to 1969 and 1980 to 2009. This data was used to compare to the data collected by the District and to obtain supplemental precipitation data for the 1960s.

Extended dry conditions have occurred within Massachusetts. The drought period of record typically referred to when discussing drought conditions occurred in the mid 1960s and was a multi-year dry event. A more recent multi-year dry event occurred from 1999 to 2002.

3.1.1 Annual Precipitation

The average annual precipitation for the NOAA Hyannis station is approximately 42 inches and the median precipitation is 41 inches. The District has measured the average annual precipitation as 50.5 inches and median as 51 inches. This means that the District on average measures approximately 10 inches more precipitation than is measured at the Hyannis station.

Annual precipitation for the NOAA Hyannis station for the 1960s is provided in Figure 3-1. The precipitation starts to decrease in 1963, with a low of 27.5 inches for the year 1965, then the annual precipitation increases toward normal and exceeds normal for the year 1967. For the four year period from 1963 through 1966, approximately 142.4 inches of rain was recorded.

Figure 3-2 provides the annual precipitation NOAA Hyannis station for the period from 1980 to 2009. This data show that there was a dry period from 1993-1995 (low precipitation year 1995 with 29.9 inches) and again from 2000-2001 (low precipitation year 2001 with 29.0 inches). The data sets for the years 1998 and 1999 for this station are incomplete. Comparing the 1993-1995 three year total of 96.84 inches with the 1964-1966 three year total of 103.5 inches shows that dry period in the 1990s was slightly drier than the 1960s. Additionally, the 2000-2001 two year total of 59.2 inches is less than the 1964-1965 two year total of 64.6 inches. This showed that the 1960s drought was not a singular occurrence and is likely to be repeated in the future.

Figure 3-3 provides the annual precipitation for the Dennis Water District rain gauge for the years 1980 to 2009. The District's data shows dry periods during 1980 to 1982 and 1999 to 2002. The lowest two year total for 1999 and 2000 was 79 inches, which is 20 inches more than the lowest two year totals measured at the Hyannis station. This implies that there is generally more precipitation in Dennis than in Hyannis, so the precipitation measured at the Hyannis station in the 1960s may not be representative of what occurred in Dennis during the same period.

Figure 3-4 compares the precipitation measured at the Dennis and Hyannis rain gauges. Generally more precipitation is measured at the Dennis gauge. This is valuable information to have when deciding what data to use in monitoring for drought conditions. If the District were to use the precipitation data reported by NOAA for the gauge at Hyannis and compare it to the average precipitation for the Dennis data, it may unnecessarily trigger a drought condition. Therefore, the District should continue to monitor and record precipitation at the Main Office location to be able to compare future precipitation to the average calculated from the historical data.

Figure 3-1
Annual Precipitation 1960s
Hyannis Meteorological Station
Data from NOAA National Climatic Data Center

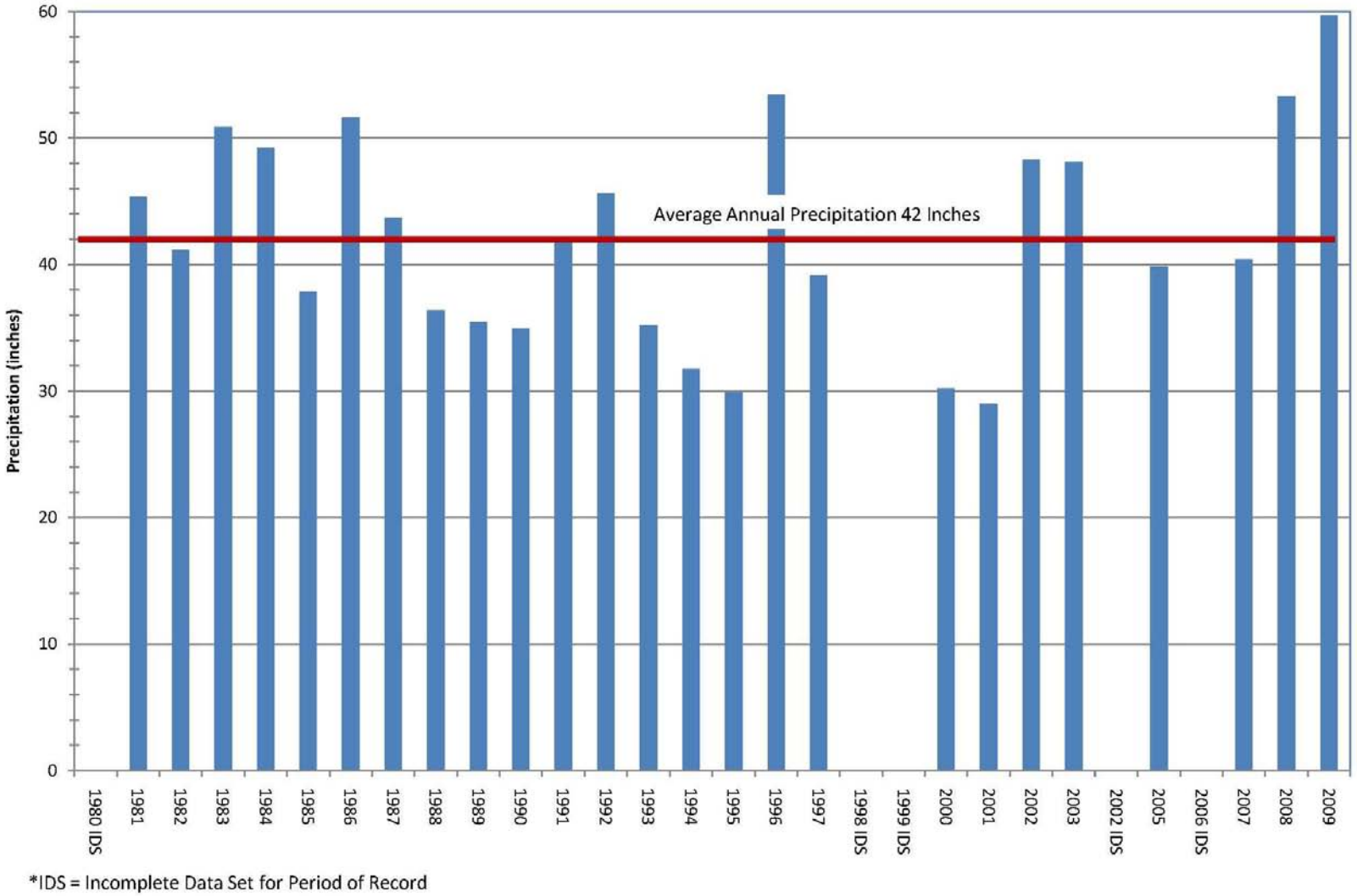

Figure 3-2
Annual Precipitation 1980-2009
Hyannis Meteorological Station
Data from NOAA National Climatic Data Center

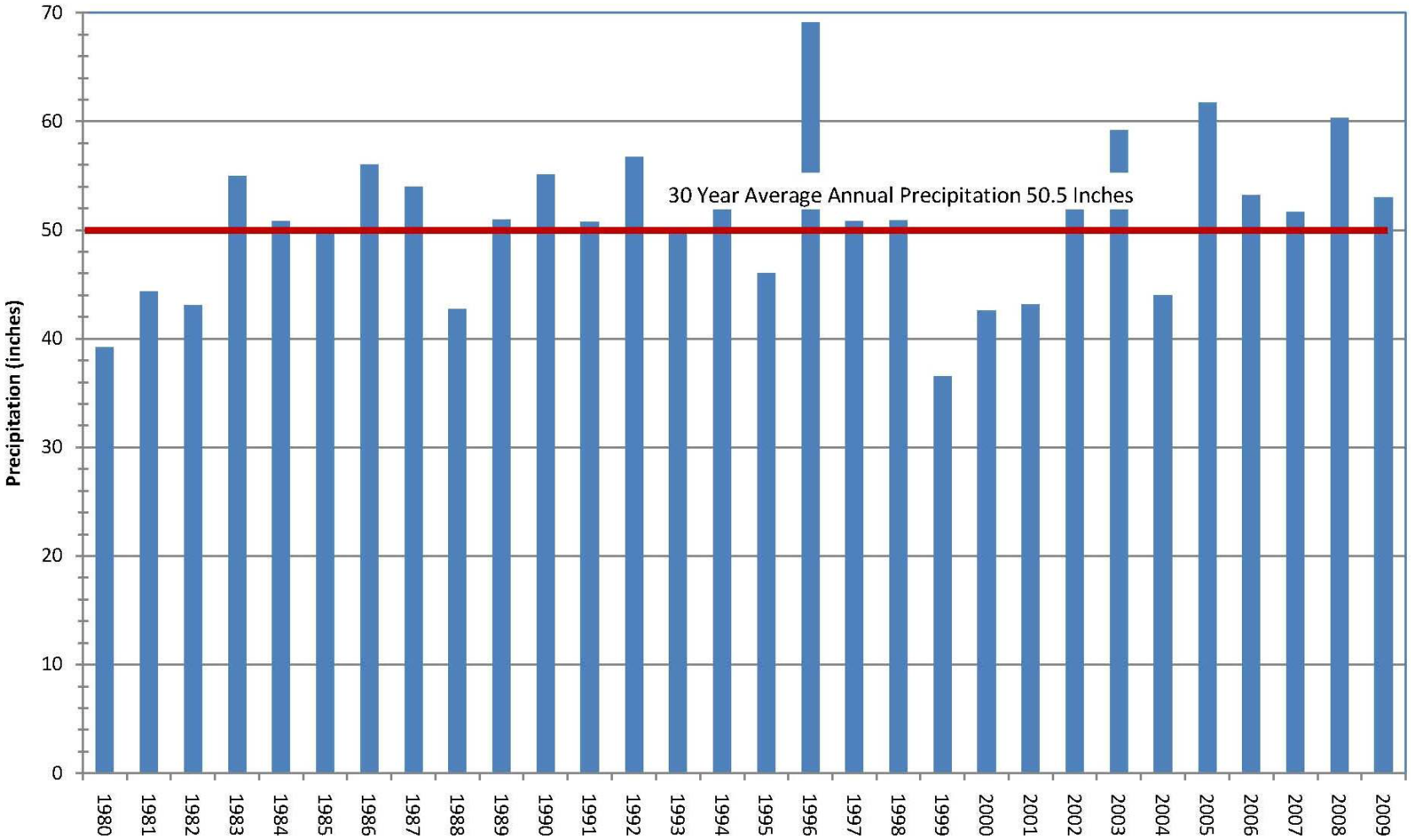

Figure 3-3
Annual Precipitation 1980-2009
Dennis Water District Rain Gauge Station
Data from Dennis Water District

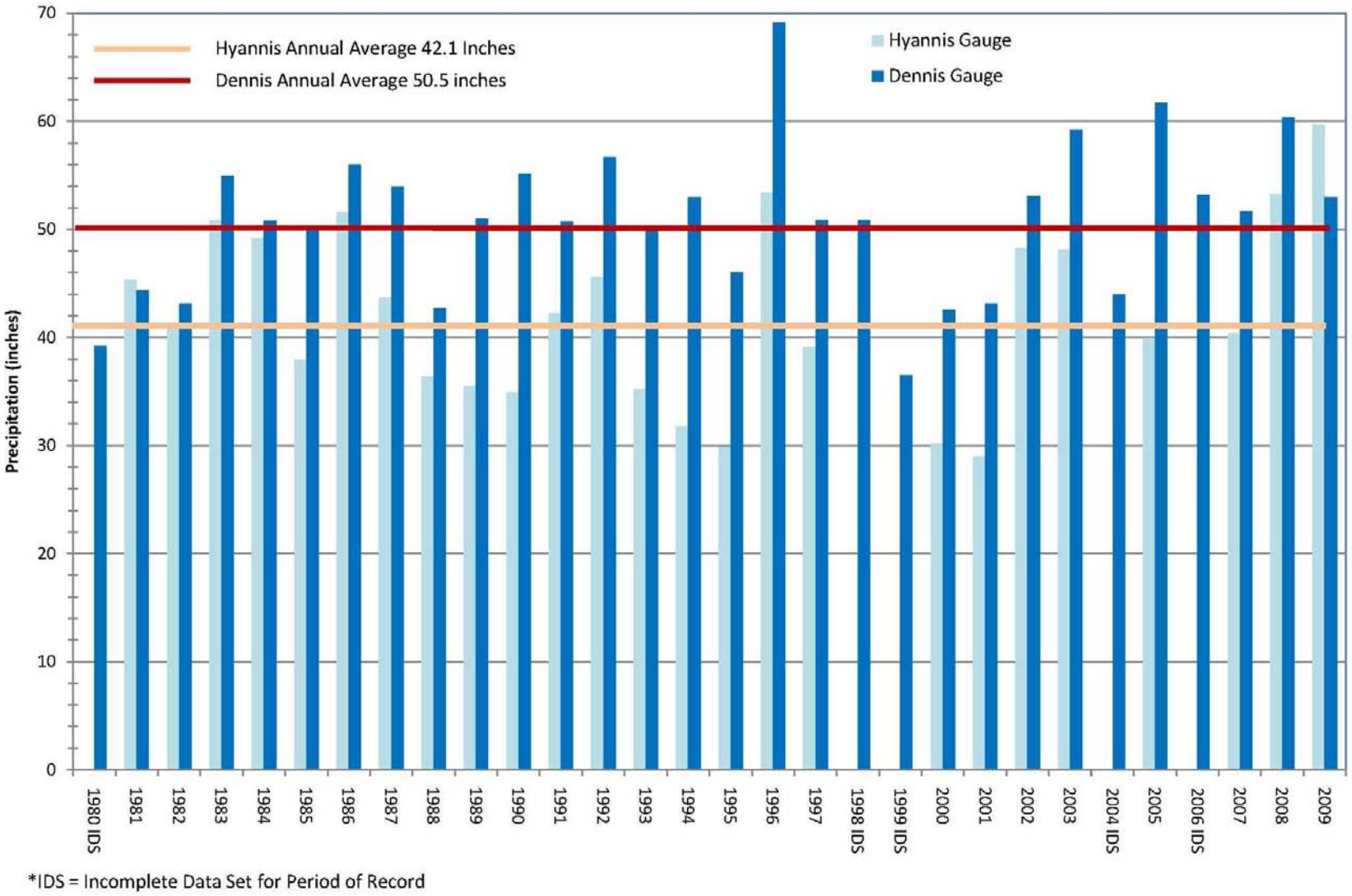

Figure 3-4
Annual Precipitation 1980-2009
Dennis and Hyannis Rain Gauge Stations
Data from Dennis Water District and NOAA National Climatic Data Center

3.1.2 Monthly Precipitation

As described in Section 2.0 of this plan, the Cape Cod aquifer recharges regularly from precipitation in the form of rain, ice and snow. This means that the aquifer recharges throughout the year. An estimated 45 percent of the average annual precipitation or about 19 to 22 inches per year rapidly soaks into the soil and becomes groundwater recharge. It is better for infiltration if the precipitation is provided in a steady form rather than high intensity storms such as with hurricanes.

The 30-year precipitation data obtained from the Dennis Water District and NOAA was used to calculate the average, median, minimum and maximum monthly precipitation values. Monthly precipitation totals can be used as an indicator of drought conditions. The precipitation for the year may be at average, but there may have been a 3 month dry period followed by wet months. It is important to be aware of the monthly precipitation. However, for Cape Cod, having a 3 month dry period may not create a drought condition.

The average or mean value is the average of each value over the 30-year period. The median is the value exceeded 50% of the time over the 30-year period. The average or median values may be used to set the drought indicators. However, the average value is more likely to be affected by extreme minimums and maximums. The median value is a more accurate representation of the "normal" value.

It is important to note that just because one month may have less than the median precipitation, it does not in of itself mean that a drought is occurring. Refer to Section 5.0 of this plan for a description of the drought indicators and triggers.

Table 3-1 provides the 30-Year Average, Median, Minimum and Maximum Monthly Precipitation amounts for each month of the year for the Hyannis meteorological station. Figure 3-5 shows this same data in a graphical form.

Table 3-2 provides the 30-Year Average, Median, Minimum and Maximum Monthly Precipitation amounts for each month of the year for the Dennis rain gauge station. Figure 3-6 shows this same data in a graphical form.

Figure 3-7 compares the median monthly precipitation observed at the Dennis rain gauge and the Hyannis meteorological station.

Generally, the median monthly precipitation calculated using the Dennis data is greater than the median monthly precipitation calculated using the Hyannis data. Approximately 8 to 28% more precipitation would be expected at the Dennis rain gauge than at the Hyannis station. This is valuable information to have when deciding what data to use in monitoring for drought conditions. If the District were to use the precipitation data reported by NOAA for the gauge at Hyannis and compare it to the average precipitation for the Dennis data, it may unnecessarily trigger a drought condition. Therefore, the District should continue to monitor and record precipitation at the Main Office location to be able to compare future precipitation to the median monthly precipitation calculated from the historical data.

Table 3-1
30-Year Monthly Precipitation Data
Hyannis Meteorological Station

Month	Monthly Precipitation (inches)			
	Average	Median	Minimum	Maximum
January	3.44	3.28	1.23	6.97
February	3.20	2.5	1.13	6.35
March	4.27	4.51	0.71	9.53
April	3.90	3.74	1.34	8.24
May	3.32	2.83	0.9	10.27
June	3.10	2.78	0	7.59
July	3.04	2.58	0.84	10.02
August	3.18	2.95	0.22	10.16
September	3.39	2.36	0.94	13.67
October	3.77	3.63	0.97	9.39
November	4.02	3.84	0.61	8.7
December	4.26	3.88	0.59	8.28

Data from NOAA National Climatic Data Center
30-Year Data from 1980 to 2010 was used to calculate the average, median, minimum and maximum monthly precipitation.

Table 3-2
30-Year Monthly Precipitation Data
Dennis Rain Gauge Station

Month	Monthly Precipitation (inches)			
	Average	Median	Minimum	Maximum
January	4.36	4.1	1.69	8.42
February	3.68	3.45	1.35	7.25
March	5.59	5.22	0.81	11.09
April	4.74	4.2	0.56	9.74
May	3.90	3.45	1.81	7.67
June	3.74	3.48	0.04	11.2
July	3.15	2.84	0.52	8.22
August	3.53	3.51	0.47	11.42
September	3.75	2.94	0.77	15.01
October	4.49	3.97	1.45	10.73
November	4.82	4.87	0.88	9.28
December	5.17	4.36	1.61	10.13

Data from Dennis Water District
30-Year Data from 1980 to 2010 was used to calculate the average, median, minimum and maximum monthly precipitation.

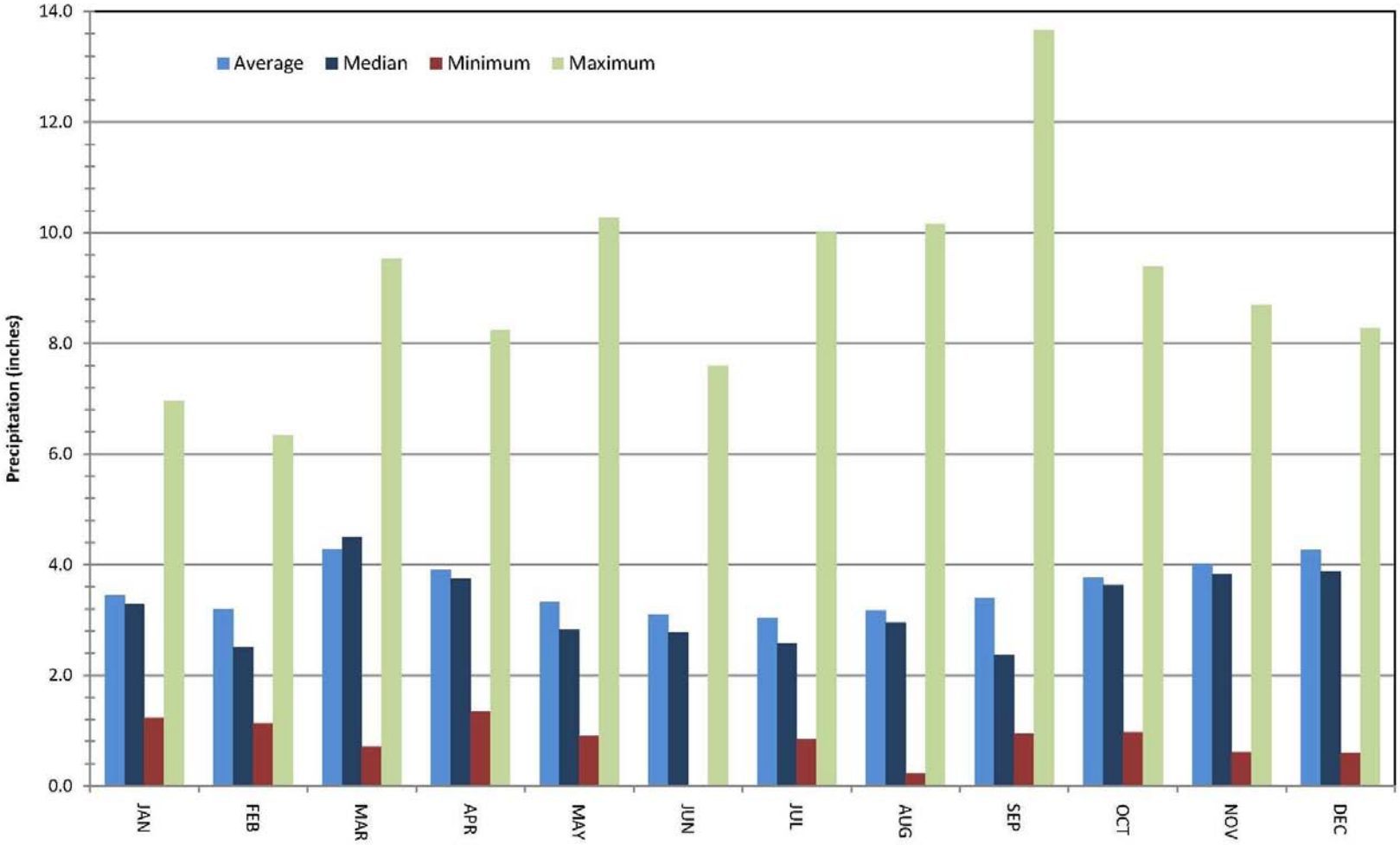

Figure 3-5
30-Year Monthly Precipitation Data
Hyannis Meteorological Station
Data from NOAA National Climatic Data Center

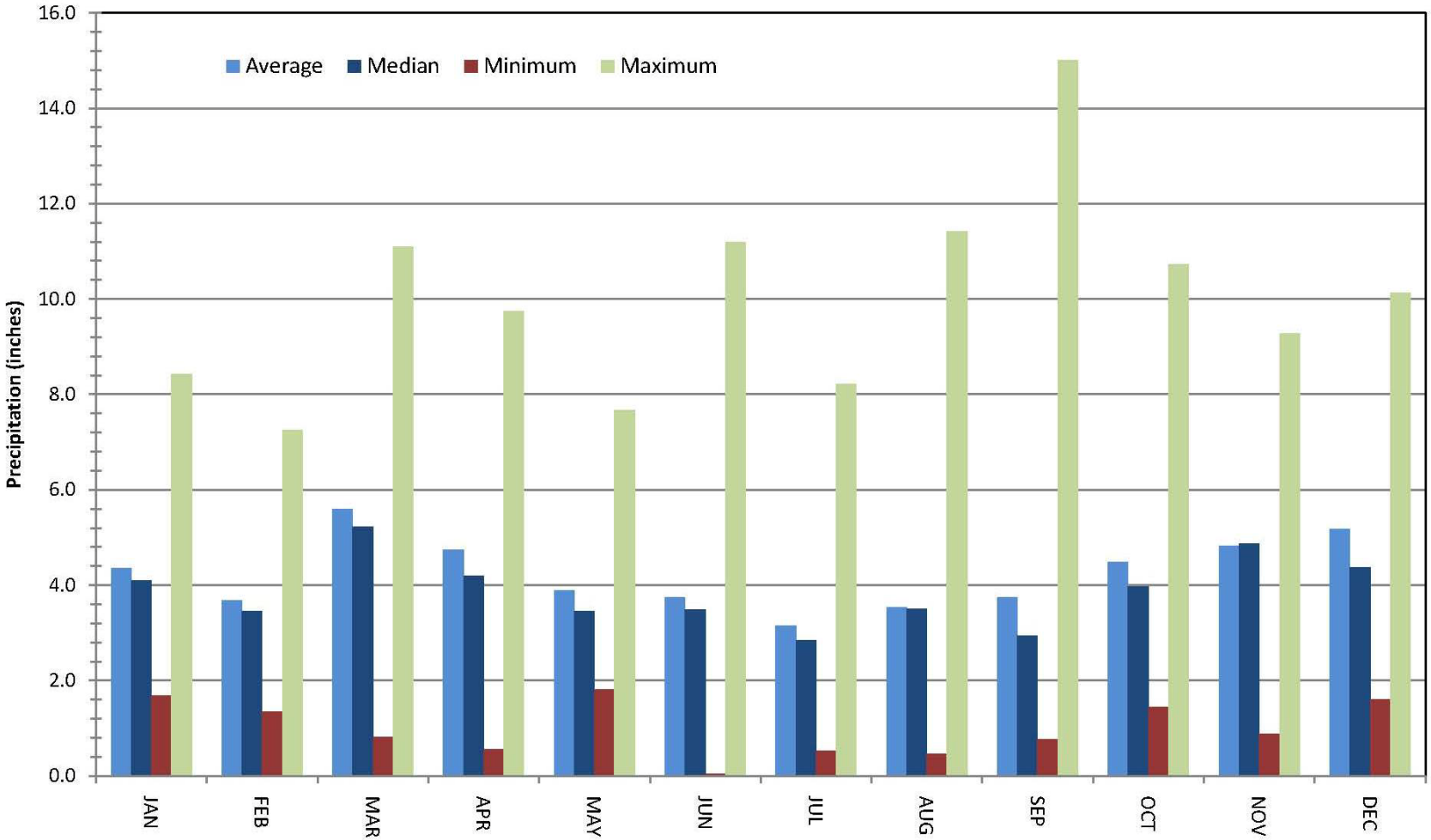

Figure 3-6
30-Year Monthly Precipitation Data
Dennis Rain Gauge Station
Data from Dennis Water District

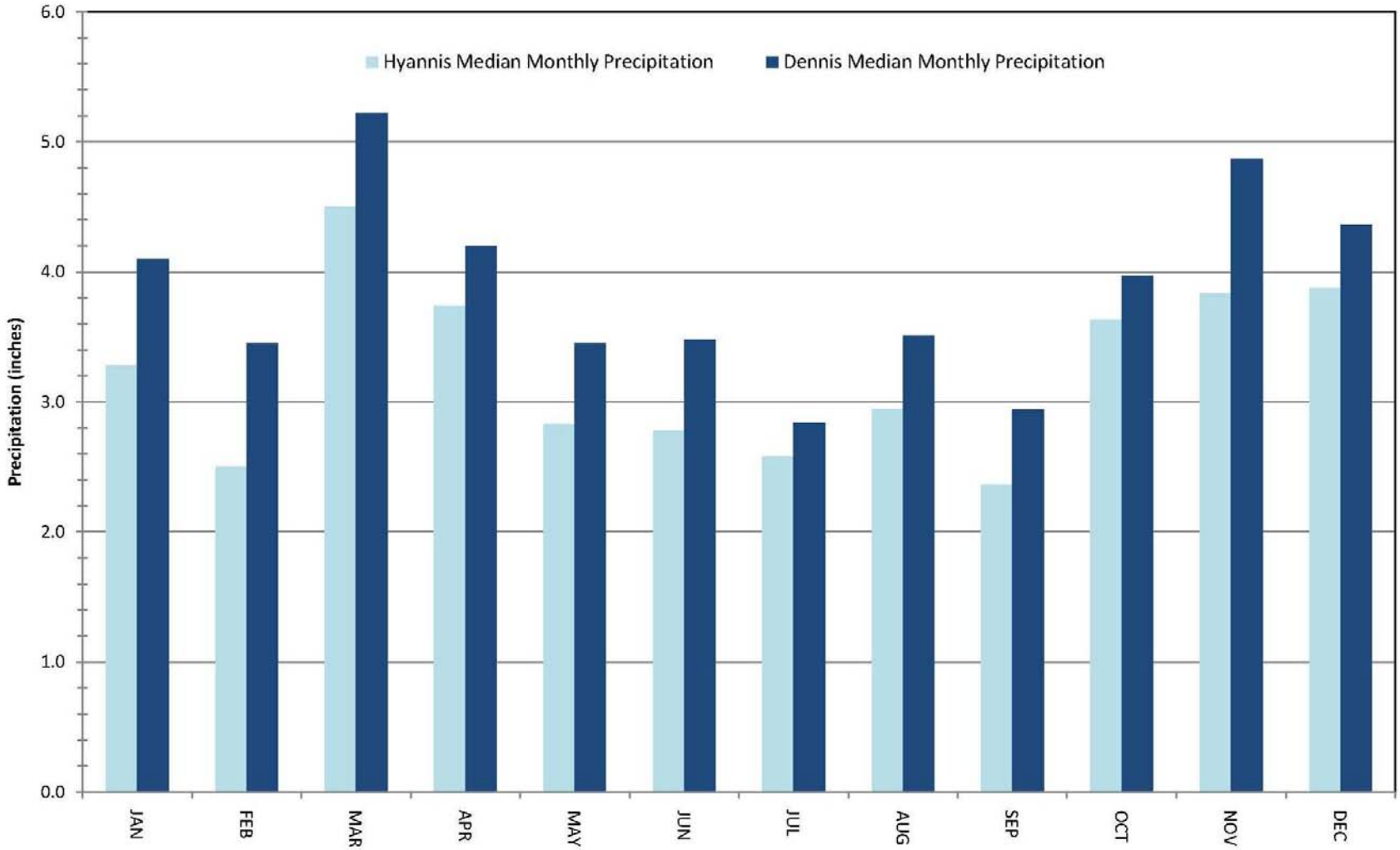

Figure 3-7
30-Year Median Monthly Precipitation Data
Dennis and Hyannis Rain Gauge Station
Data from Dennis Water District and NOAA National Climatic Data Center

3.2 Monitoring

The District can monitor the precipitation through use of rain gauges or data collected by NOAA. The District currently measures and records precipitation at the Main Office location using a rain gauge that meets the standards used by weather officials. These officials typically utilize an 8-inch Standard Rain Gauge consisting of a large cylinder with a funnel and smaller measuring tube inside of it as shown in Figure 3-8. The smaller measuring tube has an exaggerated scale and allows for more precise rainfall measurements. Up to 1-inch can be measured with the smaller tube. Rainfall more than 1-inch will overflow into the cylinder surrounding the measuring tube.

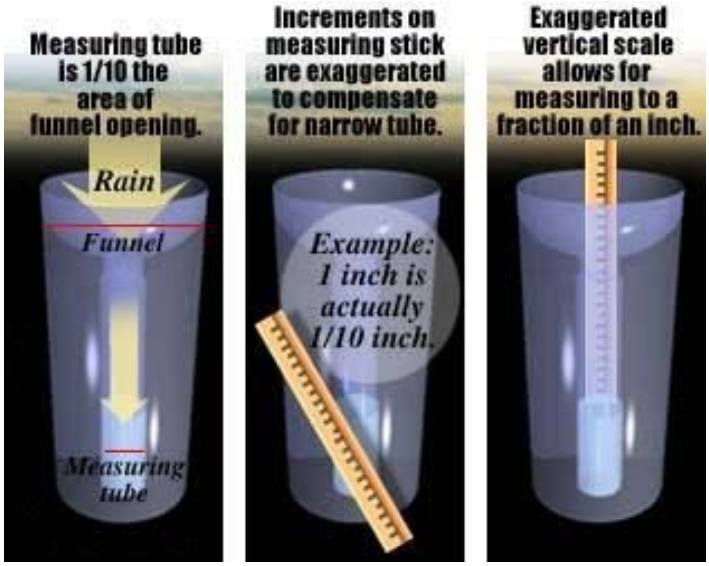

Figure 3-8
Official Rain Gauge

Data collected by NOAA is available at the following websites:

http://www.weather.gov/view/prodsByState.php?state=ma&prodtype=climate

http://weather.noaa.gov/weather/current/KHYA.html

http://www.ncdc.noaa.gov/oa/climate/climatedata.html#daily

http://www.ncdc.noaa.gov/oa/mpp/digitalfiles.html#DIG

The normal or median monthly precipitation for the Dennis and Hyannis stations are provided in Table 3-3. Whichever data is used for drought monitoring going forward, how the data is collected must be consistent. This means that if the District elects to continue measuring and monitoring data at the Main Office, then this future data should be compared to the median monthly precipitation for the Dennis location. The future precipitation data collected at the Dennis location cannot be compared to the median monthly data for the Hyannis station.

Table 3-3
30-Year Median Monthly Precipitation Data
Dennis and Hyannis Rain Gauge Stations

Month	Hyannis Gauge Median Monthly Precipitation (inches)	Dennis Gauge Median Monthly Precipitation (inches)
January	3.28	4.1
February	2.5	3.45
March	4.51	5.22
April	3.74	4.2
May	2.83	3.45
June	2.78	3.48
July	2.58	2.84
August	2.95	3.51
September	2.36	2.94
October	3.63	3.97
November	3.84	4.87
December	3.88	4.36

Hyannis Gauge data from NOAA National Climatic Data Center
Dennis Gauge data from Dennis Water District
30-Year Data from 1980 to 2010 was used to calculate the median monthly precipitation.

Section 4.0
Groundwater Levels and Monitoring

4.1 Groundwater Levels

Groundwater levels can be used as an indicator of drought conditions. USGS defines normal as groundwater levels that are in the range of 25th-74th percentile of the period of record. Groundwater levels within the normal range can include situation when groundwater levels are less than an average condition.

The USGS has monitoring wells located on Cape Cod and collects real time data of groundwater levels for some wells and monthly levels for other wells. The USGS uses this data to track groundwater level conditions. For each monitoring well, the USGS has assigned normal, below normal and above normal conditions. These conditions are based on the percentile of the period of record. Figure 4-1 provides a summary of the percentile ranges used by the USGS for groundwater levels.

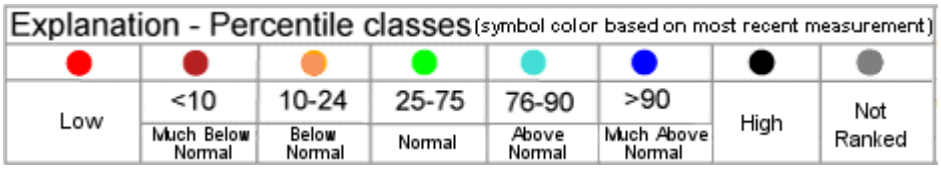

Figure 4-1
USGS Monitoring Wells Groundwater Level Ranking
Based on Percentile Ranges for Periods of Record

There are USGS monitoring wells in the Dennis Water District service area. Well Site 414210070090901 - MA-DGW 158 and Well Site 414402070083901 - MA-DGW 123. The water level data from this well can be used by the District to monitor for drought conditions to supplement the District's well data. Groundwater level data for these wells is collected monthly.

The MADEP requests water systems within the Monomoy Lens utilize data from a well located in Brewster, MA (Well Site 414630070014901 - MA-BMW 22). Data for this well is collected as "real-time" data, meaning that groundwater level conditions are updated automatically throughout the day.

The relationship of groundwater levels within the Brewster well with those observed in the Dennis Water District Well No. 12 and the USGS monitoring wells in Dennis, MA was evaluated during the development of this plan. More information regarding this analysis is provided in Appendix A. Ultimately it was determined that all four wells have the same general trend over time with groundwater levels increasing and decreasing in a similar pattern. Therefore, the District intends on using groundwater level data from the USGS well in Brewster and Well No. 12 to assess drought conditions.

The following sections provide more detailed information about the USGS well in Brewster and the District's Well No. 12.

4.1.1 USGS Monitoring Well MA-BMW 22 – Brewster, MA

The USGS monitoring well in Brewster (Site Number: 414630070014901 - MA-BMW 22) is located south of Route 6A (Latitude 41°46'30", Longitude 70°01'49" NAD27) as shown in Figure 4-2.

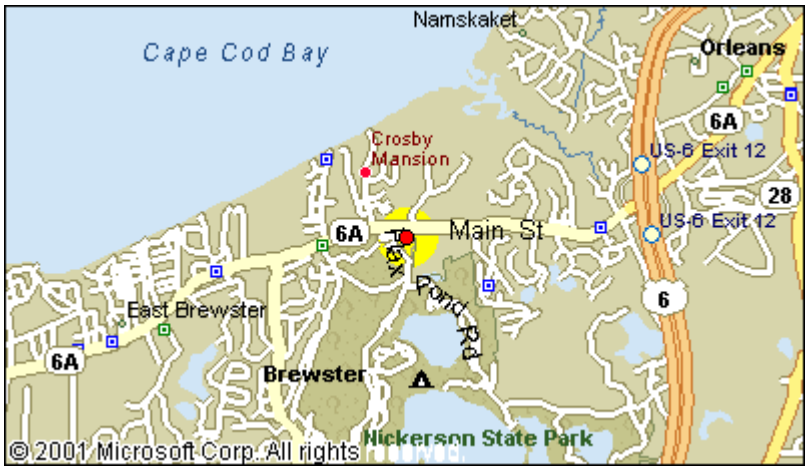

Figure 4-2
Location of USGS Monitoring Well in Brewster, MA
USGS Site Number: 414630070014901 - MA-BMW 22

The well depth is 52.0 feet, hole depth is 52.0 feet and land surface altitude is 50.45 feet above sea level NGVD29. The well was completed in "Sand and gravel aquifers (glaciated regions)." The USGS began monitoring the groundwater level in this well in 1962 and continues to this day. The USGS provides the real time data for this well on-line and also provides the median water level for each day, month and year.

Table 4-1 shows the median monthly groundwater levels in each percentile range.

Figure 4-3 provides a graph of the median monthly groundwater levels from 1980 to 2010.

Table 4-1
Median Monthly Groundwater Level Percentile Ranges
USGS Monitoring Well BMW 22 – Brewster, MA

	Groundwater Level Measured Down from Surface (Assumes Surface is 0 or Datum)							
Month	**Lowest Median**	**10th %ile**	**25th %ile**	**50th %ile**	**75th %ile**	**90th %ile**	**Highest Median**	**Number of Years**
Jan	33.6	33.07	32.19	31.14	30.36	29.74	28.97	47
Feb	33.52	32.96	32.1	30.98	29.96	29.4	29.02	47
Mar	33.55	32.71	31.62	30.88	29.75	29.2	28.77	47
Apr	33.25	32.36	31.19	30.37	29.16	28.6	28.15	47
May	33.28	32.04	31.23	29.93	28.87	28.58	28.13	46
Jun	32.91	32	31.3	30.15	29.07	28.63	28.42	47
Jul	33.05	32.35	31.55	30.57	29.48	28.86	28.15	48
Aug	33.33	32.62	31.96	30.85	29.82	29.12	28.69	45
Sep	33.55	32.96	31.91	31.13	30.26	29.42	28.77	44
Oct	33.68	33.18	32.35	31.55	30.68	29.82	28.97	45
Nov	33.78	33.22	32.52	31.6	30.83	30.03	29.12	45
Dec	33.49	33.13	32.26	31.62	30.82	29.99	29.21	45

Data from USGS
Water Levels between the 25th and 75th percentile are considered normal
USGS Site Number: 414630070014901 - MA-BMW 22
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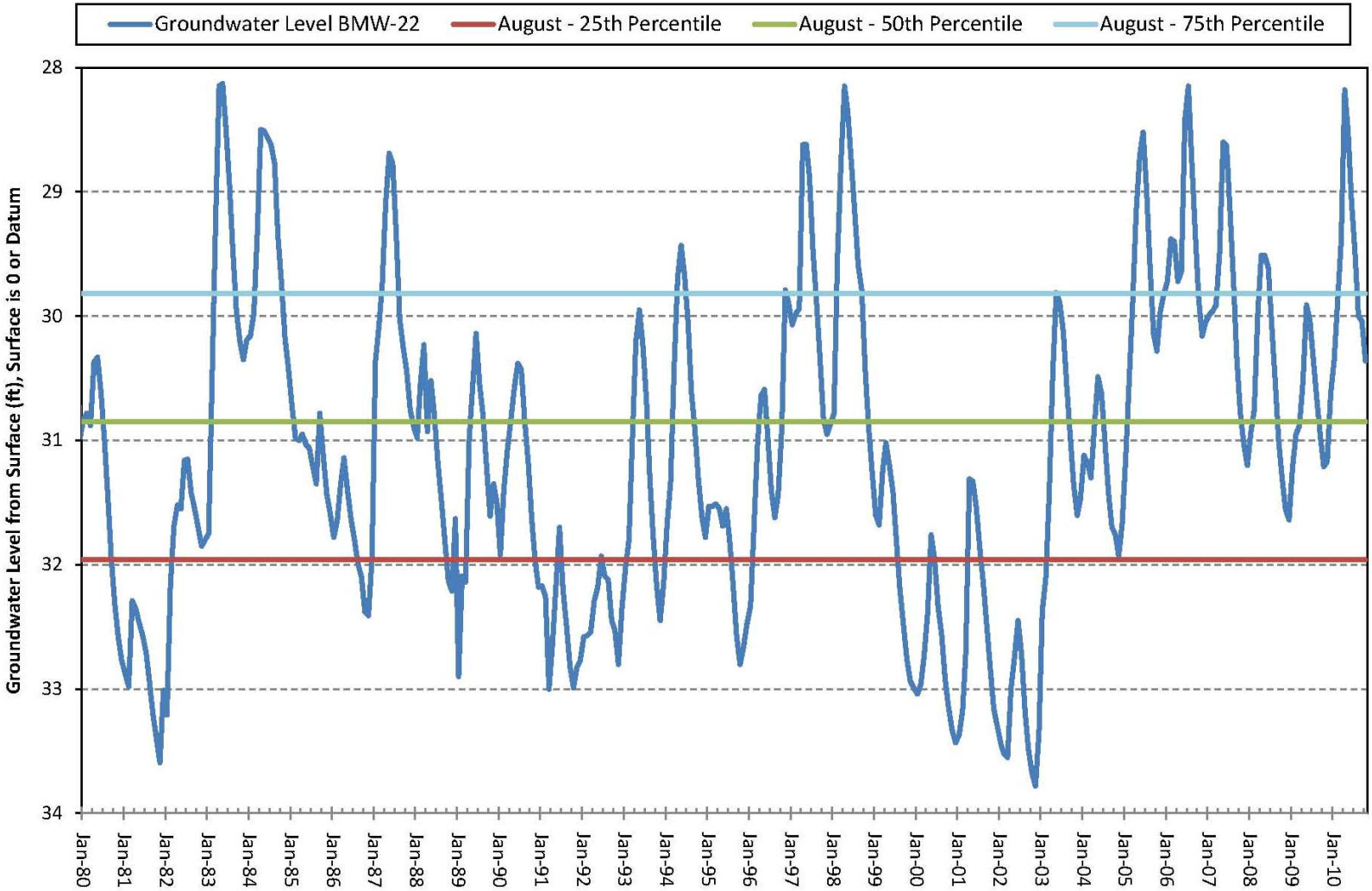

Figure 4-3
Median Monthly Groundwater Level – Brewster: 1980 to 2010
USGS Site Number: 414630070014901 - MA-BMW 22

4.1.2 Dennis Water District Groundwater Wells

The District monitors groundwater level in each of its supply wells. For the purposes of drought monitoring, the District will utilize Well No. 12 located off of Old Chatham Road as shown on Figure 4-4. This well is a gravel packed well representative of the wells within the system. Well No. 12 is rated for 700 gpm and is 79 feet deep.

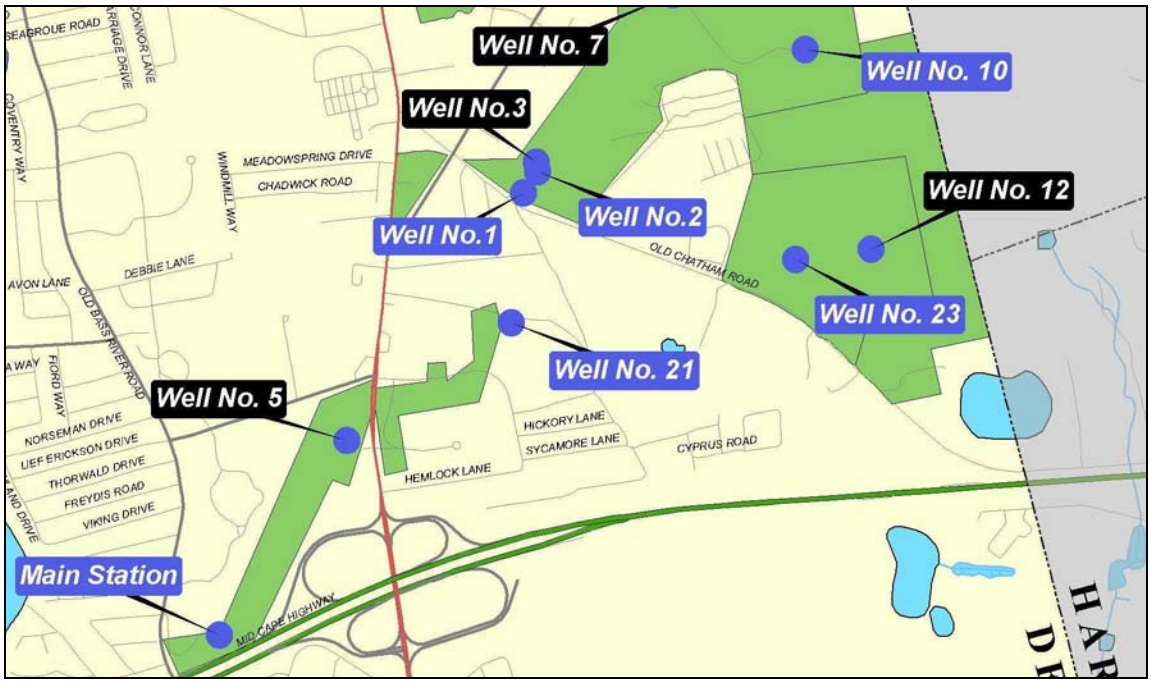

Figure 4-4
Dennis Water District Well No. 12 Locus Map

Table 4-2 shows the median monthly groundwater levels in each percentile range.

Figure 4-5 provides a graph of the median monthly groundwater levels from 1988 to 2010.

Table 4-2
Median Monthly Groundwater Level Percentile Ranges
Dennis Water District Well No. 12

	Groundwater Level Measured Down from Surface (Assumes Surface is 0 or Datum)							
Month	**Lowest Median**	**10th %ile**	**25th %ile**	**50th %ile**	**75th %ile**	**90th %ile**	**Highest Median**	**Number of Years**
Jan	19.6	23.9	23.58	22.7	21.65	20.51	24.7	22
Feb	19.1	24.4	23.8	22.4	21.4	20.0	25.1	22
Mar	18.9	24.08	23.4	21.3	20.15	19.12	24.9	22
Apr	17.5	23.5	22.05	21.0	19.85	18.86	24.1	22
May	17.4	23.26	21.58	21.2	19.5	18.75	24.2	22
Jun	18.3	24.04	23.35	21.8	19.8	18.84	24.9	22
Jul	19.4	25.18	24.3	23.27	21.25	20.54	26.9	22
Aug	20.7	26.06	24.95	23.5	22.6	21.52	26.9	22
Sep	18.4	25.36	24.5	23.6	22.2	21.52	26.8	22
Oct	20.4	25.0	24.35	23.8	22.45	21.9	25.8	22
Nov	20.1	25.17	24.7	23.99	22.62	20.94	25.6	22
Dec	20.5	24.3	24.0	23.0	22.3	20.6	24.9	22

Data from Dennis Water District
Water Levels between the 25th and 75th percentile are considered normal
Well No. 12, Old Chatham Road

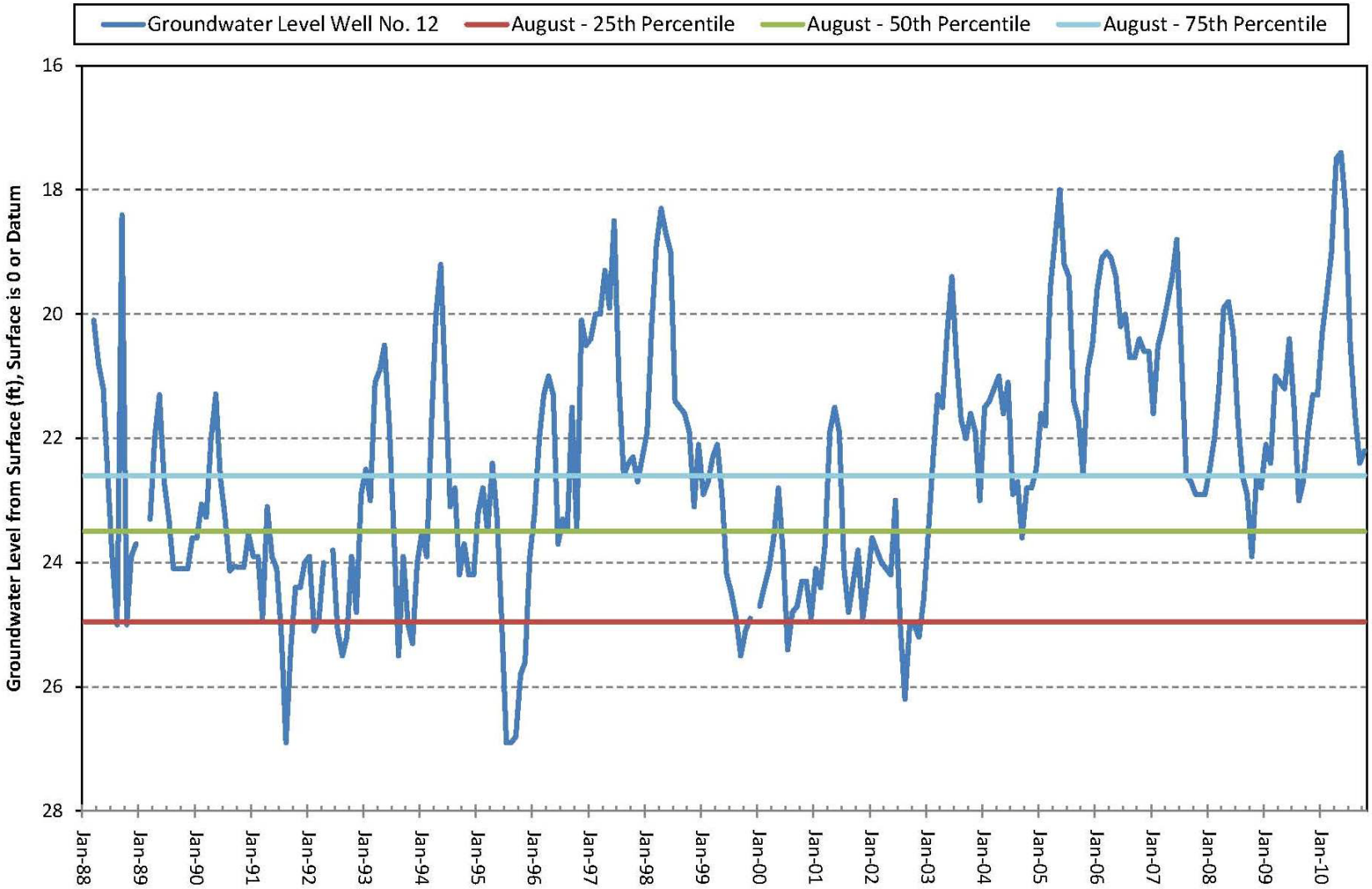

Figure 4-5
Median Monthly Groundwater Level – Well No. 12: 1988 to 2010
Dennis Water District Well No. 12

4.2 Monitoring

The District will need to continue monitoring of groundwater levels within their wells. Well No. 12 will be used for monitoring of drought conditions. The District should periodically check the groundwater levels in the USGS well.

USGS groundwater level information for wells on Cape Cod is available from the USGS on-line at the following website:

http://groundwaterwatch.usgs.gov/countymaps/MA_001.html

Data for the USGS monitoring well in Brewster is available on the following website:

http://groundwaterwatch.usgs.gov/AWLSites.asp?S=414630070014901

Table 4-3 provides a summary of the monthly groundwater levels that will be used to identify drought conditions.

Table 4-3
Normal Groundwater Level Ranges

Month	USGS Well BMW 22 Brewster, MA			Dennis Water District Well No. 12		
	Normal Range			Normal Range		
	25th %ile	50th %ile	75th %ile	25th %ile	50th %ile	75th %ile
Jan	32.19	31.14	30.36	23.58	22.7	21.65
Feb	32.1	30.98	29.96	23.8	22.4	21.4
Mar	31.62	30.88	29.75	23.4	21.3	20.15
Apr	31.19	30.37	29.16	22.05	21.0	19.85
May	31.23	29.93	28.87	21.58	21.2	19.5
Jun	31.3	30.15	29.07	23.35	21.8	19.8
Jul	31.55	30.57	29.48	24.3	23.27	21.25
Aug	31.96	30.85	29.82	24.95	23.5	22.6
Sep	31.91	31.13	30.26	24.5	23.6	22.2
Oct	32.35	31.55	30.68	24.35	23.8	22.45
Nov	32.52	31.6	30.83	24.7	23.99	22.62
Dec	32.26	31.62	30.82	24.0	23.0	22.3

Data from USGS and Dennis Water District
USGS Site Number: 414630070014901 - MA-BMW 22
Groundwater Level Measured Down from Surface (Assumes Surface is 0 or Datum)
Water Levels between the 25th and 75th percentile are considered normal.

Section 5.0
Drought Indicators and Triggers

5.1 Overview

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 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 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. Figure 5-1 provides a flow chart of the sequences and consequences of drought events.

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 will provide communities and water users predictable responses to dry conditions and droughts.

The state has identified five general action levels related to drought conditions:

1. Normal
2. Advisory
3. Watch
4. Warning
5. Emergency

The state recommends that local drought indices factor in both water resource conditions and system specific responses to those conditions at the local level. Local drought management plans are system specific so the terminology for drought action levels is allowed to differ from that used for the state action levels.

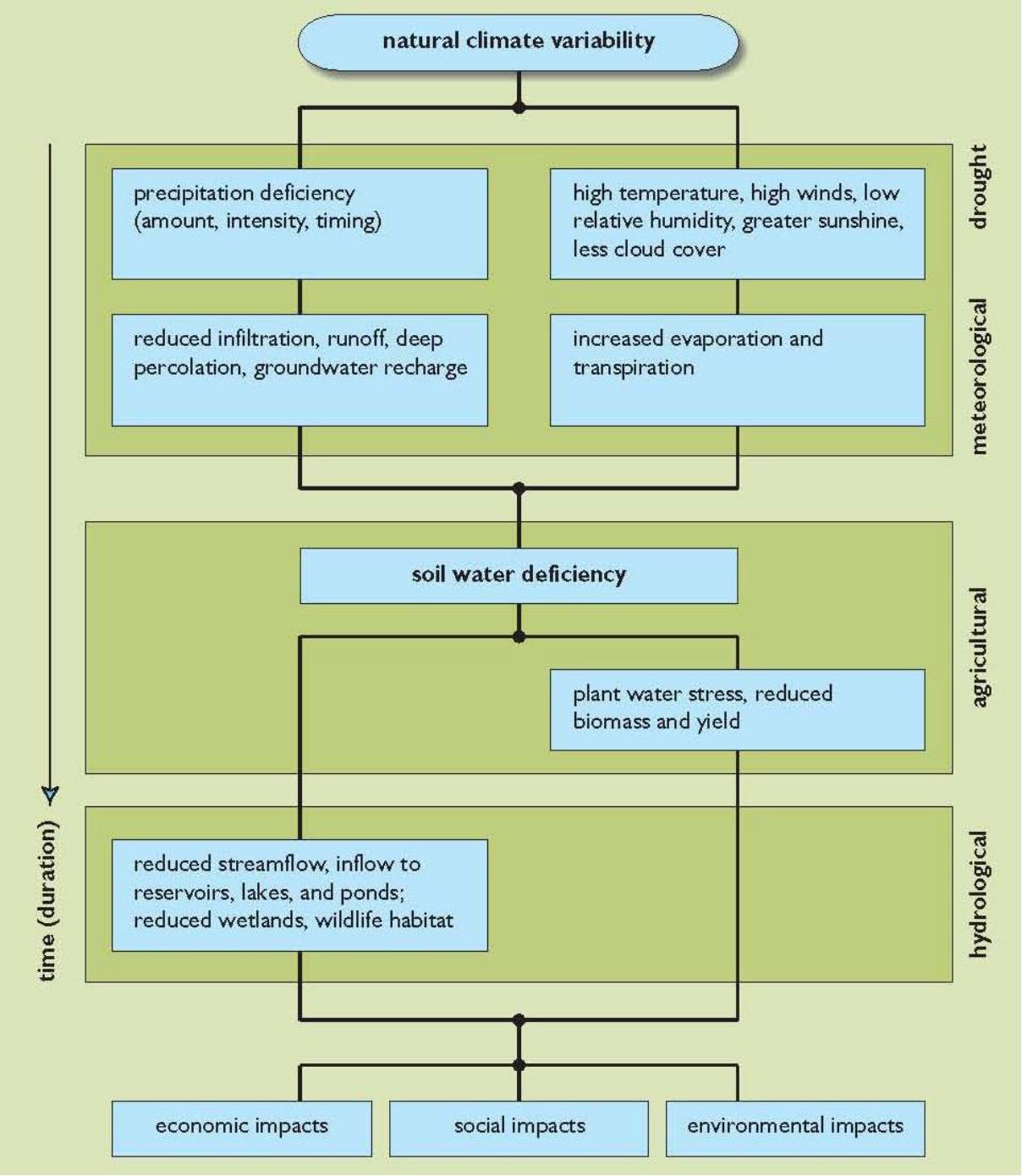

Figure5-1

Flow Chart of Sequences and Consequences of Drought Events

(Source: Water Resources Systems Planning and Management)

5.2 Drought Indicators and Triggers

The state uses seven indicators to assess the severity of a drought: (1) Palmer Drought Severity Index, (2) Crop Moisture Index, (3) Fire Danger, (4) Precipitation, (5) Groundwater levels, (6) Streamflow levels, and (7) Index Reservoir levels. For the Dennis Water District, the indicators that are best suited given the natural resources and system specifics are (1) precipitation and (2) groundwater levels.

Precipitation monitoring involves a comparison of measured precipitation amounts to 30-year averages or medians. The average or mean value is the average of each value over the 30-year period. The median is the value exceeded 50% of the time over the 30-year period. For this plan, the median value is considered the "normal" value.

Cumulative monthly precipitation for 3, 6 and l2-month periods are factored into the drought determination.

Groundwater level monitoring involves a comparison of the measures levels to the normal levels. 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 situation when groundwater levels are less than an average condition. A drought level determination is based on the number of consecutive months that groundwater levels are below normal.

The Dennis Water District will use precipitation data monitored at the District's Main Office for drought monitoring. The District will use groundwater level data provided by the USGS and as monitored by the District for Well No. 12 for drought monitoring.

Table 5-1 provides a summary of the drought triggers for the various action levels.

Table 5-2 provides the normal monthly precipitation and groundwater levels.

Table 5-1
Drought Action Levels and Indicators

Action Level	=	Drought Triggers		
		Precipitation	+	Groundwater
Normal	=	1 month below normal	+	2 consecutive months below normal 50th percentile
Advisory	=	3 months cumulative below normal	+	4 consecutive months below normal 50th percentile
Watch	=	6 months cumulative below normal	+	6 consecutive months below normal 50th percentile **or** 1 month below 25th percentile
Warning	=	12 months cumulative below normal	+	12 consecutive months below normal 50th percentile **or** 6 months below 25th percentile
Emergency	=	12 months cumulative below normal	+	24 consecutive months below normal 50th percentile **or** 12 months below 25th percentile

Both precipitation and groundwater triggers must be met to trigger drought action level.

Table 5-2
Normal Monthly Precipitation and Groundwater Levels

Month	Normal Monthly Precipitation (inches)	USGS Well BMW 22 Brewster, MA		Dennis Water District Well No. 12	
		25th %ile	50th %ile	25th %ile	50th %ile
January	4.1	32.19	31.14	23.58	22.7
February	3.45	32.1	30.98	23.8	22.4
March	5.22	31.62	30.88	23.4	21.3
April	4.2	31.19	30.37	22.05	21.0
May	3.45	31.23	29.93	21.58	21.2
June	3.48	31.3	30.15	23.35	21.8
July	2.84	31.55	30.57	24.3	23.27
August	3.51	31.96	30.85	24.95	23.5
September	2.94	31.91	31.13	24.5	23.6
October	3.97	32.35	31.55	24.35	23.8
November	4.87	32.52	31.6	24.7	23.99
December	4.36	32.26	31.62	24.0	23.0

Dennis Precipitation data from Dennis Water District
30-Year Data from 1980 to 2010 was used to calculate the median or normal monthly precipitation.
Groundwater data from USGS and Dennis Water District
USGS Site Number: 414630070014901 - MA-BMW 22
Groundwater Level Measured Down from Surface (Assumes Surface is 0 or Datum)

5.3 Determination of the End of a Drought

Determinations on the end of a drought or to reduce the drought level will focus two key drought indicators: (1) precipitation and (2) 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 making this a good indicator of a long-term recovery to normal conditions. A drought emergency will end when the conditions that led to the specific emergency have abated.

Drought warnings, watches and advisories can be reduced based on:

(1) Normal levels of precipitation and/or

(2) Groundwater levels within the normal range.

In order to return to a normal status:

(1) Ground water levels must be in the normal range and

(2) Three (3) months of precipitation must be cumulatively above normal

Part of this interpretation of the short and long-term measures, precipitation will include the need to discount the effect of short-duration large storms such as hurricanes. 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.

Section 6.0
Drought Trigger Response Actions

6.1 Overview

Local governments or waters suppliers, either independently or in conjunction with the MADEP are responsible for the management of their system to ensure that they can provide water sufficient to meet public health and safety needs. When dry conditions occur, actions by local government and water suppliers can range from requesting voluntary compliance with water use restrictions to declarations of local water emergencies (either under local bylaw or through petition to the MADEP) based on the status of their local water supplies.

The state has identified five general action levels related to drought conditions:

1. Normal
2. Advisory
3. Watch
4. Warning
5. Emergency

The levels provide a basic framework from which to take actions to assess, communicate, and respond to drought conditions.

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 are necessary.

6.2 Assessing Drought Action Levels

The superintendent will be responsible for monitoring of precipitation and groundwater levels and responsible for determining when to impose and when to modify drought action levels.

6.3 Response to Drought Action Levels

Each drought action level will have specific responses as described below.

6.3.1 Normal

A normal condition allows the District's Superintendent to monitor monthly precipitation and groundwater levels and compare to the historic levels.

6.3.2 Advisory

A Drought Advisory condition requires the District request voluntary water restrictions. The District will declare this request in accordance with the District By-Laws.

The District would post this request on the District website and notify Town officials, local newspapers and local cable television.

6.3.3 Watch

A Drought Watch condition requires the District impose mandatory water restrictions. Odd/Even Law Watering Lawn watering at facilities with odd numbered addresses would be permitted only on odd numbered days. Lawn watering at facilities with even numbered addresses would be permitted only on even numbered days.

The District would declare a State of Water Conservation in accordance with the District's Water Use Restriction By-Laws. The District through its Board of Water Commissioners may declare a State of Water Conservation upon a determination by a majority vote of the Board that a shortage of water exists, and that conservation of water is necessary to insure adequate supply to all consumers under all conditions.

The District would request permission from the MADEP to impose a mandatory water restriction.

The District would post this request on the District website and notify Town officials, local newspapers and local cable television.

6.3.4 Warning

A Drought Warning condition requires the District impose mandatory water restrictions. Outdoor water use would be limited to two days per week.

The District would declare a State of Water Conservation in accordance with the District's Water Use Restriction By-Laws. The District through its Board of Water Commissioners may declare a State of Water Conservation upon a determination by a majority vote of the Board that a shortage of water exists, and that conservation of water is necessary to insure adequate supply to all consumers under all conditions.

The District would request permission from the MADEP to impose a mandatory water restriction.

The District would post this requirement on the District website and notify Town officials, local newspapers and local cable television.

6.3.5 Emergency

A Drought Emergency condition requires the District impose mandatory water restrictions and possibly provide alternative water supply to its system. An Outdoor Watering Ban would be applied. Lawn watering, and all other forms of nonessential outdoor water use would be prohibited. Filling of swimming pools would be prohibited. The use of automatic lawn sprinkler systems would be prohibited.

The District would declare a State of Water Conservation in accordance with the District's Water Use Restriction By-Laws. The District through its Board of Water Commissioners may declare a State of Water Conservation upon a determination by a majority vote of the Board that a shortage of water exists, and that conservation of water is necessary to insure adequate supply to all consumers under all conditions.

The District would request permission from the MADEP to impose a mandatory water restriction.

The District would post this requirement on the District website and notify Town officials, local newspapers and local cable television.

Use of alternative water supplies would be done so in cooperation with the MADEP.

6.4 State Authority

MADEP 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 system, whether caused by drought conditions or for other reasons. The declaration of a State of Water Supply Emergency may be necessary at times. The MADEP Policy, SOP or Guideline #87-05, provides guidance on the MADEP's policies and procedures with regards to declaring, terminating and extending a state of water supply emergency. MADEP's authority for addressing water supply shortage emergencies is derived from the Water Management Act related to ensuring the provision of safe drinking water. Refer to Section 7.0 of the District's Emergency Response Plan for more details regarding declaration of a State of Water Supply Emergency.

Section 7.0
Water Use Restriction By-Law

7.1 Water Use Restriction By-Law

The District has a Water Use Restriction By-Law to protect, preserve and maintain public health, safety and welfare whenever there is in force a state of water supply conservation or state of water supply emergency. The by-law and gives the District the authority to regulate water use through declaration of a State of Water Conservation, as follows.

"Article Five Water Use Restriction
Section One: Authority - This Bylaw is adopted by the Dennis Water District under its home rule powers, its police powers to protect public health and welfare and its power under M.G.L. C.40, §21 et seq. This bylaw implements the District's authority to regulate water use pursuant to C.41, §69B.

Section Two: Purpose - The purpose of this bylaw is to protect, preserve and maintain the public health, safety and welfare whenever there is in force a state of water supply conservation or a state of water supply emergency by providing for enforcement of any duly imposed restrictions, requirements, provisions or conditions imposed by the District or by the Department of Environmental Protection.

Section Three: Definitions

Enforcement Authority shall mean the Dennis Water District Board of Water Commissioners having responsibility for the operation and maintenance of the water supply. The Board of Water Commissioners may also designate any other local body having police powers as an enforcement authority.

Water Supply Emergency shall mean a state of water supply emergency declared by the Department of Environmental Protection under M.G.L. C21G, §15-17.

State of Water Supply Conservation shall mean a state of conservation declared by the District pursuant to section four of this bylaw.

Water Users or Water Consumers shall mean all public and private users of the District's public water system, irrespective of any person's responsibility for billing purposes for water used at any particular facility.

Person shall mean any individual, corporation, trust, partnership or association or other entity.

Public notice of a State of Water Conservation shall be given under section six of this bylaw before it may be enforced.

Section Four: Declaration of a State of Water Conservation

The District through its Board of Water Commissioners may declare a State of Water Conservation upon a determination by a majority vote of the Board that a shortage of water exists, and that conversation of water is necessary to insure adequate supply to all consumers under all conditions.

Section Five: Restricted Water Uses

A declaration of a State of Water Conservation issued by the Board of Water Commissioners may include one or more of the following restrictions, conditions, or requirements restraining the use of water for nonessential purposes as necessary to protect the water supply, which shall be included in the public notice required under section six.

A) Odd/Even Law Watering Lawn watering at facilities with odd numbered addresses is permitted only on odd numbered days. Lawn watering at facilities with even numbered addresses is permitted only on even numbered days.

B) Outdoor Watering Ban. Lawn watering, and all other forms of nonessential outdoor water use are prohibited.

C) Outdoor Watering Hours. Outdoor watering is permitted only during off-peak hours, to be specified in the declaration of a state of water conservation and public notice thereof.

D) Filling Swimming Pools. Filling of swimming pools is prohibited.

E) Automatic Lawn Sprinkler Use. The use of automatic lawn sprinkler systems is prohibited.

Section Six: Public Notification of a State of Water Supply Conservation

Notification of any provision, restriction, requirement or condition imposed by the District as part of a State of Water Conservation shall be published in a newspaper of general circulation within the District, or by such other means reasonably calculated to reach and inform all users of water of the state of conservation. Any restriction imposed under section five shall not be effective until such notification is provided.

Section Seven: 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 upon a determination that the water supply shortage no longer exists. Notification of the termination of a state of water conservation shall be given in the same manner as notice of the state of water conservation is given.

Section Eight: State of Water Emergency; Restricted Water Use

Upon notification of the public that a declaration of a state of water emergency has been declared by the Department of Environmental Protection, no person shall violate any provision, restriction, requirement, condition or order approved or issued by the Department intended to bring about an end to the emergency.

Section Nine: Penalties

Any person violating this bylaw shall be liable to the District in the amount of $50.00 for the first violation and $100.00 for each subsequent violation which shall insure to the District for such uses as the Board of Water Commissioners may direct. Fines shall be recovered by indictment, or on complaint before the District Court, or by noncriminal disposition in accordance with Section 21D of Chapter 40 of the general laws. Each separate issuance of a citation pursuant to this section shall constitute a separate violation.

Section Ten: Severability

The invalidity of any portion or provisions of this bylaw shall not invalidate any other portion or provision thereof. (Adopted October 17, 1996)”

Appendix A
Groundwater Level Analysis

A.1 Historical Groundwater Levels

As described in Section 4.0, groundwater levels will be used to assess drought conditions. As part of the development of this plan, an analysis of which wells to use for monitoring conditions was completed. The USGS reports groundwater level data for several wells on Cape Cod. The MADEP proposes using one well, BMW-22, located in Brewster for the assessment of drought, since this well has monthly data from 1962 to 2002 and daily, real-time data from 2002 to 2010. Groundwater levels for most of the other monitoring wells are obtained manually once a month.

This appendix provides a summary of the analysis completed to compare the trends of groundwater levels in well BMW-22 with the trends observed in two monitoring wells located in Dennis and one of the District's wells (Well No. 12). Information regarding the two USGS monitoring wells located in Dennis is provided in the following sub-sections. Information regarding the USGS monitoring well in Brewster and the District's Well No. 12 is presented in Section 4.0.

A.1.1 USGS Monitoring Well DGW-158 Dennis, MA

The USGS monitoring well in Dennis (Site Number: 414210070090901 - MA-DGW 158) is located east of Route 134, just north of Route 6 (Latitude 41°42'10", Longitude 70°09'09") as shown in Figure A-1.

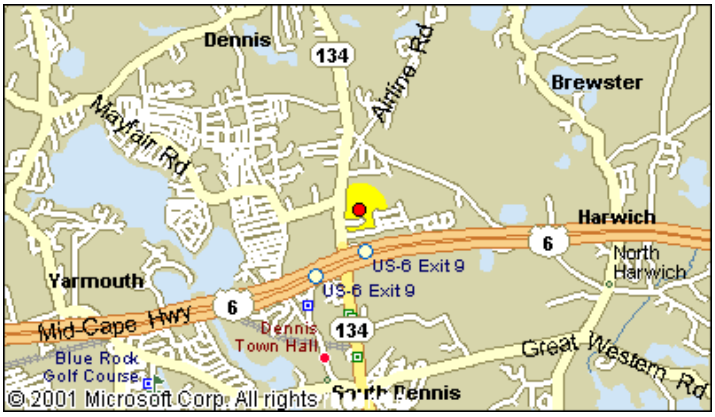

Figure A-1
Location of USGS Monitoring Well – DGW 158
USGS Site Number: 414210070090901 - MA-DGW 158

The well depth is 57.5 feet, hole depth is 65.0 feet and land surface altitude is 35.94 feet above sea level NGVD29. The well was completed in "Sand and gravel aquifers (glaciated regions)." The USGS began monitoring the groundwater level in this well in 1975 and continues to this day. The USGS provides the median water level for each month.

Table A-1 shows the median monthly groundwater levels in each percentile range.

Figure A-2 provides a graph of the median monthly groundwater levels from 1980 to 2010.

Table A-1
Median Monthly Groundwater Level Percentile Ranges
USGS Site Number: 414210070090901 - MA-DGW 158, Dennis, MA

	Groundwater Level Measured Down from Surface (Assumes Surface is 0 or Datum)							
Month	**Lowest Median**	**10th %ile**	**25th %ile**	**50th %ile**	**75th %ile**	**90th %ile**	**Highest Median**	**Number of Years**
Jan	19.87	19.71	18.88	17.65	16.93	15.64	14.65	28
Feb								0
Mar	19.84	19.15	17.94	16.89	15.62	14.65	14.19	34
Apr								0
May	18.74	18.02	17.22	16.17	14.42	13.02	12.67	28
Jun	18.2	-	-	-	-	-	14.69	5
Jul	19.08	18.61	18.11	17.11	15.74	14.19	13.82	29
Aug	17.99	-	-	-	-	-	13.76	7
Sep	20.16	19.47	18.56	17.89	16.35	15.69	14.49	30
Oct								0
Nov	20.19	19.76	19.04	18.26	16.93	16.52	14.47	32
Dec	18.85	-	-	-	-	-	16.79	5

Data from USGS
Water Levels between the 25th and 75th percentile are considered normal
USGS Site Number: 414210070090901 - MA-DGW 158
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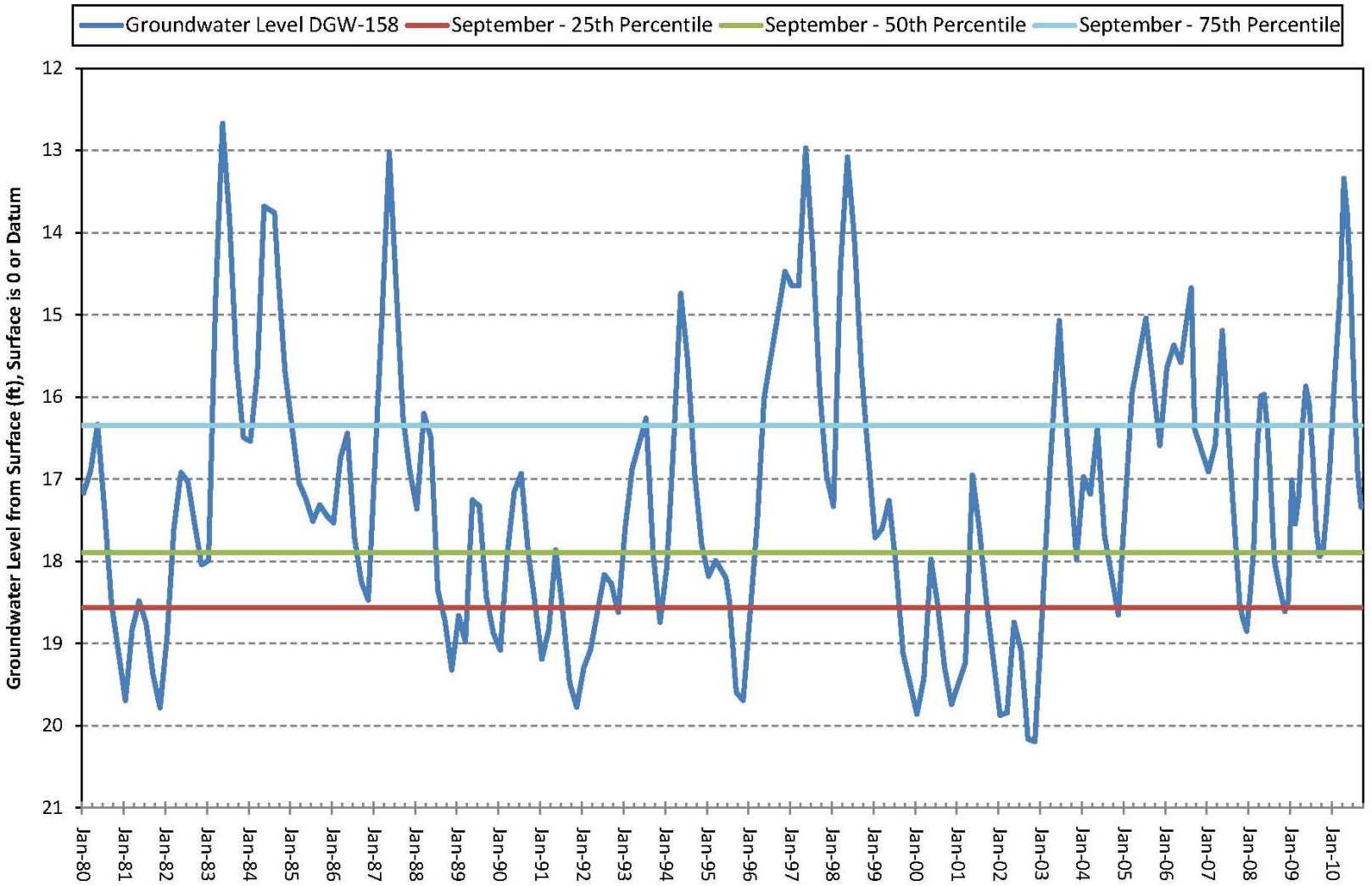

Figure A-2
Median Monthly Groundwater Level – DGW-158: 1980 to 2010
USGS Site Number: 414210070090901 - MA-DGW 158

A.1.2 USGS Monitoring Well DGW-123 Dennis, MA

The USGS monitoring well in Dennis (Site Number: 414402070083901 - MA-DGW 123) is located between Route 6A and Setucket Road (Latitude 41°44'02", Longitude 70°08'39" NAD27) as shown in Figure A-3.

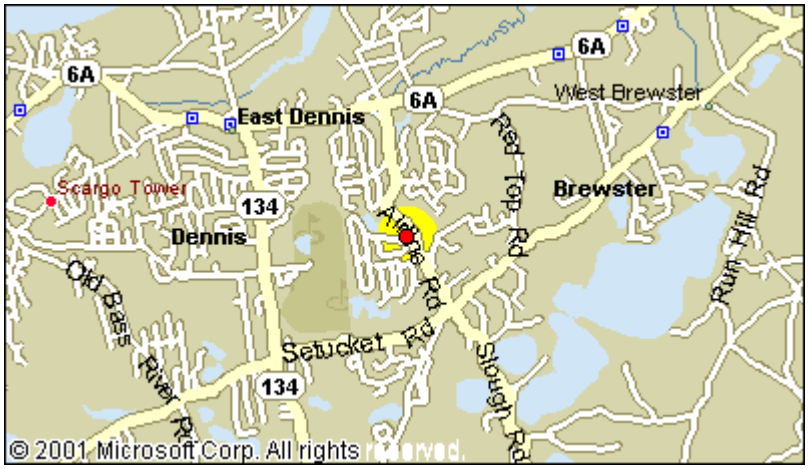

Figure A-3
Location of USGS Monitoring Well - DGW-123
USGS Site Number: 414402070083901 - MA-DGW 123

The well depth is 58.0 feet, hole depth is 78.0 feet and land surface altitude is 37.19 feet above sea level NGVD29. The well was completed in "Sand and gravel aquifers (glaciated regions)." The USGS began monitoring the groundwater level in this well in 1975 and continues to this day. The USGS provides the median water level for each month.

Table A-2 shows the median monthly groundwater levels in each percentile range.

Figure A-4 provides a graph of the median monthly groundwater levels from 1980 to 2010.

Table A-2
Median Monthly Groundwater Level Percentile Ranges
USGS Site Number: 414402070083901 - MA-DGW 123, Dennis, MA

	Groundwater Level Measured Down from Surface (Assumes Surface is 0 or Datum)							
Month	**Lowest Median**	**10th %ile**	**25th %ile**	**50th %ile**	**75th %ile**	**90th %ile**	**Highest Median**	**Number of Years**
Jan	6.89	6.37	5.76	4.59	3.68	2.99	2.74	29
Feb	7.63	6.59	5.68	4.61	3.74	2.98	2.58	31
Mar	6.84	6	4.99	4.07	2.95	2.76	2.2	34
Apr	5.97	5.61	4.7	3.65	2.76	1.99	1.88	31
May	6.27	5.81	4.56	3.89	2.54	1.95	1.86	30
Jun	6.05	5.4	4.82	4.14	2.43	2.13	1.98	30
Jul	6.55	5.76	5.2	4.4	3.31	2.67	2.31	30
Aug	6.49	5.93	5.29	4.58	3.32	2.7	2.08	30
Sep	7.24	6.35	5.71	4.91	3.6	3.1	2.55	31
Oct	7.54	6.54	6.03	5.01	3.96	3.32	3.11	31
Nov	7.28	7.03	5.95	4.89	3.91	3.1	2.91	32
Dec	6.88	6.54	5.76	4.75	3.95	3.29	2.78	26

Data from USGS
Water Levels between the 25th and 75th percentile are considered normal
USGS Site Number: 414402070083901 - MA-DGW 123
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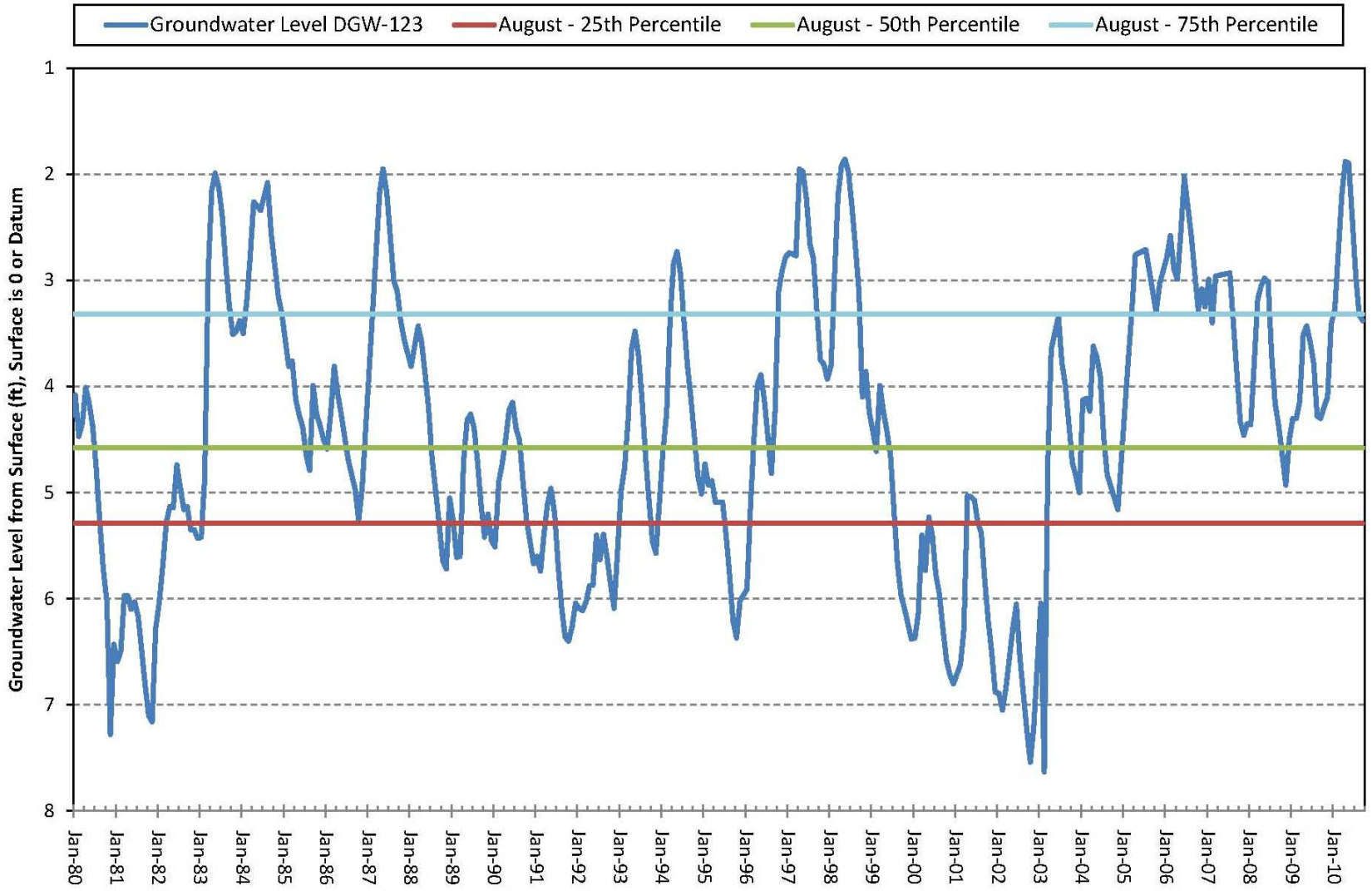

Figure A-4
Median Monthly Groundwater Level –DGW-123: 1980 to 2010
USGS Site Number: 414402070083901 - MA-DGW 123

A.2 Comparison of Groundwater Levels

The groundwater level data for each of the four wells was graphed to compare trends. This allows for a visual determination of whether or not the groundwater levels trend similarly over time. The four wells are as follows:

- Dennis Water District Well No. 12
- USGUS Site Number: 414630070014901 - MA-BMW 22, Brewster, MA
- USGS Site Number: 414210070090901 - MA-DGW 158, Dennis, MA
- USGS Site Number: 414402070083901 - MA-DGW 123, Dennis, MA

Figure A-5 provides a graph of the groundwater level data from 1988 to 2010. The data show that the groundwater levels trend similarly over time. This means that use of the USGS monitoring well, BMW-22, in Brewster will provide a close approximation of the groundwater level conditions in the District's wells.

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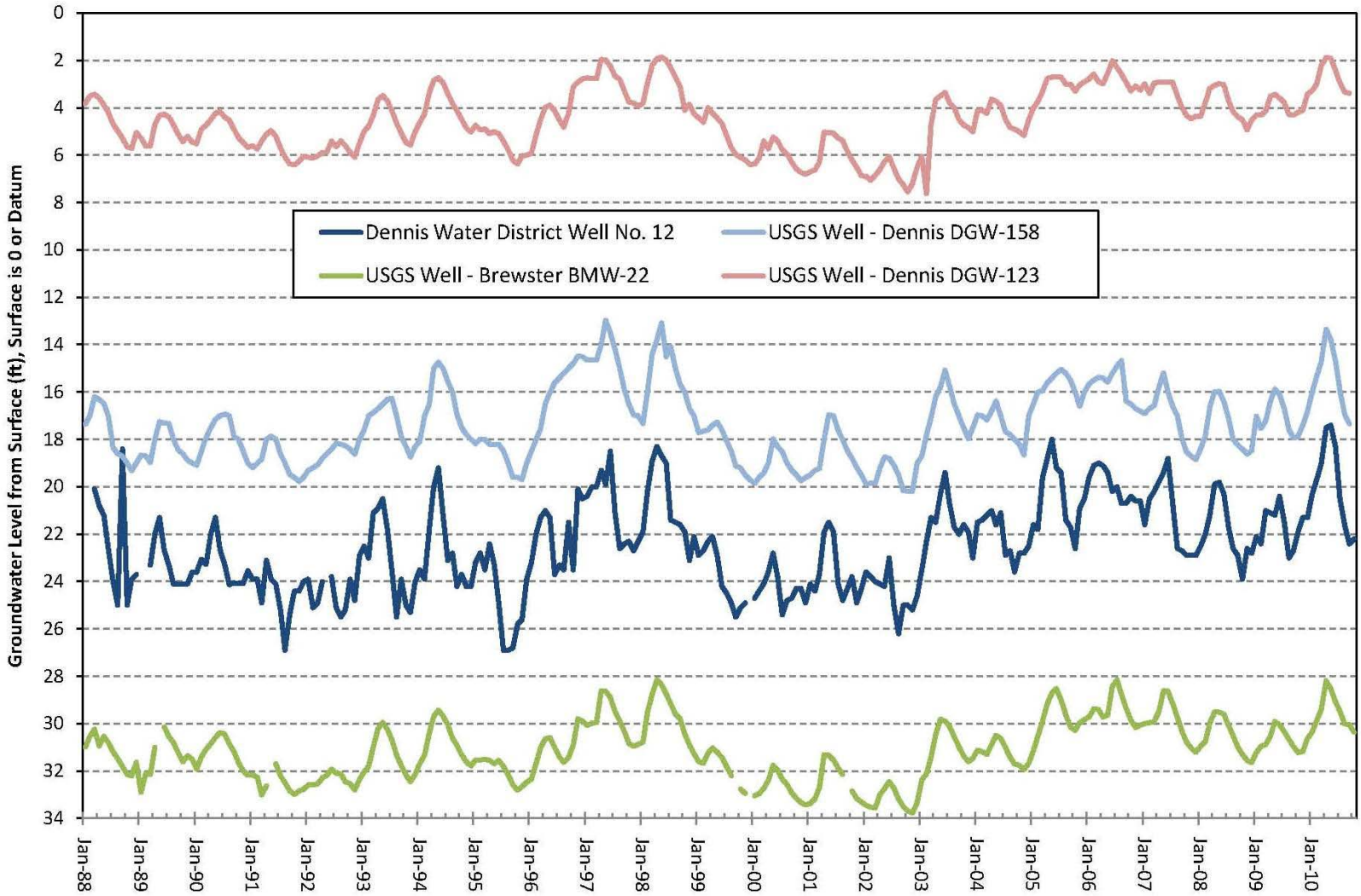

Figure A-5
Median Monthly Groundwater Level
Comparison of Wells

A.3 Historical Low Groundwater Levels

Over time there have been dry periods evident from low groundwater level observed in well BMW-22. Figure A-6 provides a graph of the historical data from 1980 to 2010. Also included are the lines for the August monthly 50th percentile and 25th percentile values for the period of record from 1962 to 2010. Values for August were selected for this graph, since the MADEP has proposed to utilize the value for August 50th percentile of 30.85 feet for assessment of drought conditions during the periods of May 1 through September 30.

Figure A-6 provides a visual representation of the periods below the 50th percentile for August in relation to the periods below the 25th percentile for August.

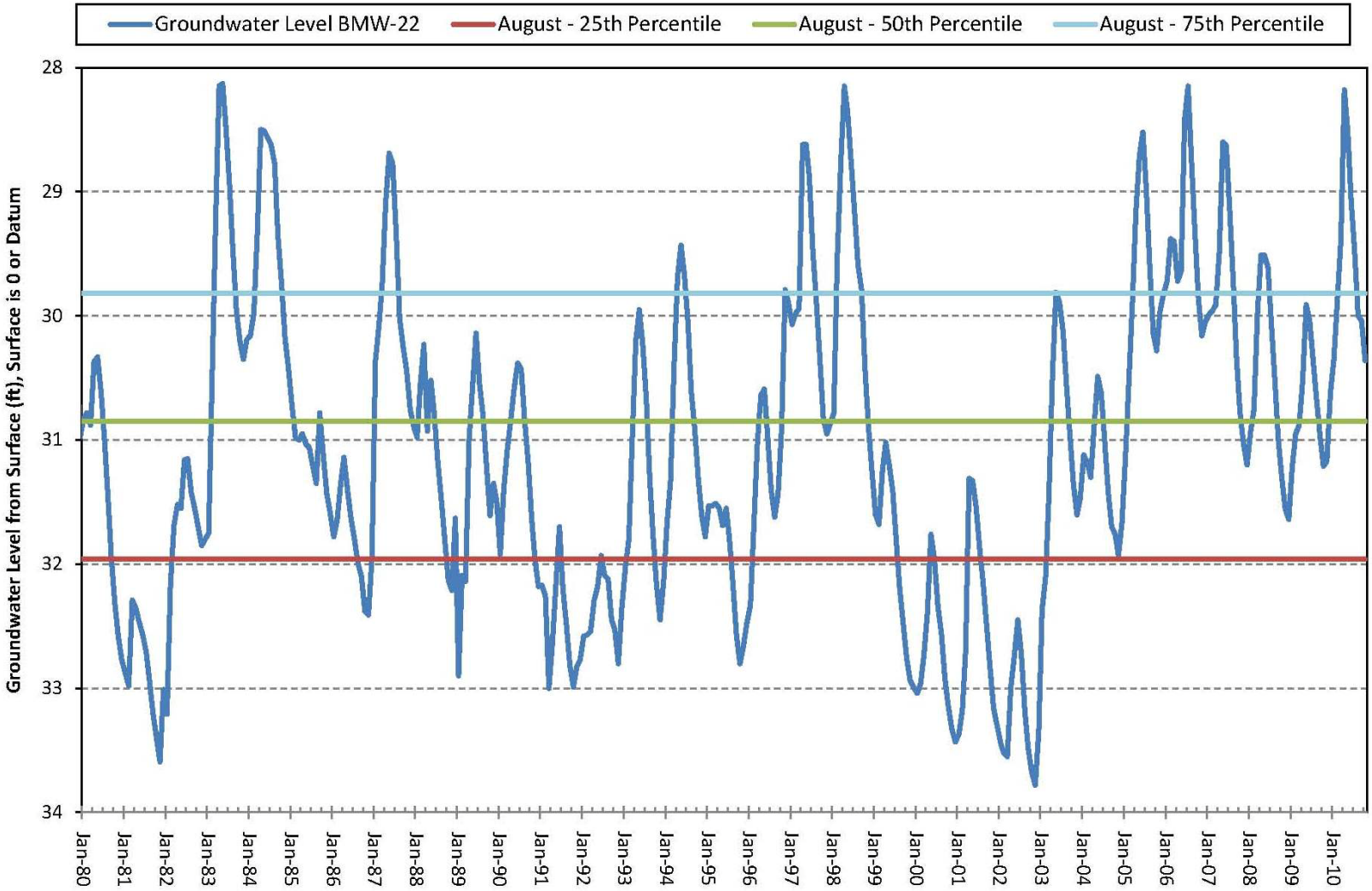

Figure A-6
Median Monthly Groundwater Level – Brewster: 1980 to 2010
USGS Site Number: 414630070014901 - MA-BMW 22