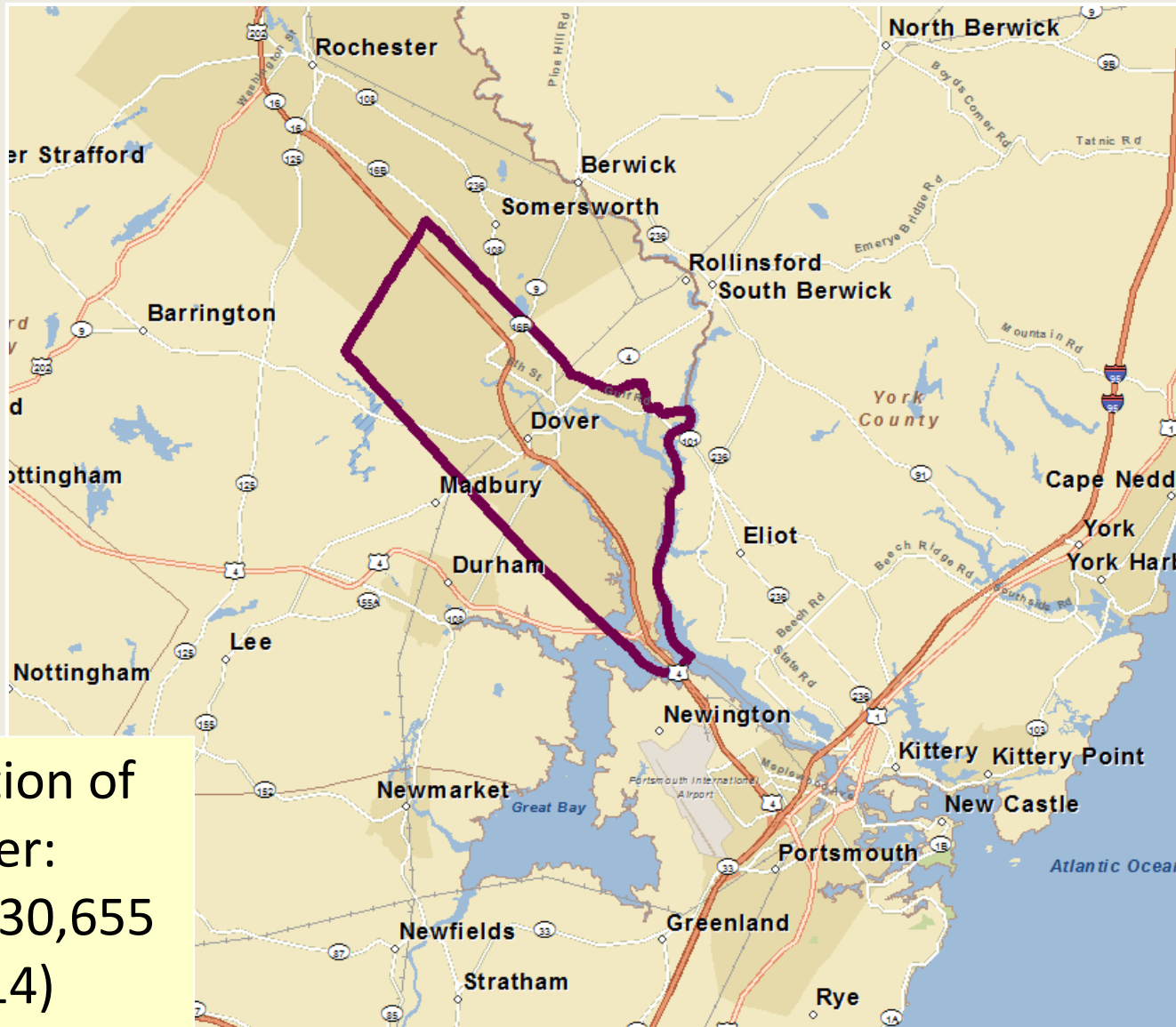


**Review of Current Drought
Conditions,
Review of Dover's Groundwater
Supply System and Groundwater
Monitoring Program,
and "Next Steps"**

City of Dover, October 19, 2016

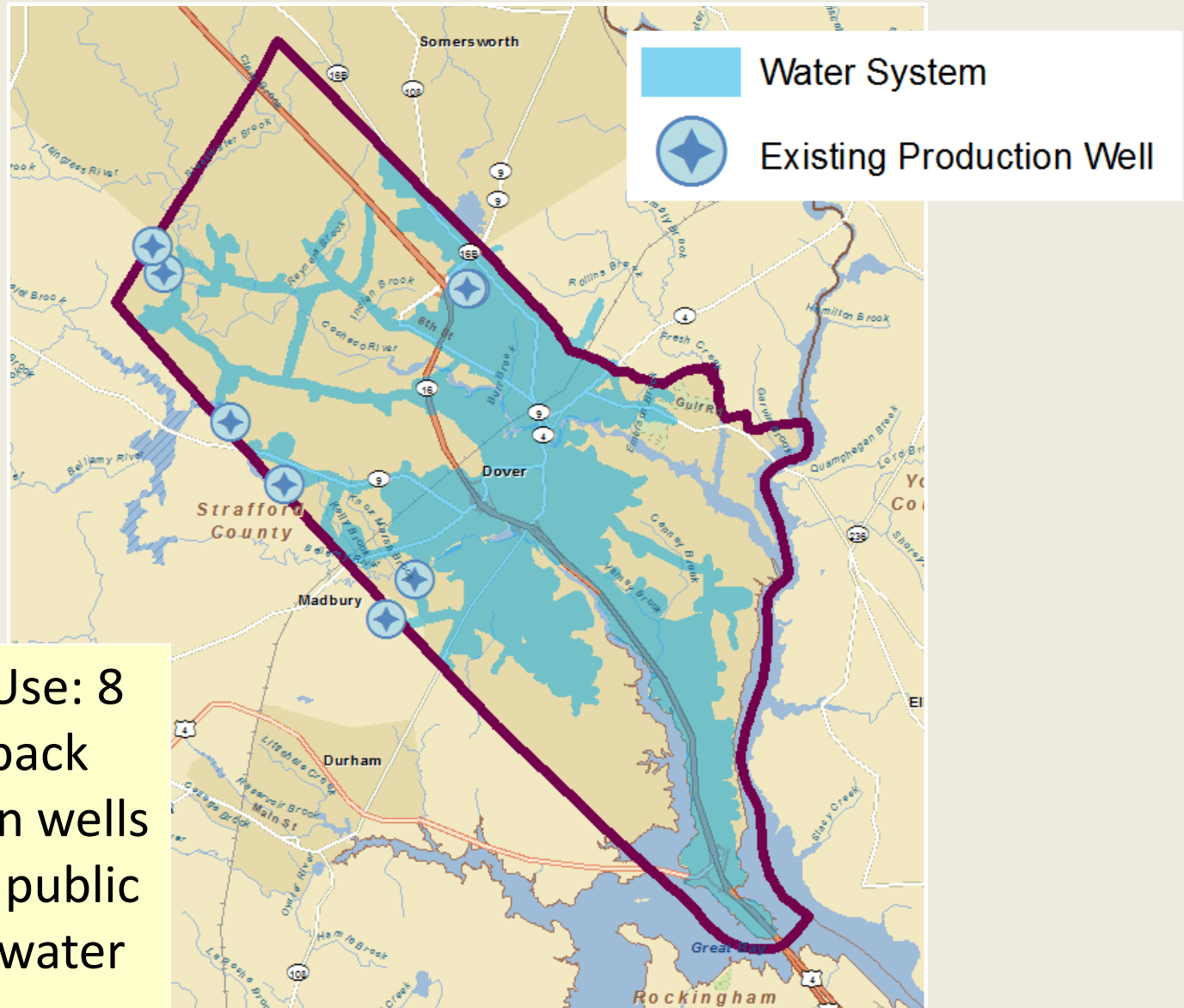
Emery & Garrett Groundwater Investigations, LLC

Seacoast Region of New Hampshire



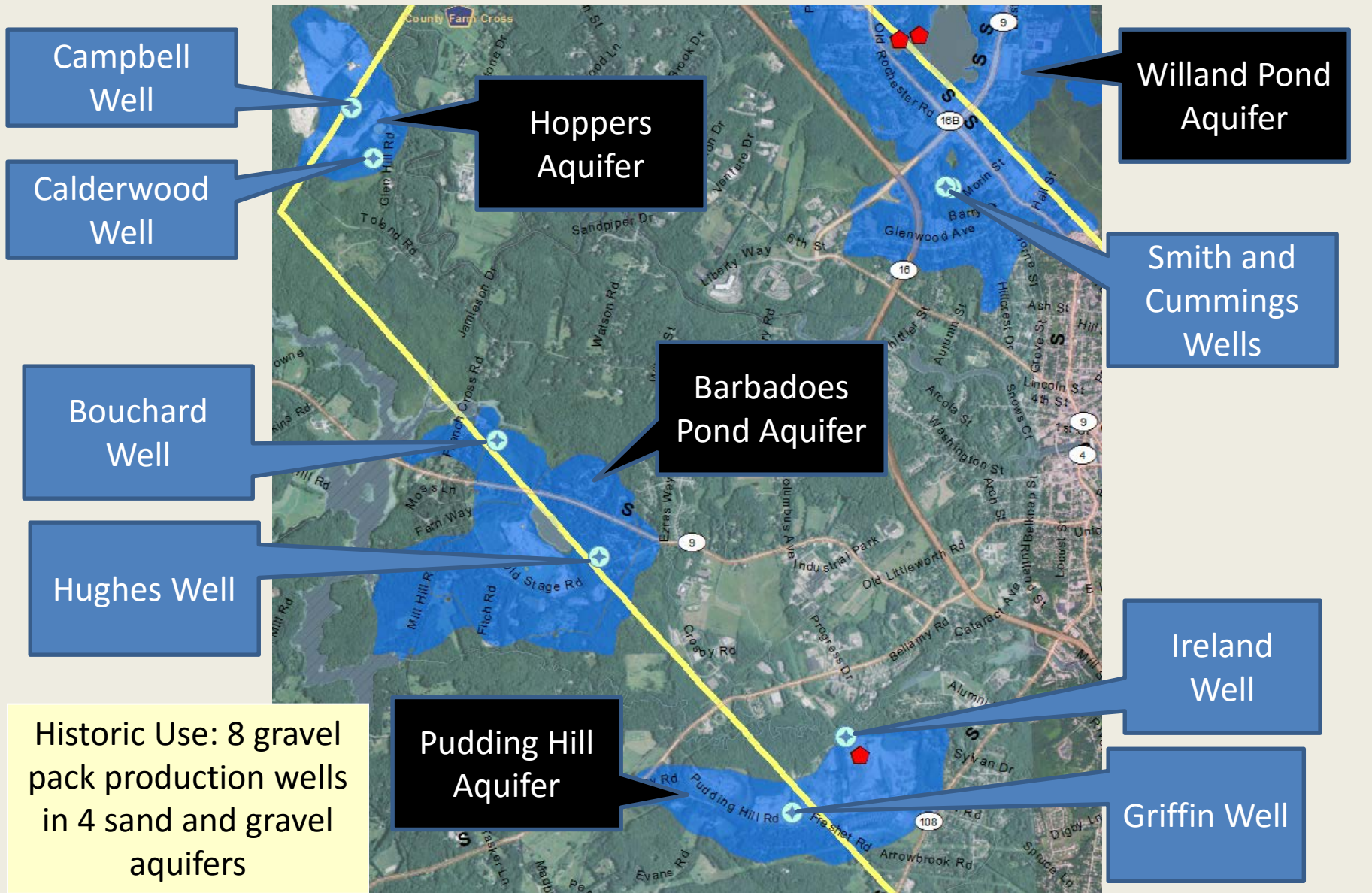
Population of
Dover:
Approx. 30,655
(2014)

Dover Groundwater Resources



Historic Use: 8
gravel pack
production wells
to supply public
drinking water
resources

Dover Groundwater Resources



National Drought Monitor Classification

Category	Description	Possible Impacts
D0	Abnormally Dry	Going into drought: ▪ short-term dryness slowing planting, growth of crops or pastures Coming out of drought: ▪ some lingering water deficits ▪ pastures or crops not fully recovered
D1	Moderate Drought	▪ Some damage to crops, pastures ▪ Streams, reservoirs, or wells low, some water shortages developing or imminent ▪ Voluntary water-use restrictions requested
D2	Severe Drought	▪ Crop or pasture losses likely ▪ Water shortages common ▪ Water restrictions imposed
D3	Extreme Drought	▪ Major crop/pasture losses ▪ Widespread water shortages or restrictions
D4	Exceptional Drought	▪ Exceptional and widespread crop/pasture losses ▪ Shortages of water in reservoirs, streams, and wells creating water emergencies



U.S. Drought Monitor Northeast

October 11, 2016
(Released Thursday, Oct. 13, 2016)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	27.65	72.35	42.96	22.04	5.04	0.00
Last Week 10/4/2016	34.88	65.12	40.99	21.98	5.61	0.00
3 Months Ago 7/12/2016	35.97	64.03	22.79	5.08	0.00	0.00
Start of Calendar Year 12/29/2015	62.10	37.90	6.60	0.00	0.00	0.00
Start of Water Year 9/27/2016	21.72	78.28	40.32	19.59	6.68	0.00
One Year Ago 10/13/2015	74.03	25.97	5.78	0.00	0.00	0.00

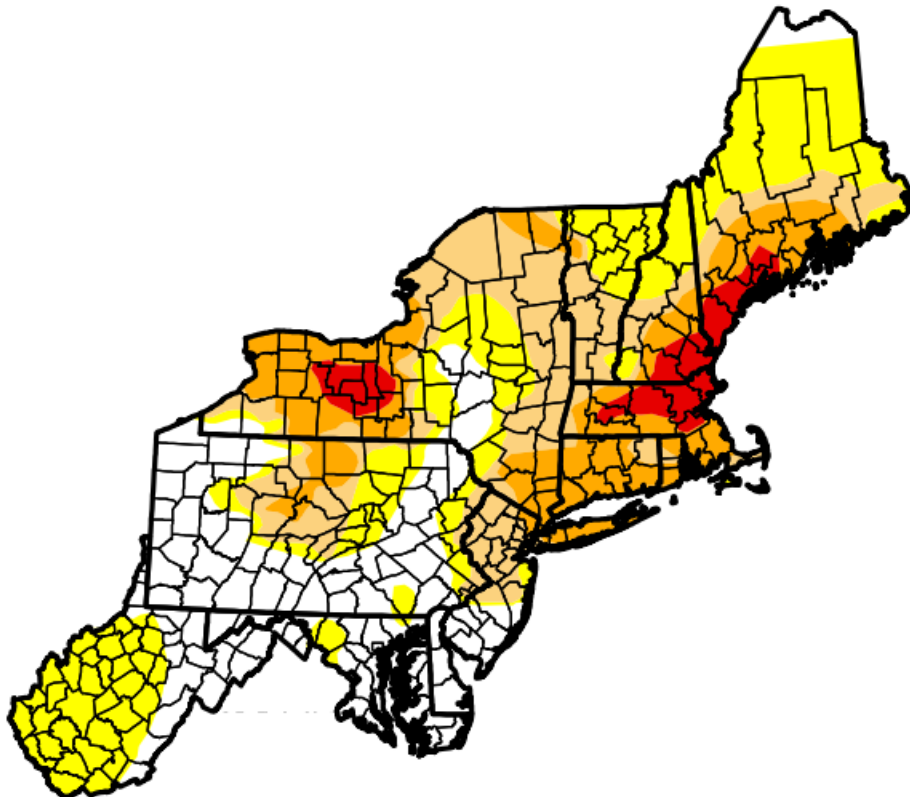
Intensity:

 D0 Abnormally Dry	 D3 Extreme Drought
 D1 Moderate Drought	 D4 Exceptional Drought
 D2 Severe Drought	

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

Brian Fuchs
National Drought Mitigation Center



<http://droughtmonitor.unl.edu/>

Known Water Use Restrictions and Bans

Last Update: September 29, 2016

September 27, 2016
(Released Thursday September 29, 2016)
Valid 8 a.m. EDT

Legend

County Boundary

Town Boundary

Municipality or Water System Status

Outdoor Use Ban

Restriction

Voluntary Restriction or Ban

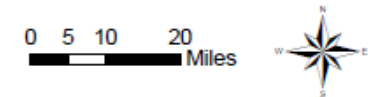
Drought Condition

Abnormally Dry

Moderate Drought

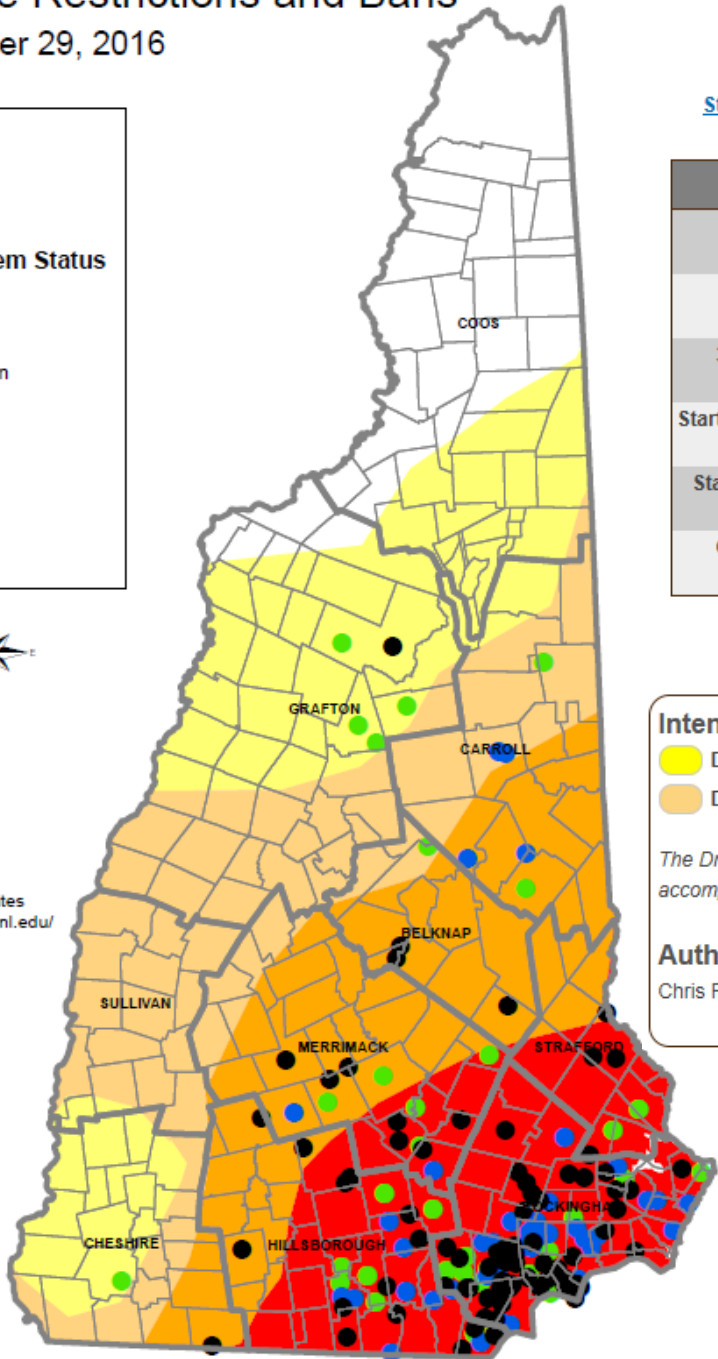
Severe Drought

Extreme Drought



Drought Conditions based on United States Drought Monitor (<http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?NH>)

Disclaimer: The status of water use restrictions and bans is based on information submitted to the New Hampshire Department of Environmental Services and may not be comprehensive.



Statistics type: Traditional Percent Area Export table: PNG CSV XLS

Week	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current 2016-09-27	15.33	84.67	62.44	40.49	19.27	0.00
Last Week 2016-09-20	23.66	76.34	52.44	29.12	19.21	0.00
3 Months Ago 2016-06-28	9.63	90.37	38.66	0.00	0.00	0.00
Start of Calendar Year 2015-12-29	50.84	49.16	14.88	0.00	0.00	0.00
Start of Water Year 2015-09-29	25.64	74.36	20.42	0.00	0.00	0.00
One Year Ago 2015-09-29	25.64	74.36	20.42	0.00	0.00	0.00

Estimated Population in Drought Areas: 1,176,114 View More Statistics

Intensity:

D0 (Abnormally Dry)

D1 (Moderate Drought)

D2 (Severe Drought)

D3 (Extreme Drought)

D4 (Exceptional Drought)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying [text summary](#) for forecast statements.

Author(s):
Chris Fenimore, NOAA/NESDIS/NCEI



U.S. Drought Monitor New Hampshire

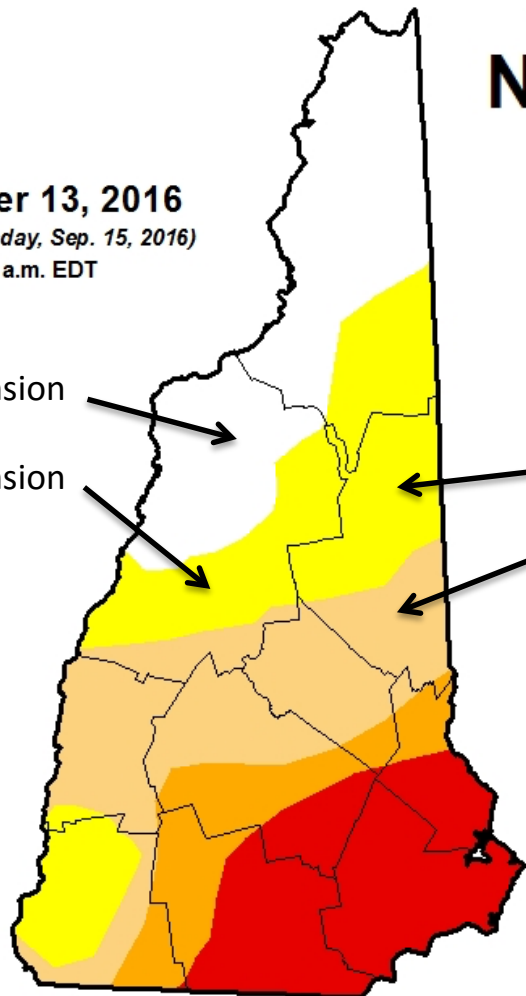
September 13, 2016

(Released Thursday, Sep. 15, 2016)

Valid 8 a.m. EDT

"D0" Expansion

"D1" Expansion



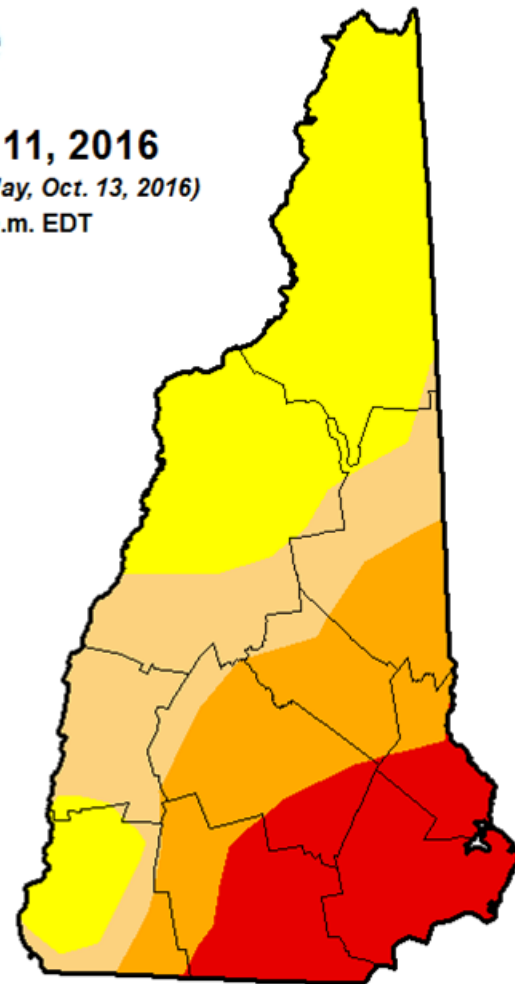
October 11, 2016

(Released Thursday, Oct. 13, 2016)

Valid 8 a.m. EDT

"D1" Expansion

"D2" Expansion

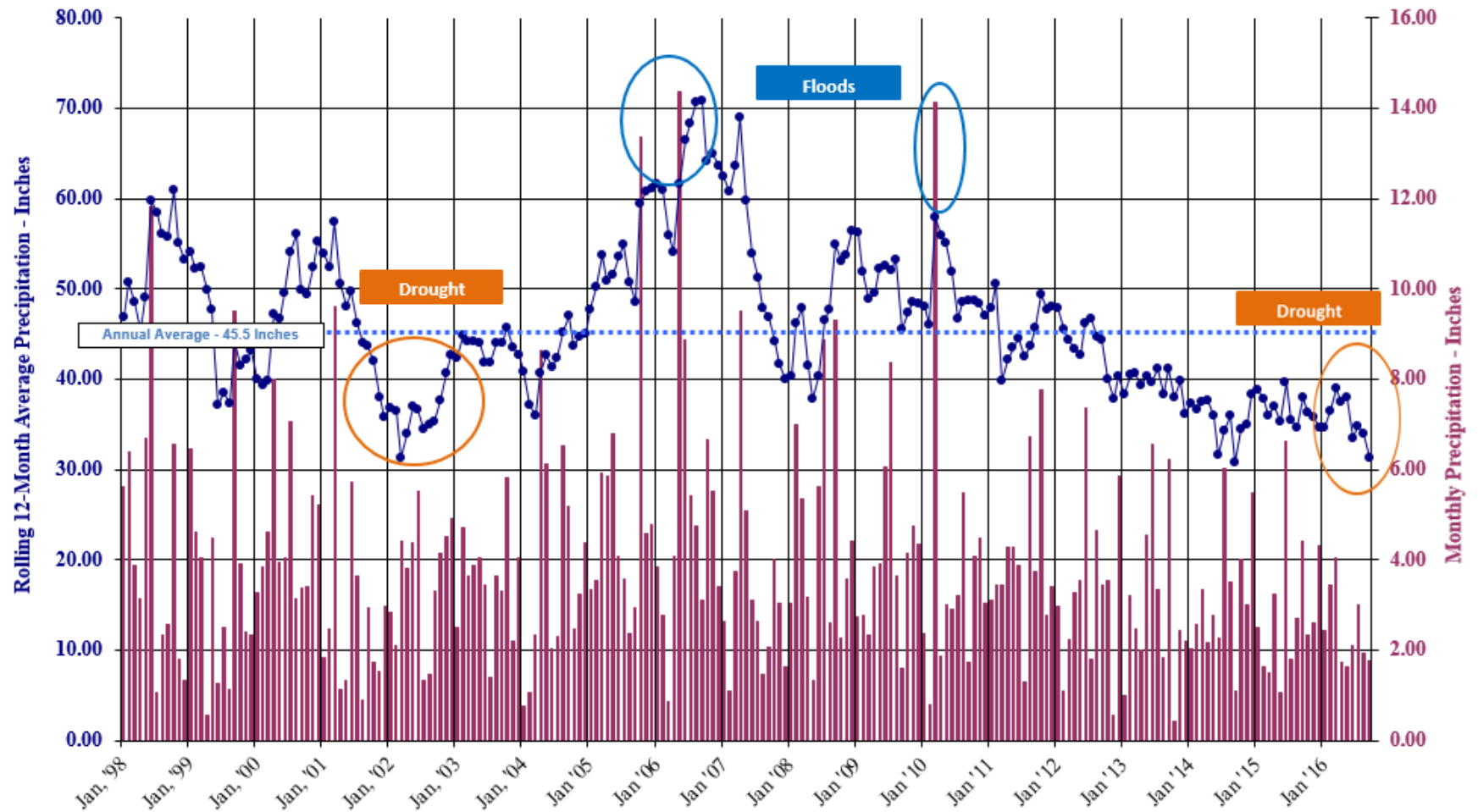


<http://droughtmonitor.unl.edu/>

Week	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
2016-09-13	23.66	76.34	52.44	29.12	19.21	0.00
2016-09-27	15.33	84.67	62.44	40.49	19.27	0.00



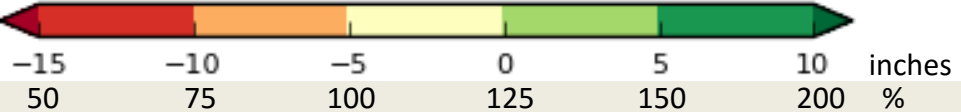
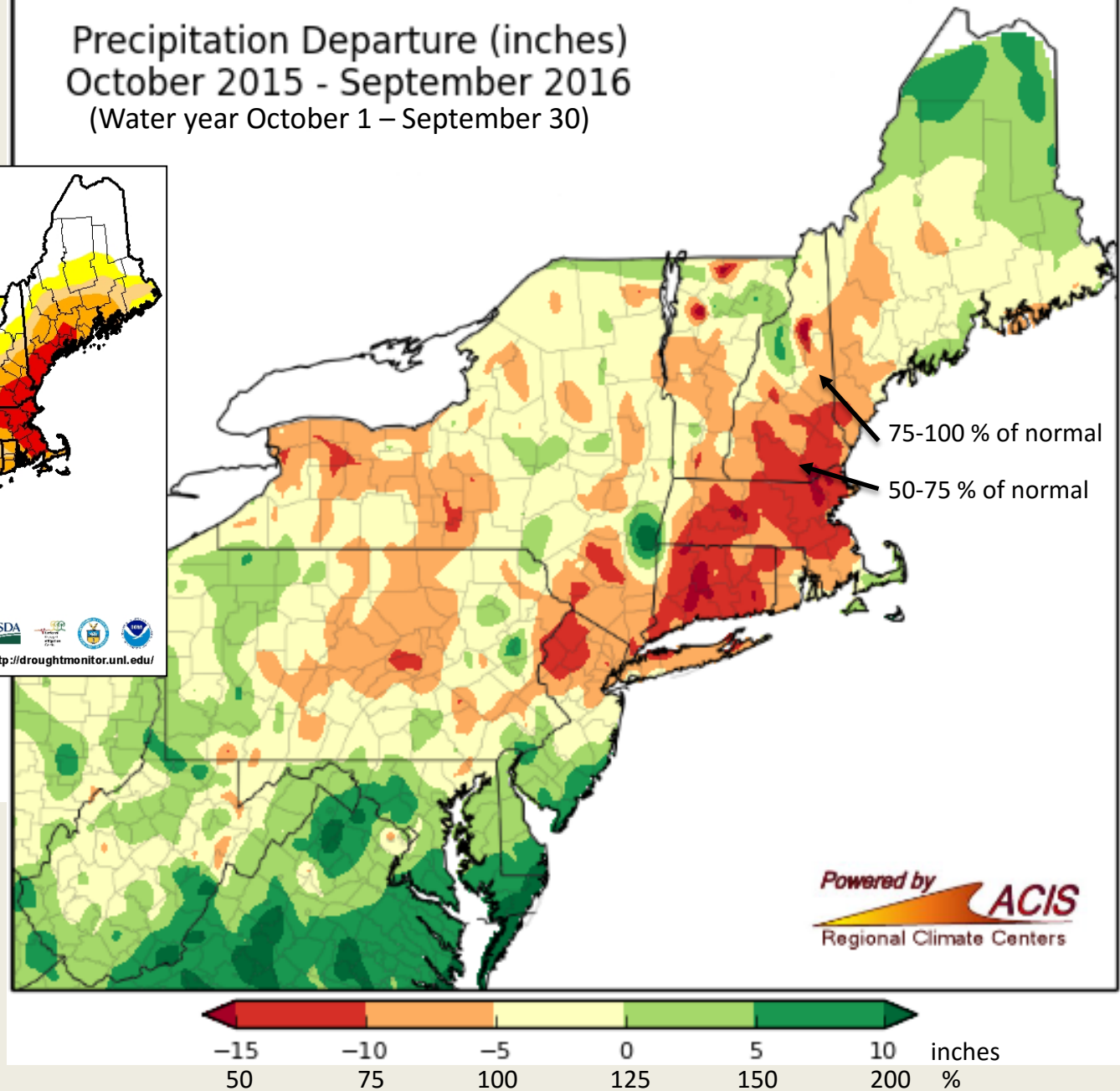
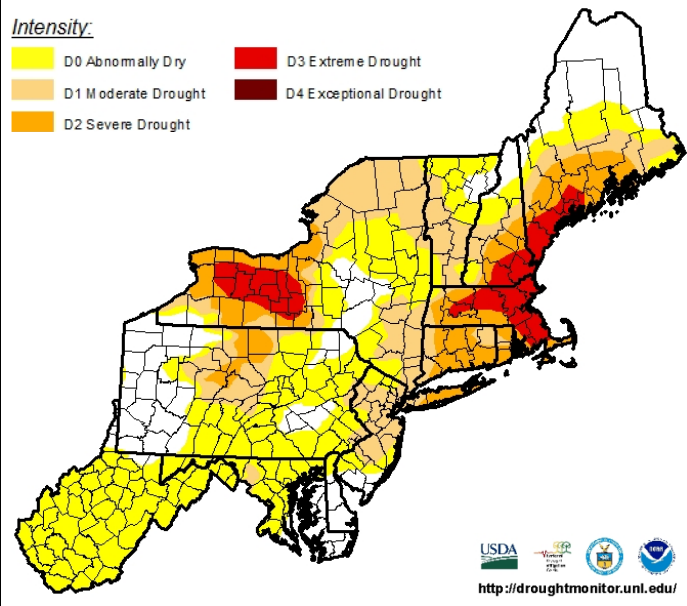
Precipitation - Portsmouth, NH - 1998 to 2016



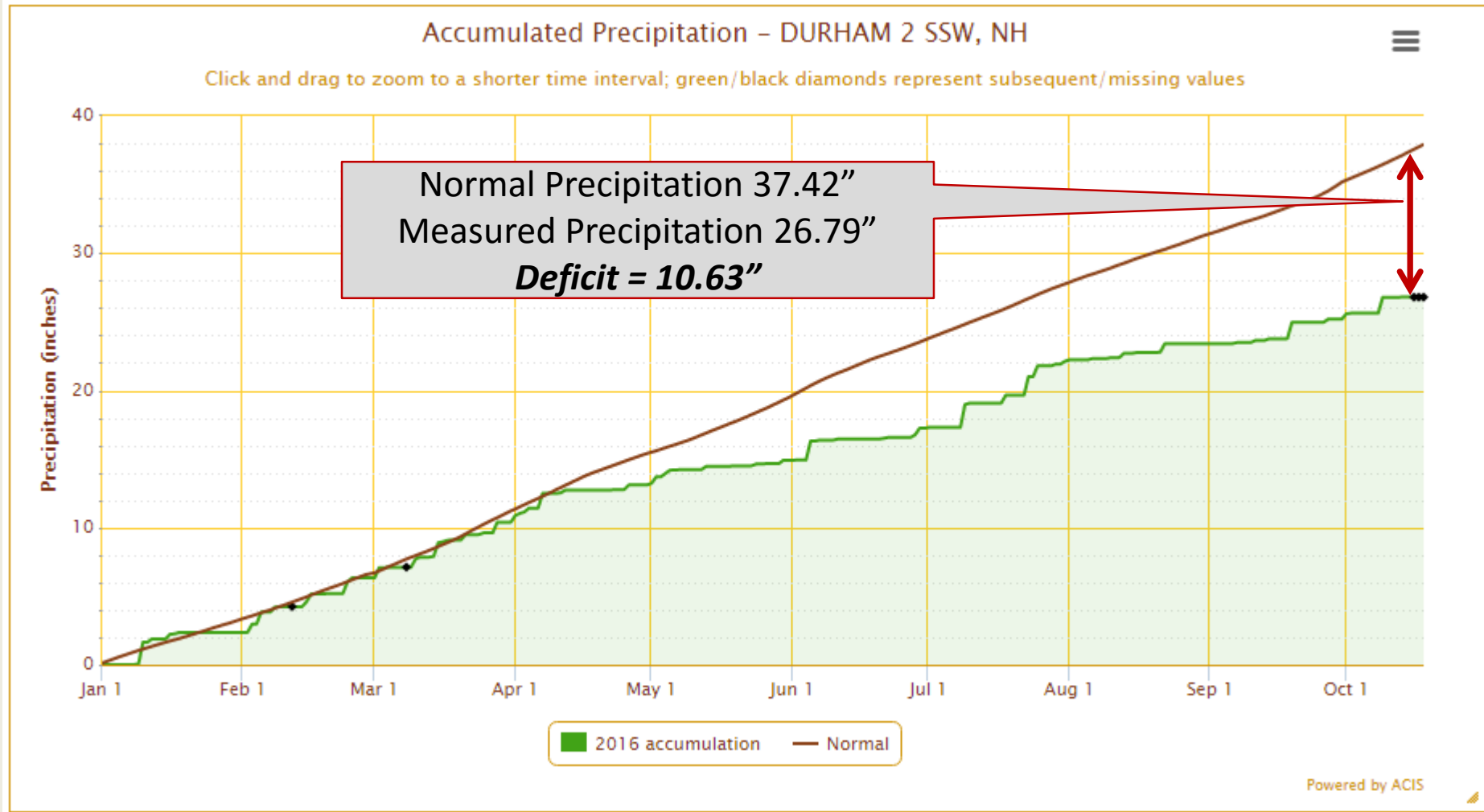
Precipitation Departure (inches) October 2015 - September 2016 (Water year October 1 – September 30)

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought



Precipitation Deficit from January 2016 to October 15, 2016



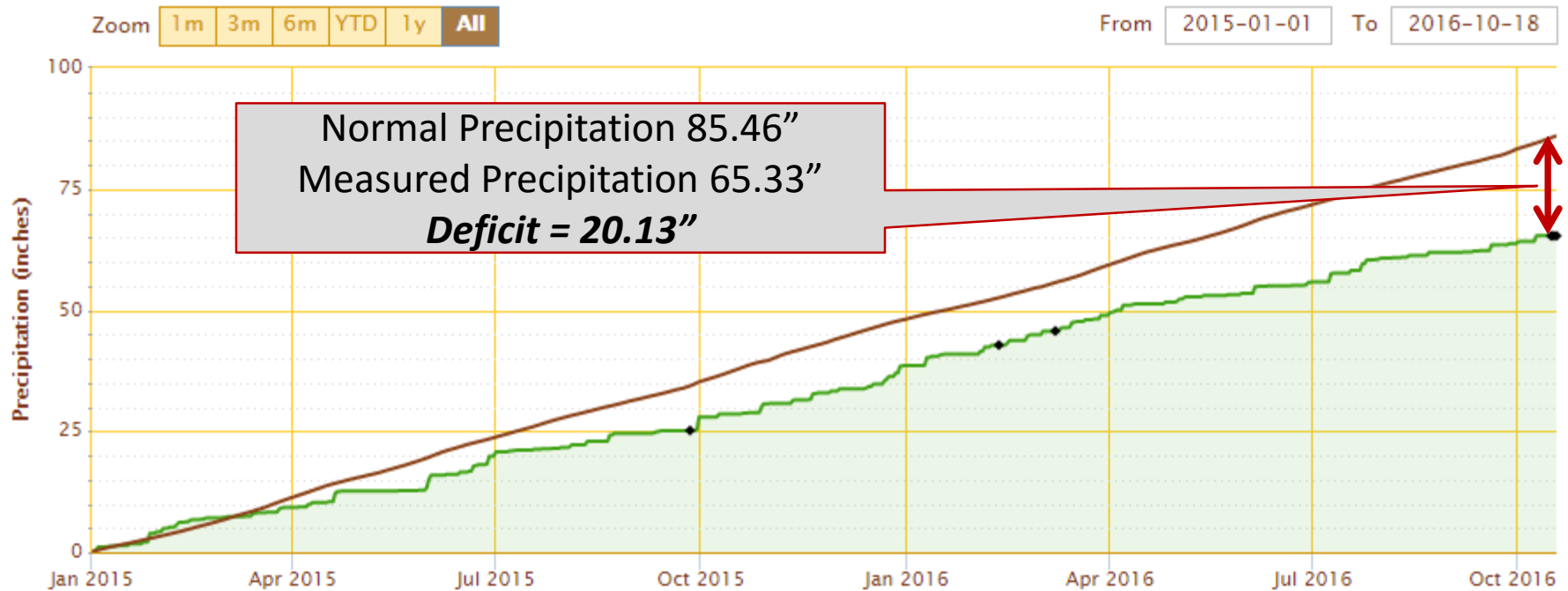
NOAA - The Applied Climate Information System (ACIS)

Emery & Garrett
Groundwater Investigations

Precipitation Deficit from January 2015 to October 15, 2016

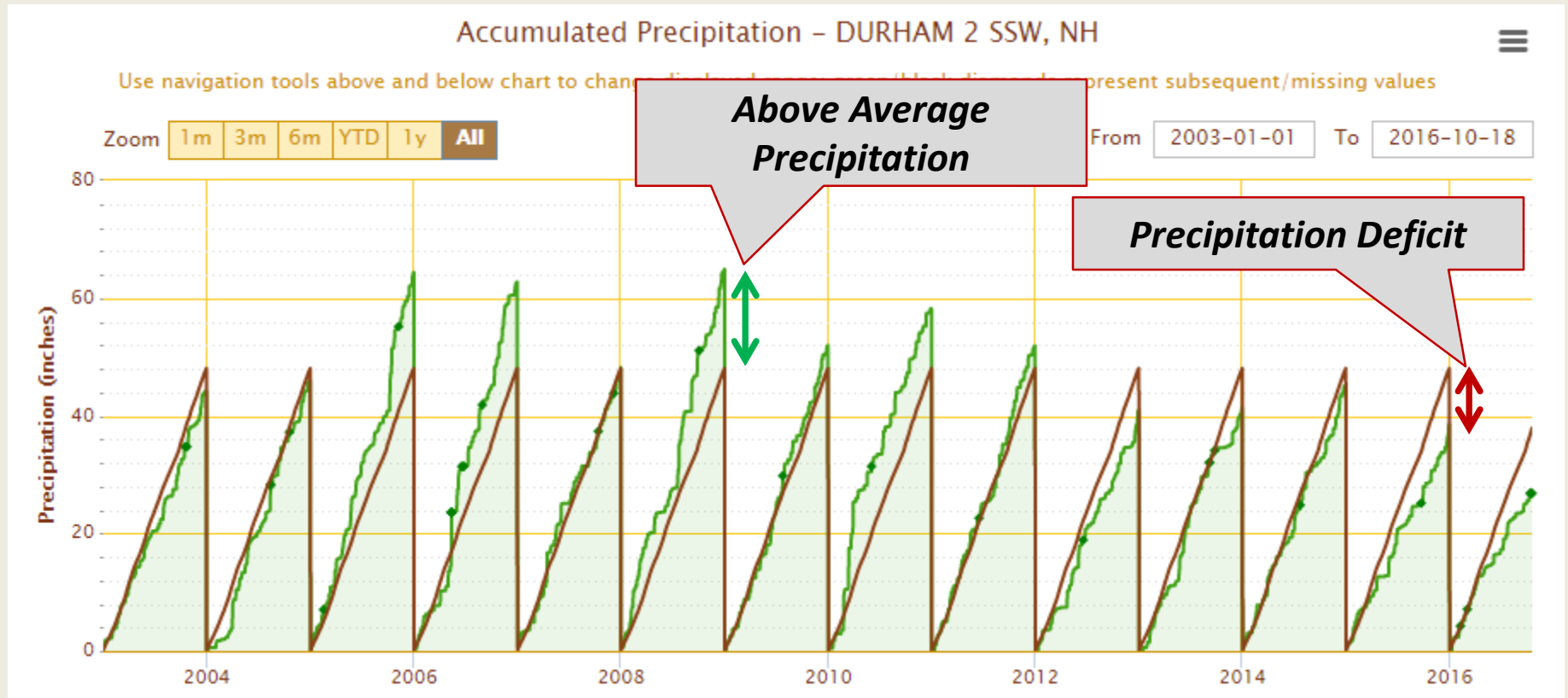
Accumulated Precipitation – DURHAM 2 SSW, NH

Use navigation tools above and below chart to change displayed range; green/black diamonds represent subsequent/missing values



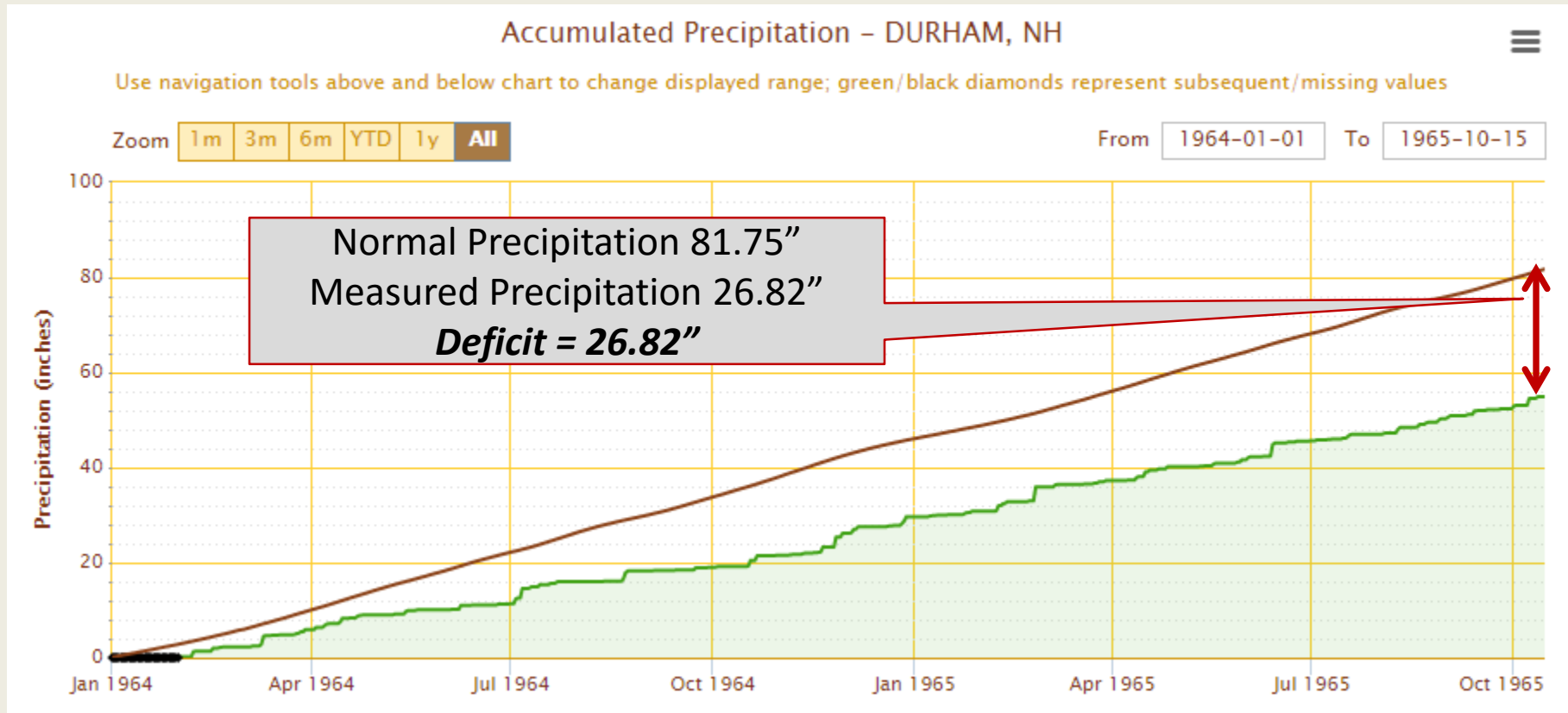
NOAA - The Applied Climate Information System (ACIS)

Accumulated Annual Precipitation from January 2003 to October 15, 2016



NOAA - The Applied Climate Information System (ACIS)

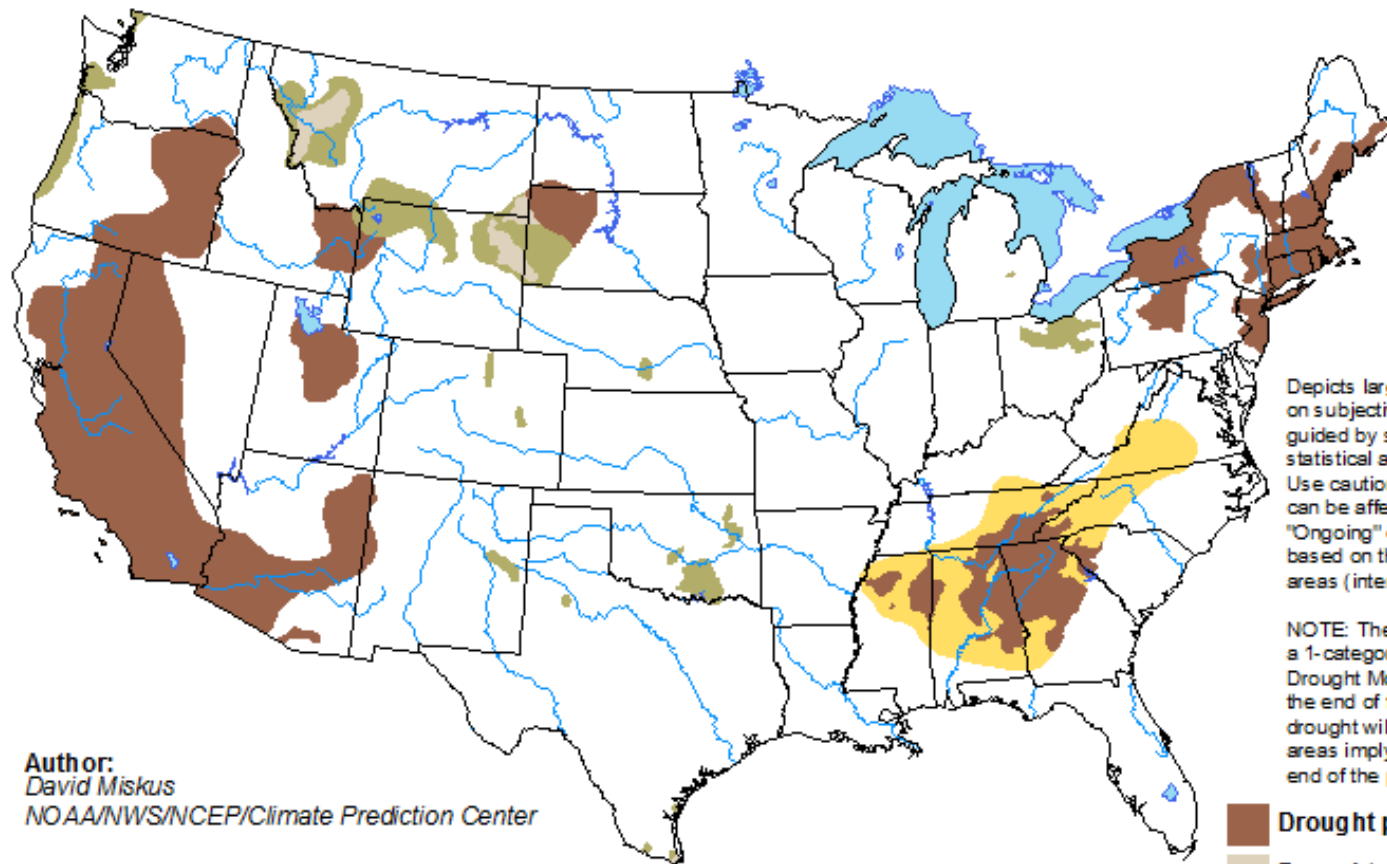
Precipitation Deficit from January 1964 to October 15, 1965



NOAA - The Applied Climate Information System (ACIS)

U.S. Seasonal Drought Outlook

valid for September 15 - December 31, 2016
Drought Tendency During the Valid Period
Released September 15, 2016



Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to D4).

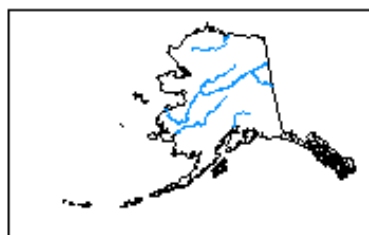
NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

Author:
David Miskus
NOAA/NWS/NCEP/Climate Prediction Center

- Drought persists
- Drought remains but improves
- Drought removal likely
- Drought development likely



<http://go.usa.gov/3eZ73>





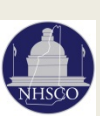
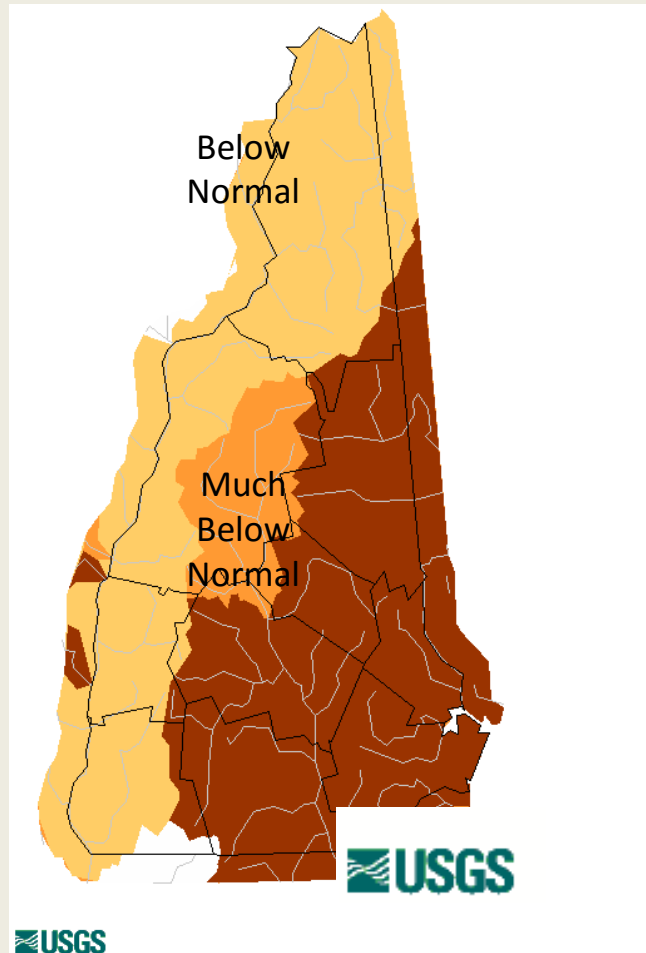
Historic Drought Related Issues

- Lake levels
- Stream flow
- Dam management
- Failing water supply wells (private & public)
- Public water supply shortages
- Restricting outdoor lawn watering
- Impacts on business, industry and agriculture
- Roadside withdrawals by tanker trucks
- Fire danger

Below Normal 7-day Average Streamflow

October 2, 2016

Explanation - Percentile classes				
Low	≤ 5	6-9	10-24	Insufficient data for a hydrologic region
Extreme hydrologic drought	Severe hydrologic drought	Moderate hydrologic drought	Below normal	



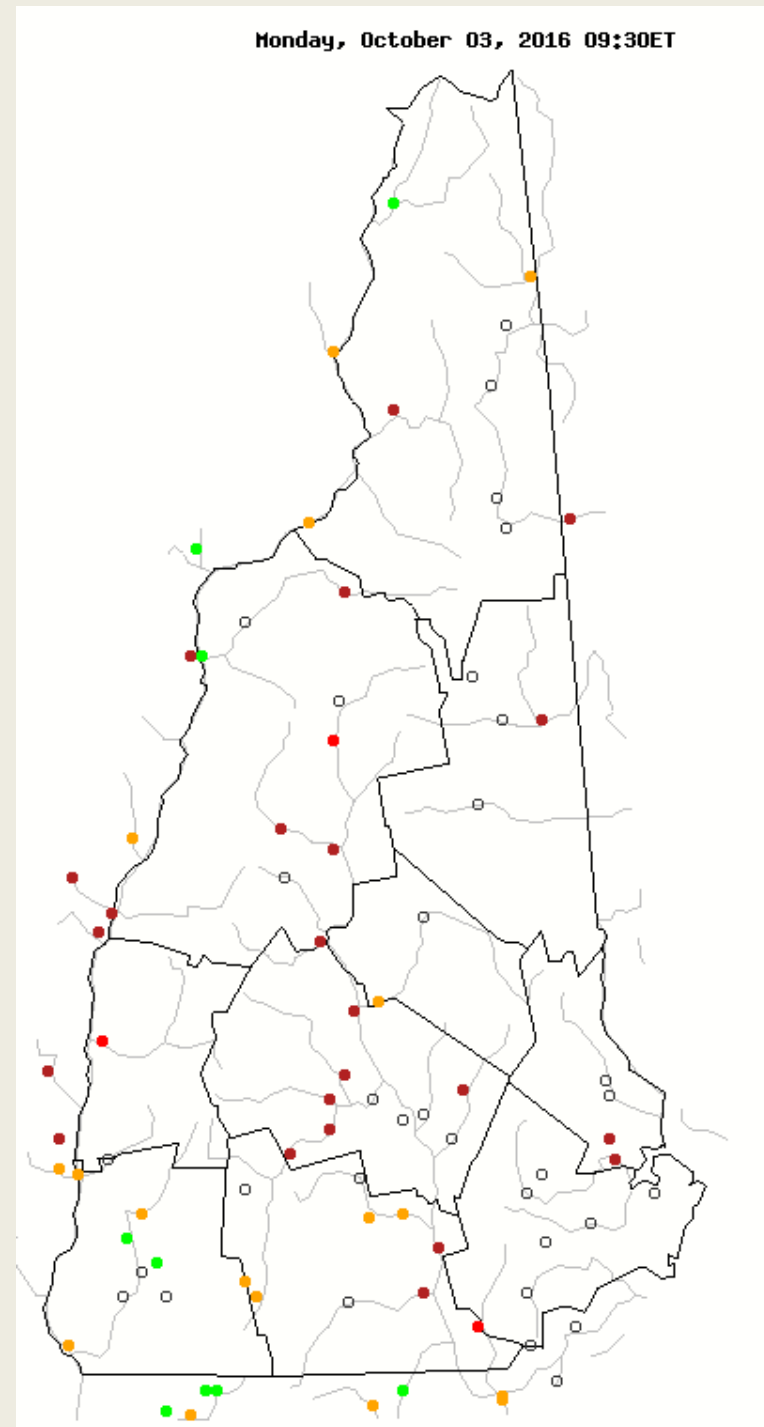
Streamflow

(10/3/2016)

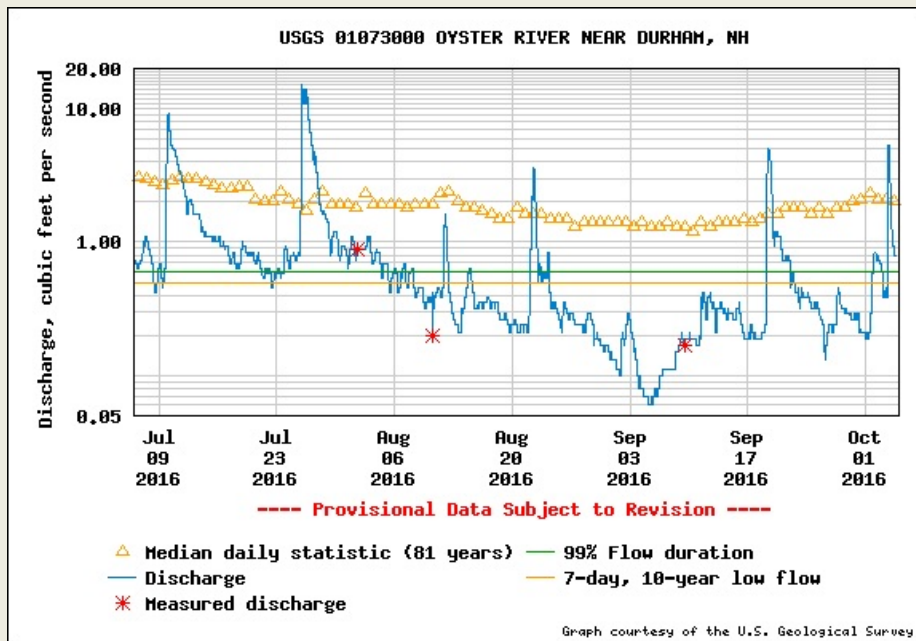
Explanation - Percentile classes							
							
Low	<10	10-24	25-75	76-90	>90	High	Not-ranked
	Much below normal	Below normal	Normal	Above normal	Much above normal		

- Piscassic, Exeter and Spicket Rivers had “0” flow in September 2016.

Oyster and Lamprey River are at historic lows. No water is going through the Oyster River intake structure for Durham/UNH.



Bellamy Watershed Flow and Reservoir Level



- Historic Low Flow in Rivers
- (82 years of record)

- Reservoir is down 3.6 feet from overflow
- Better than 2002 when it was 5 feet down
- Current withdrawal of 2.5 million gallons/day

The good news for Dover is they are dependent on groundwater resources and not surface water resources....as are many other communities in the seacoast.

However, groundwater resources can also adversely impaired by drought.



Groundwater Drought Mitigation Measures

- Large groundwater withdrawal permit volumes can be reduced based on phase of drought
- DES has the emergency authority to approve new large groundwater withdrawals
- Municipal authority can restrict or ban residential lawn watering and other outdoor water uses during drought (applies to public and *private residential wells*)
- DES may require a public water system to extend service to address a nearby emergency



Other Drought Mitigation Strategies

- **Source diversification/water resource management**
- **Artificial Recharge**
- **Water conservation**
 - Leak detection, water audits/metering, water use restrictions, model landscaping bylaws, indoor fixtures

**Actions taken (or to be taken)
by the City to further
Evaluate/Enhance/Protect
Critical Groundwater
Resources**

1) Design and development of groundwater monitoring program

(May 2016)

**Purpose of program is to
evaluate long-term water level
and water quality variations in:**

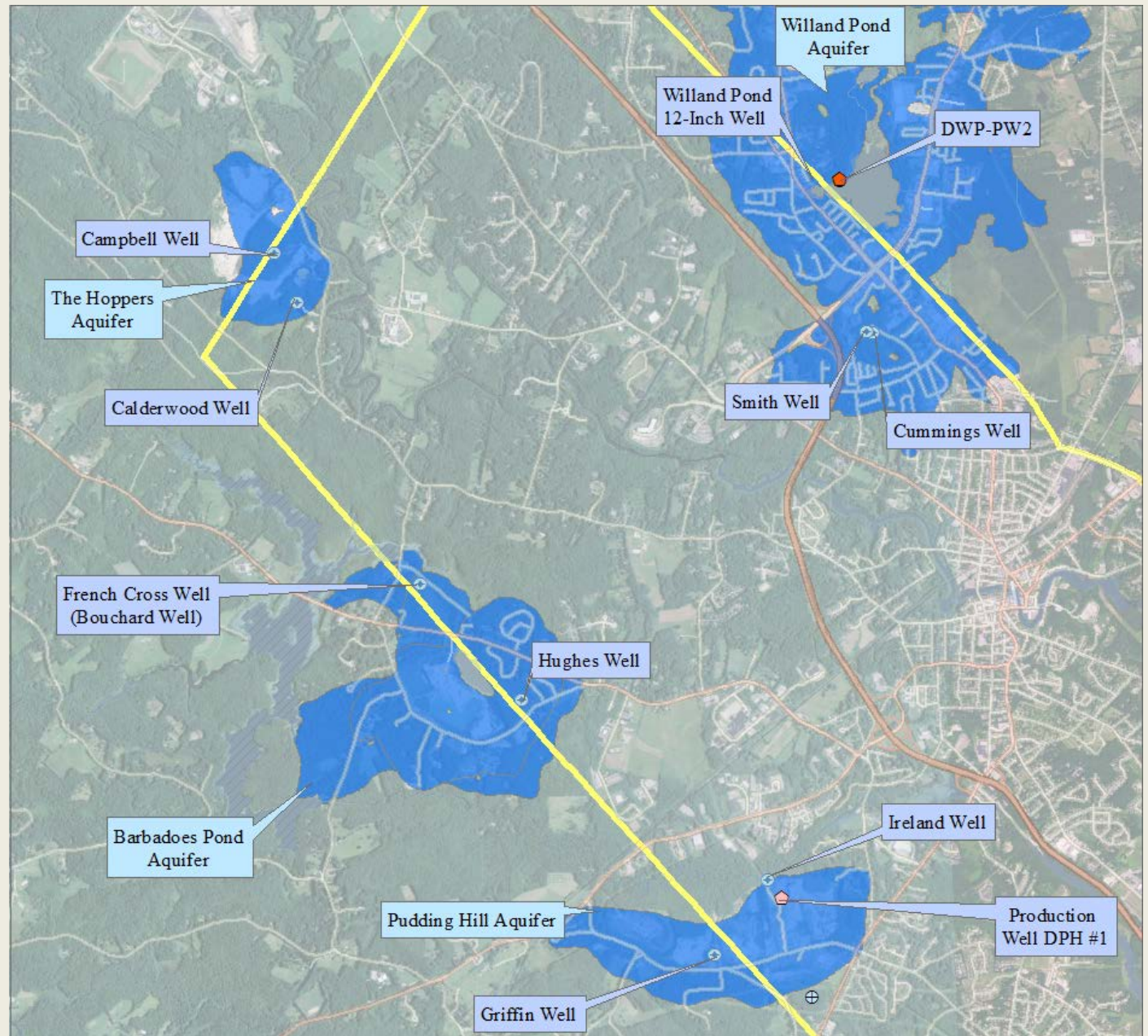
- City's production wells,**
- Surrounding aquifers, and
nearby ponds.**

**Long-term groundwater
monitoring includes 26 water
level observation locations,
starting August 2016.**

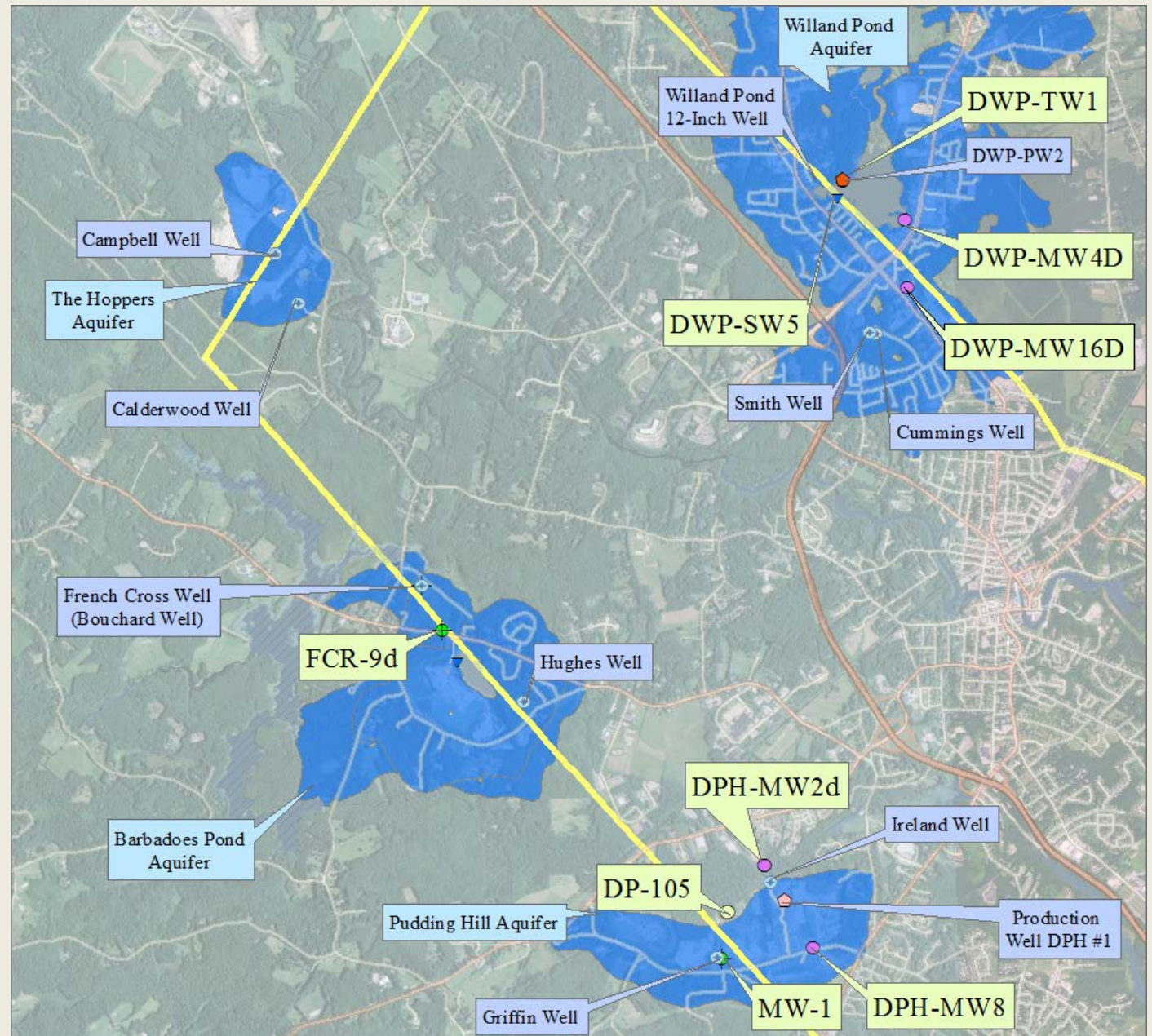
**Limited additional long-term
data has been collected since
2010.**

This
includes:

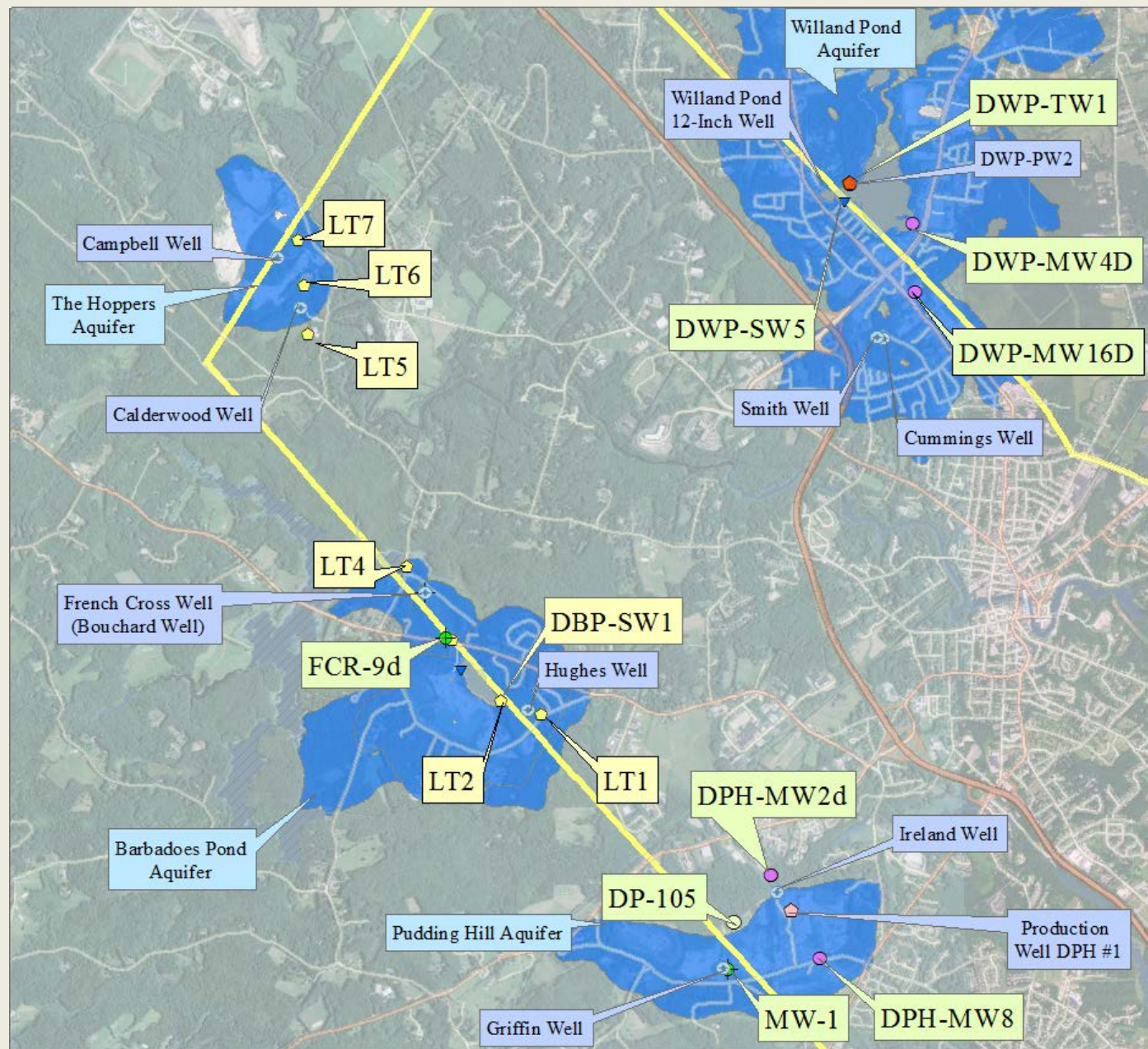
8
Existing
Water
Supply
Wells
and 3
New
Water
Supply
Wells



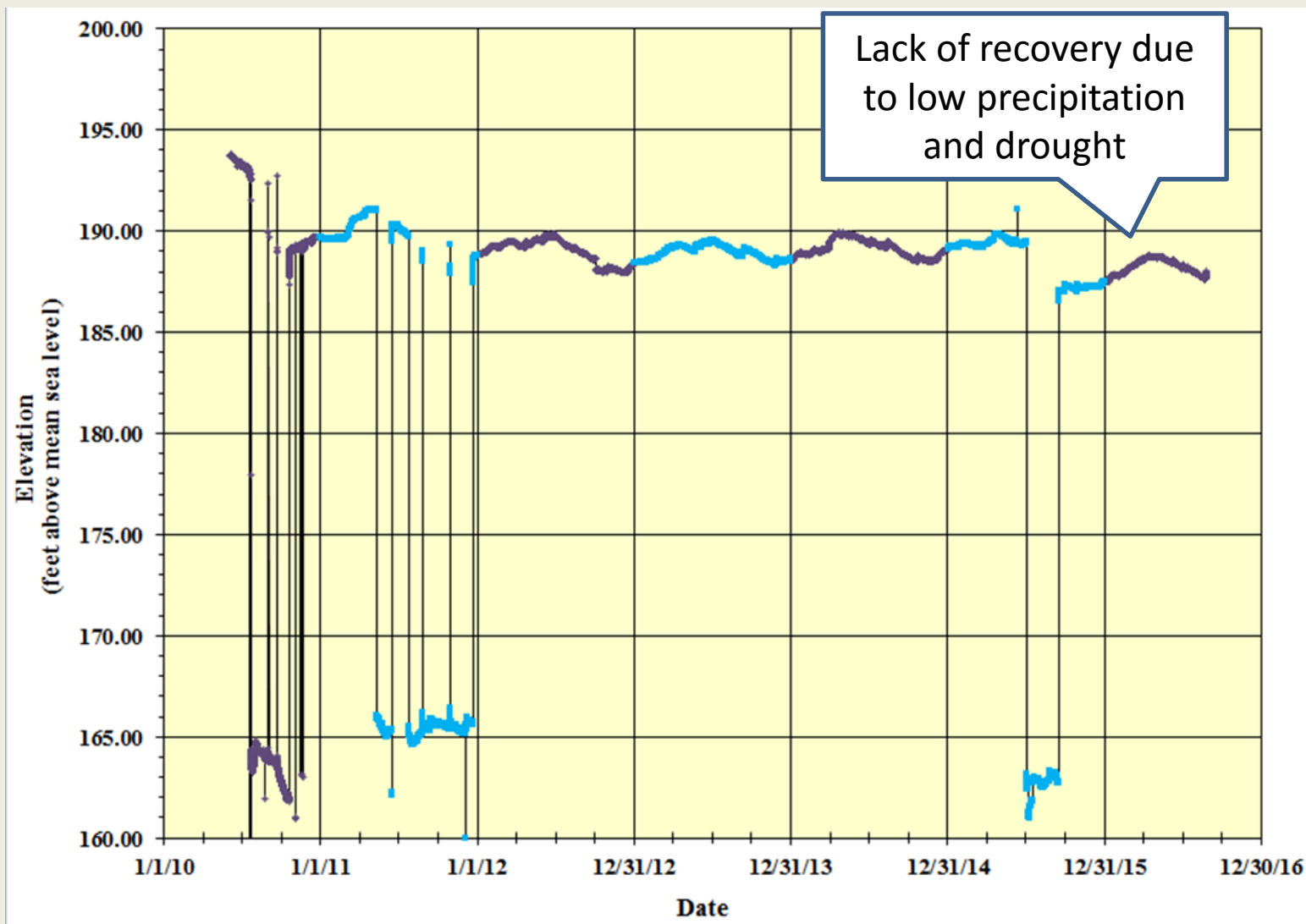
9 Previously Existing Monitoring Wells



6 New
Monitoring
Wells and 2
New Surface
Water
Stations
(Barbadoes
and Willand
Ponds)



Long-Term Water Level Variations in the Willand Pond 12-Inch Well



**The data collected will be
utilized in the future
management and protection of
the City's groundwater
resources.**

Drought Management Plan – Recommended Responses

Level 1 – Alert *Incipient Drought -*

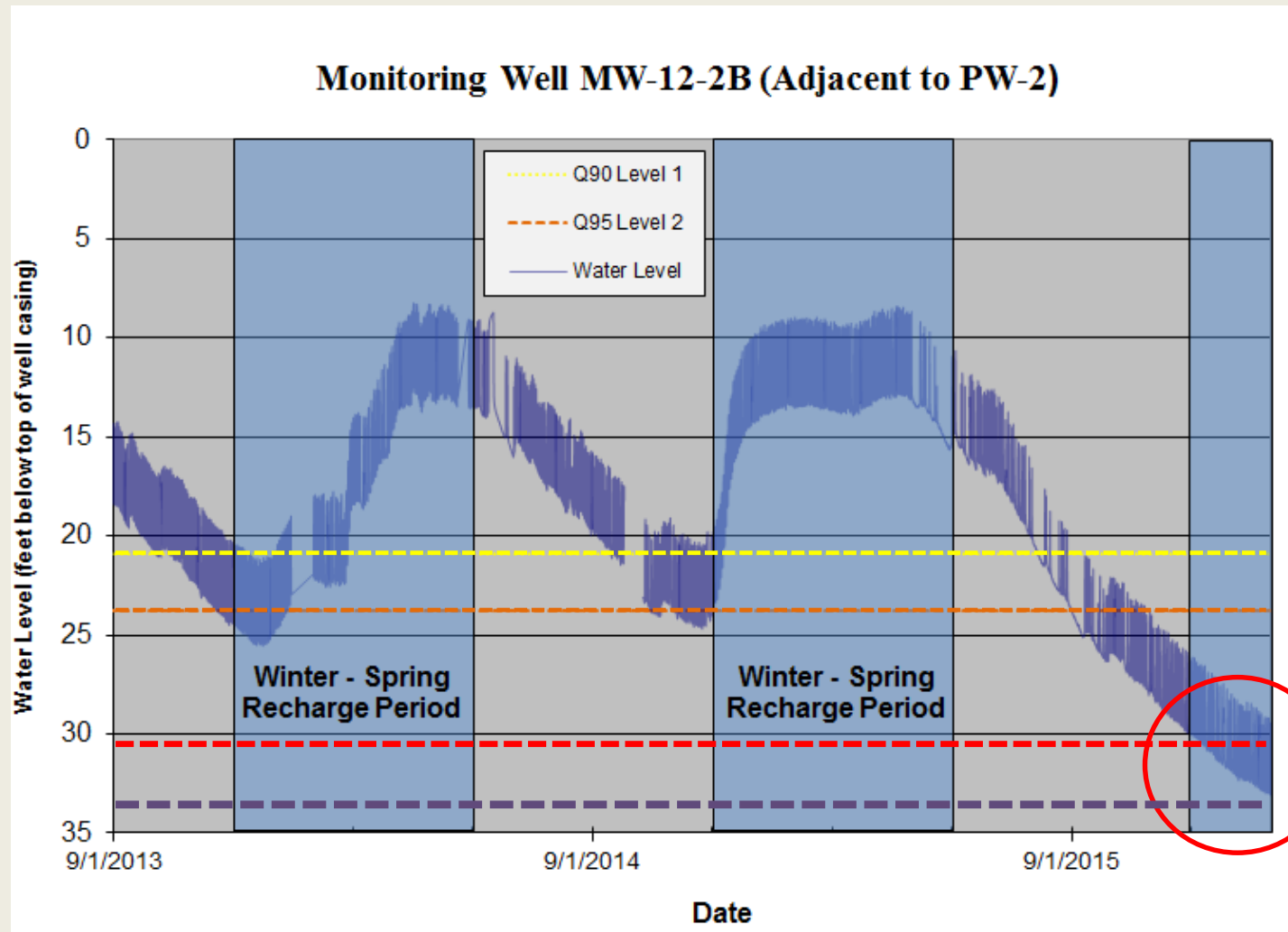
Level 2 – Warning *Moderate Drought*

Level 3 – Emergency *Severe Drought*

Level 4 – Disaster *Extreme Drought*

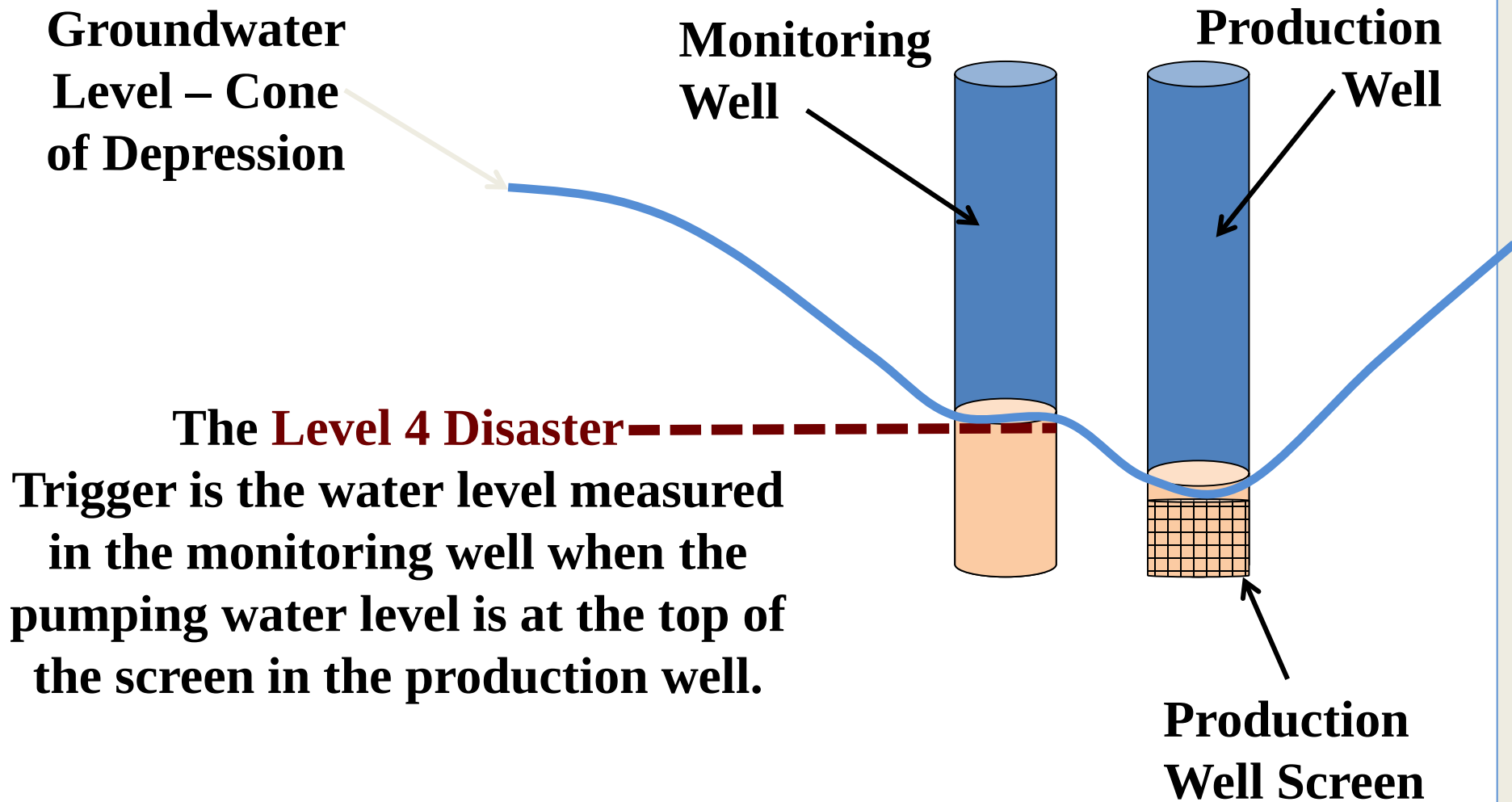
Level 1	Alert	Incipient	Increase water level monitoring frequency; monitor drought forecast and water demand.
Level 2	Warning	Moderate	Consider implementing voluntary and / or mandatory water restrictions. Consider source management to minimize groundwater impacts.
Level 3	Emergency	Severe	Implement mandatory water restrictions. Implement source management to optimize groundwater levels.
Level 4	Disaster	Extreme	Shutdown or reduce water level withdrawals from source at these levels.

What Constitutes a Drought for a Water Utility that Uses Groundwater?



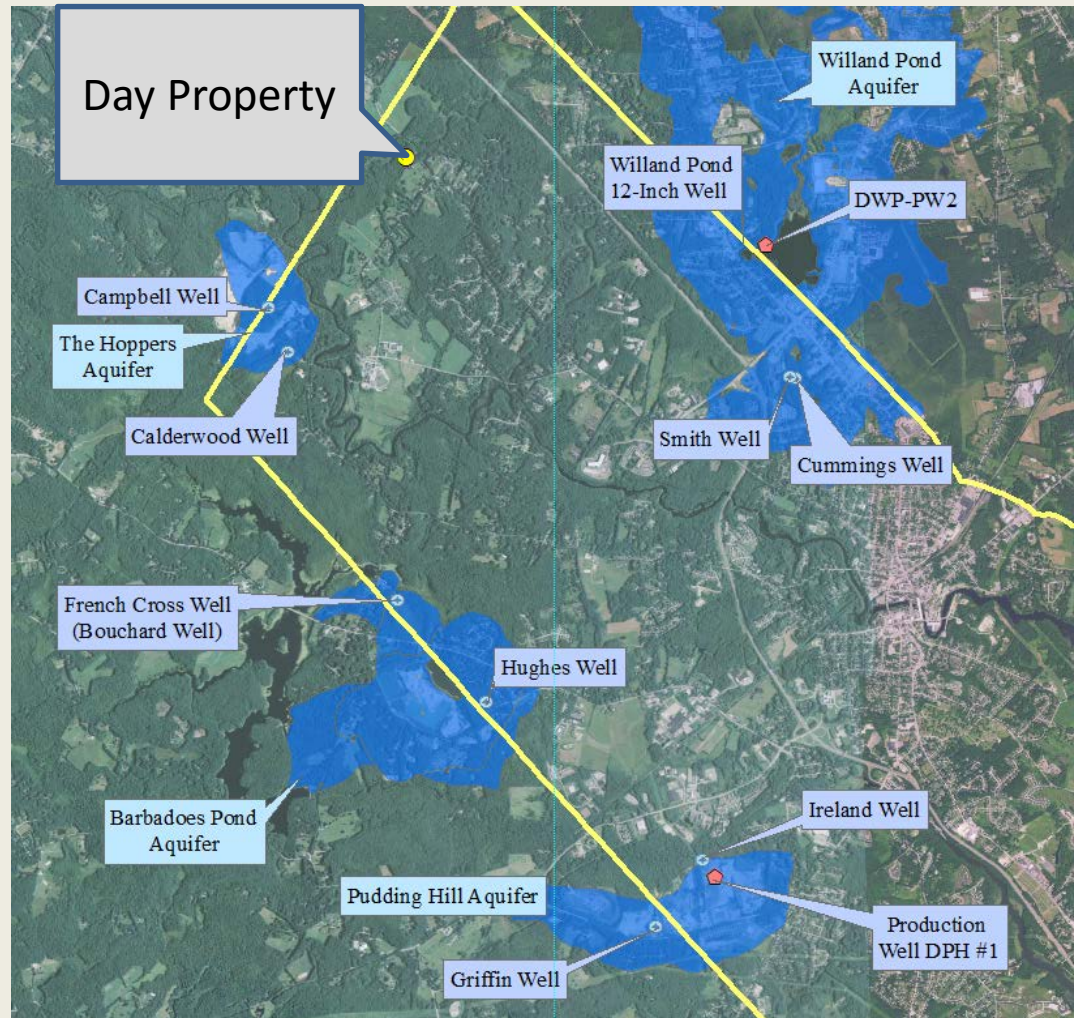
Level 4 – Disaster

The goal is to maintain the water level in the production well above the screen.

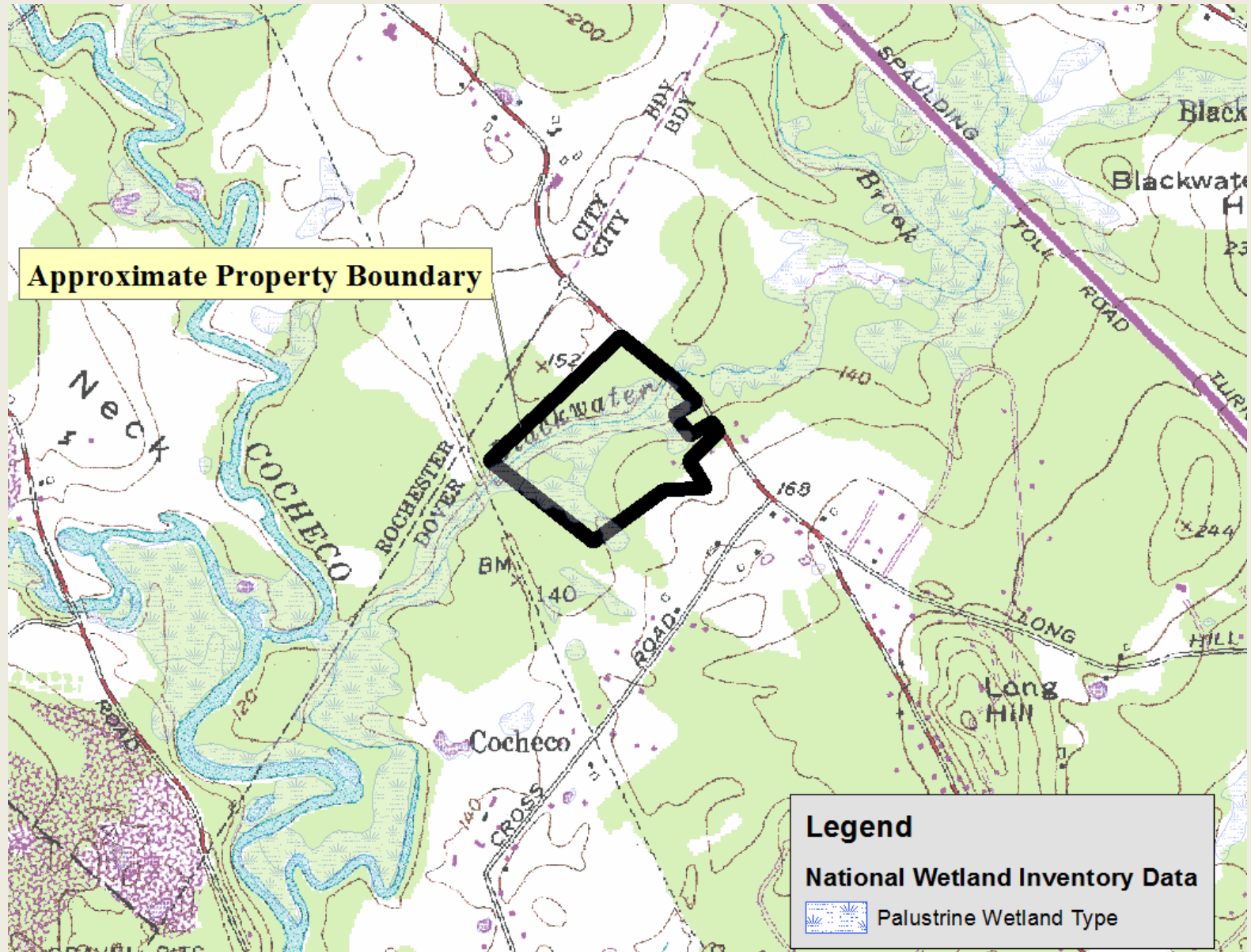


2) Developing New Bedrock Water Supply Wells for Water Resource Management and Drought Mitigation

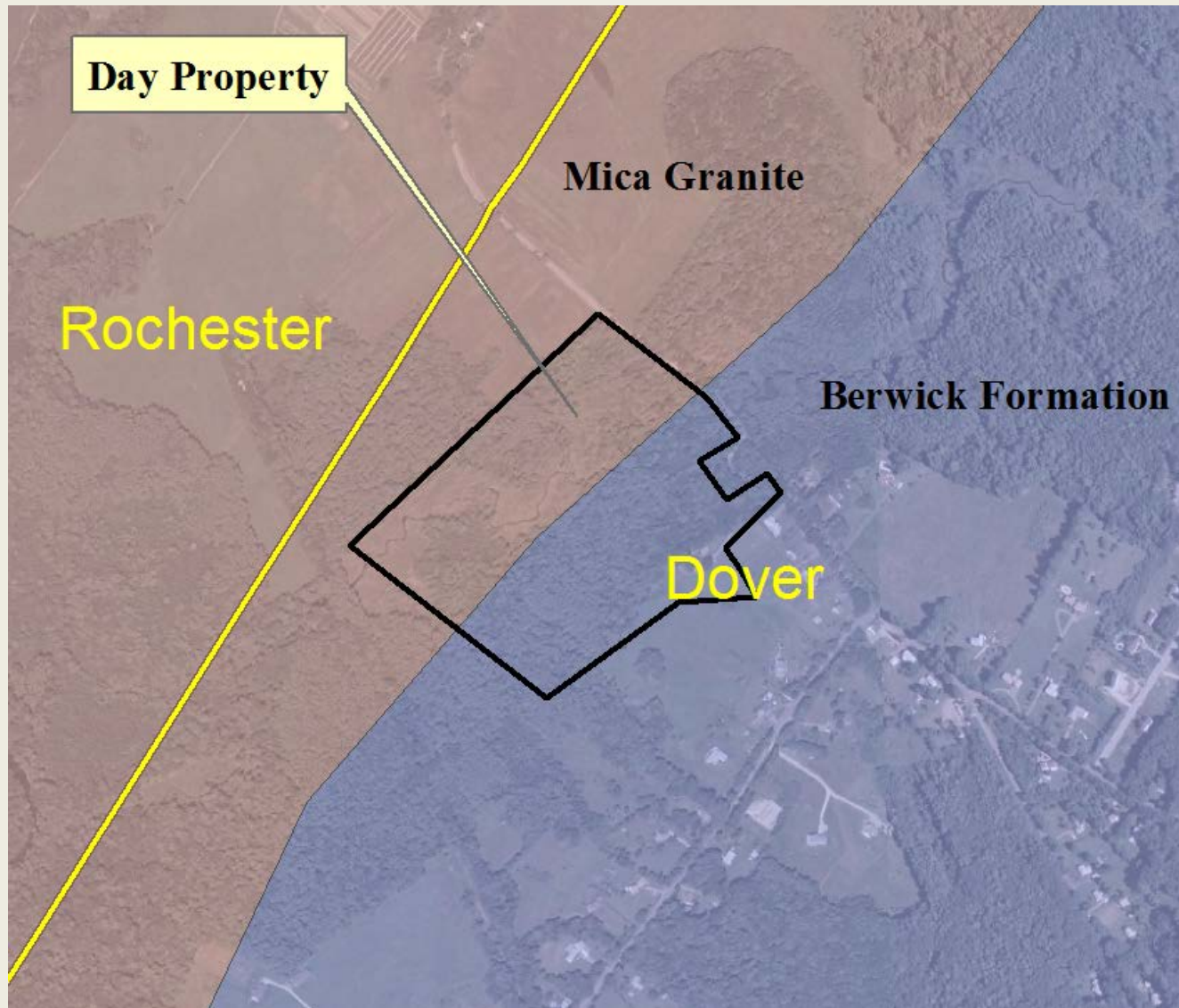
For example, additional groundwater development could be performed proximal to the Day Property



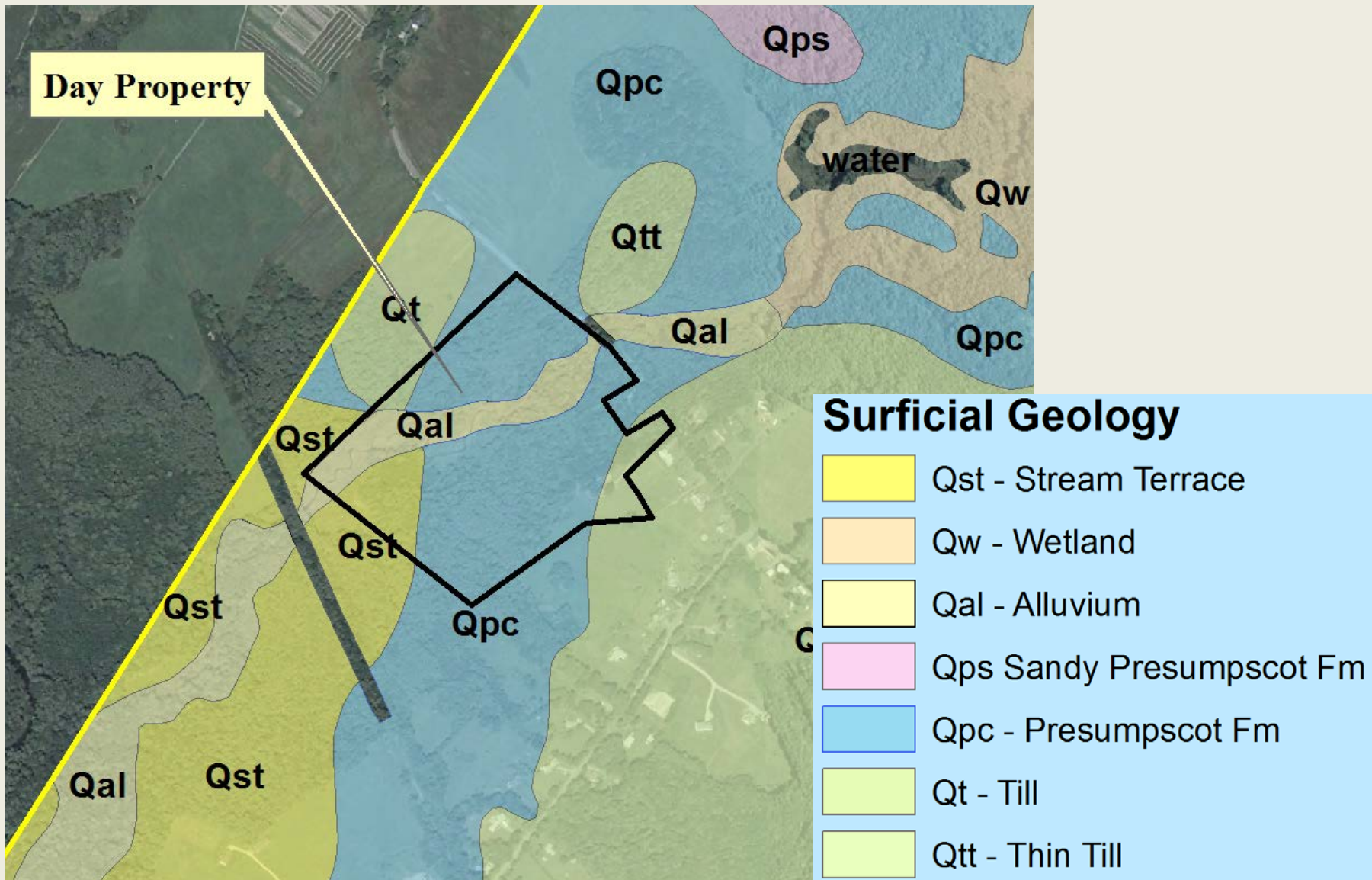
Topographic Setting



Bedrock Geology



Surficial Geology



DOV-3 Pumping Test

**Pumping Rate: 100 gpm
(144,000 gpd)**

Duration: 2 days

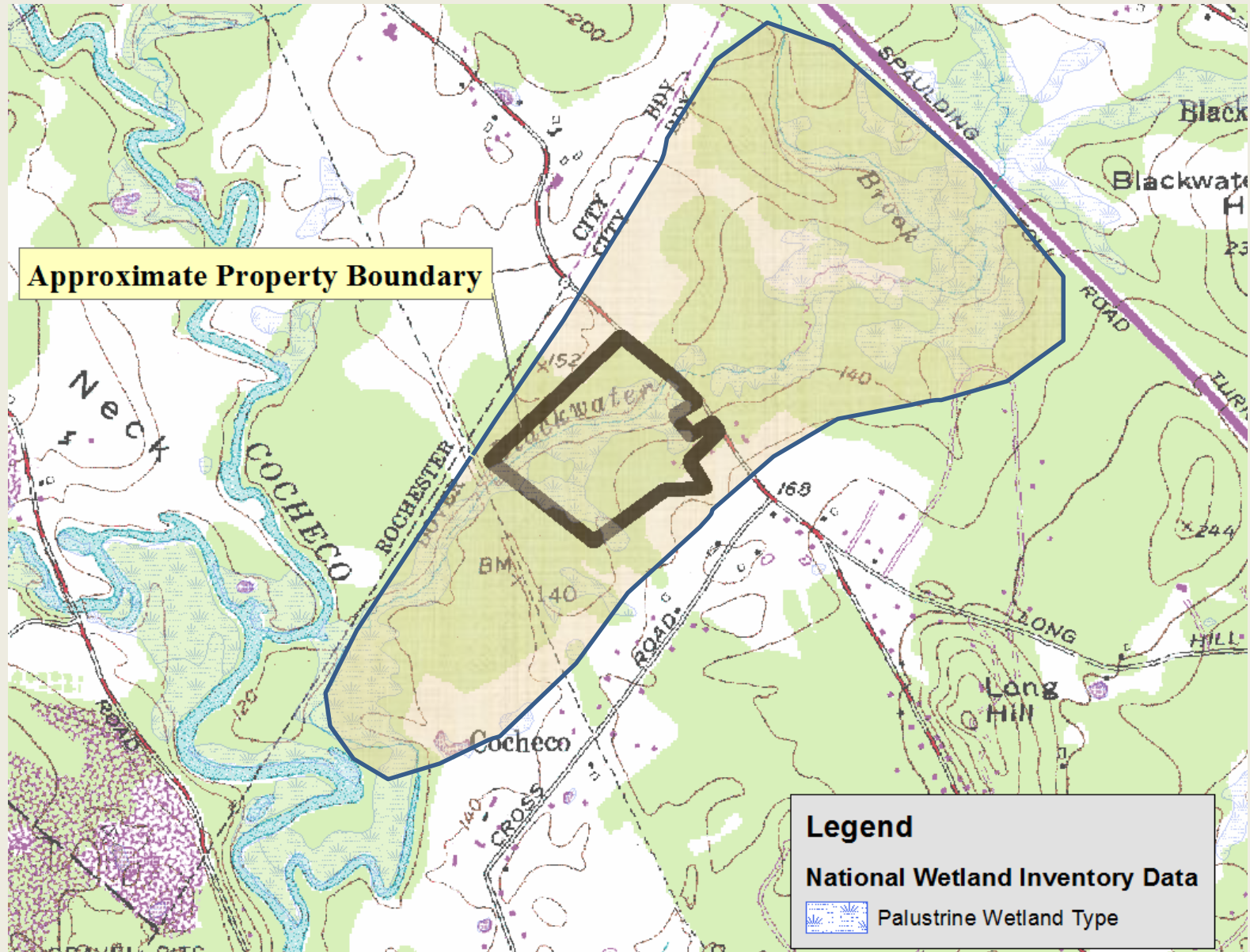
Water Level Drawdown: 311.21'

Specific Capacity: 0.32 gpm/ft

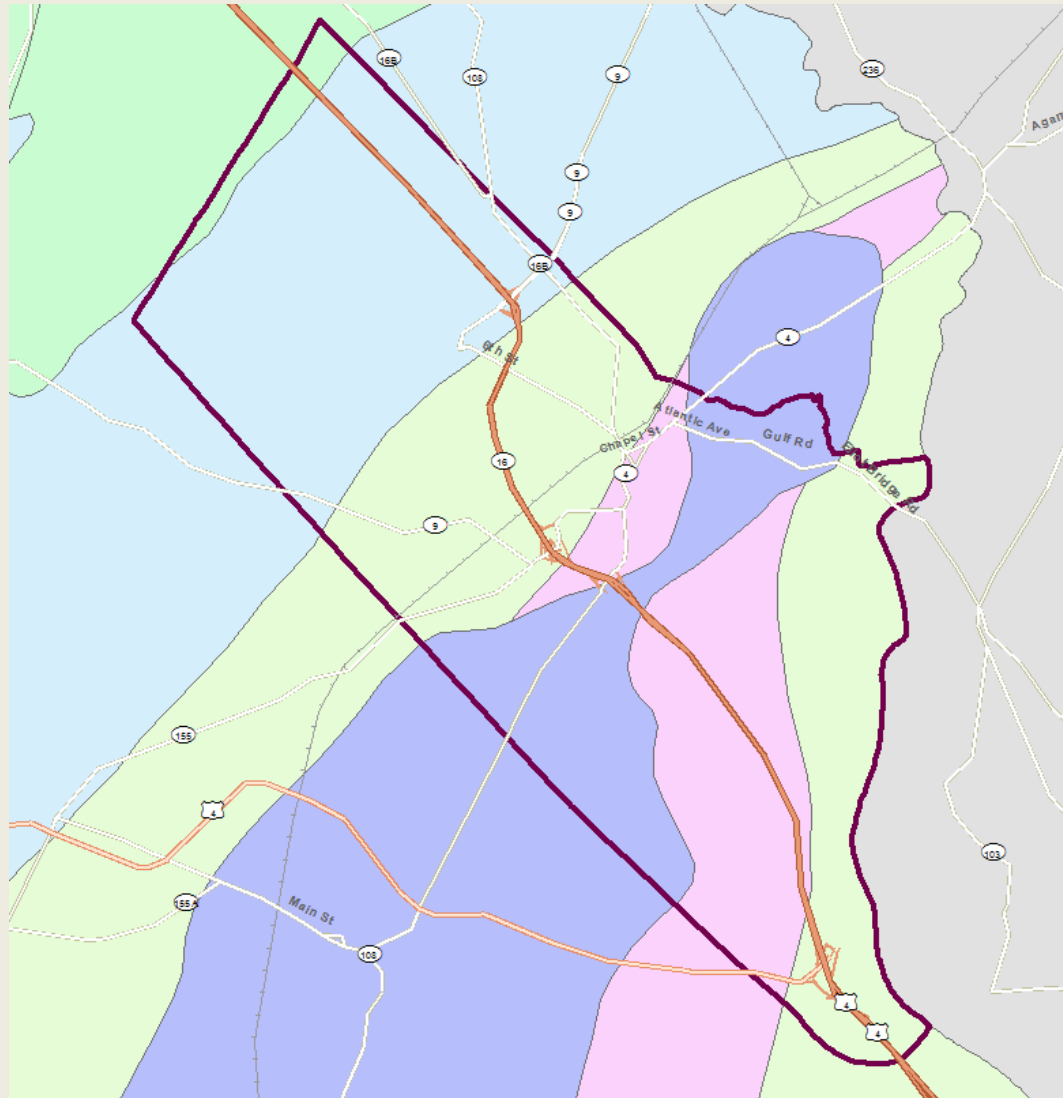
Available DD used: 90%

Recovery in 2 days: 99%

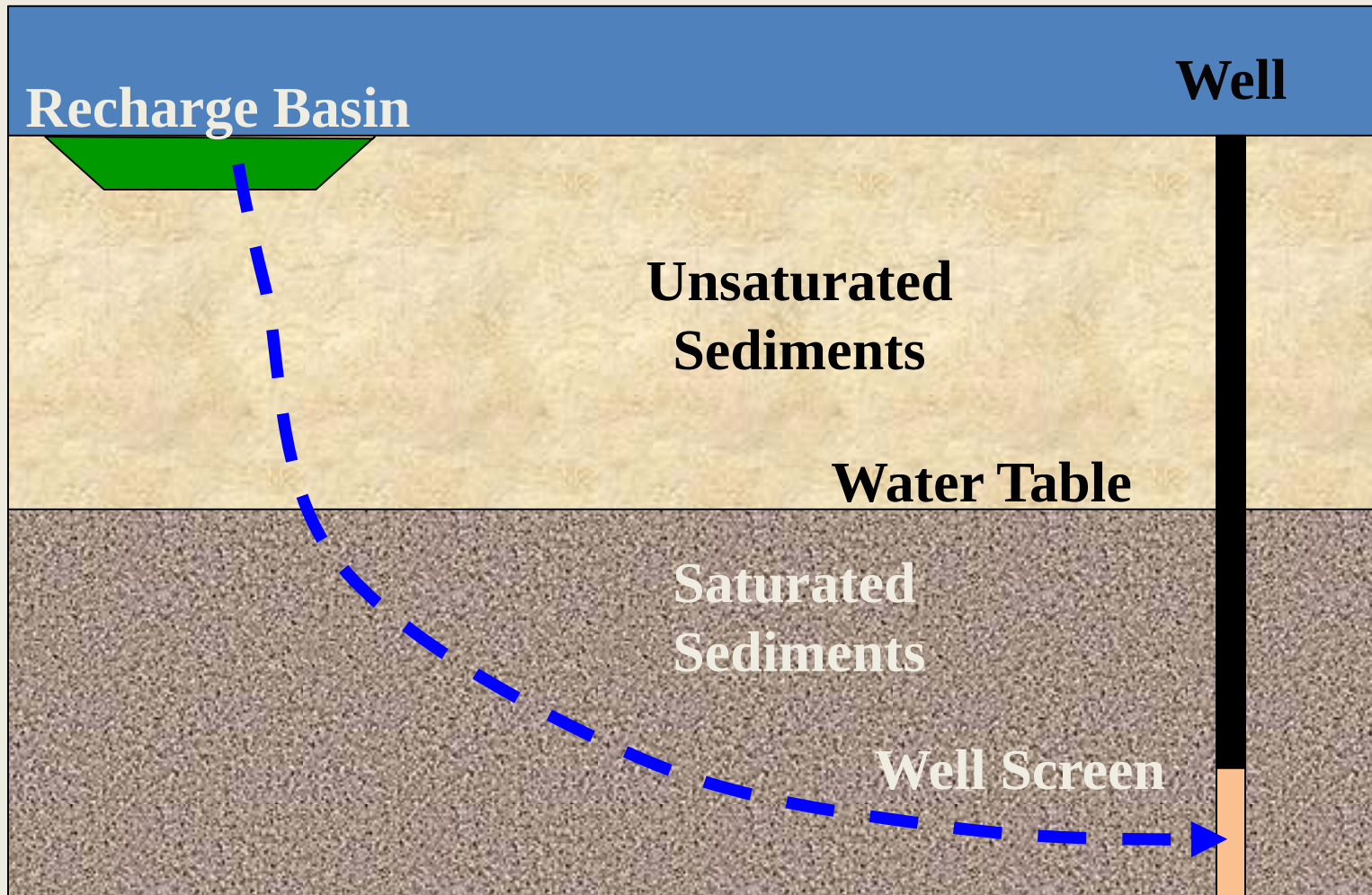
Additional Area for Investigation



City-Wide Investigation



3) Artificial Recharge development in Pudding Hill Aquifer



EGGI's Recommendations for "Next Steps"

- 1) Continue groundwater monitoring program through 2026 (extension of contract required);**
- 2) Consider taking actions based on results of groundwater monitoring program that may require water use restrictions;**

EGGI's Recommendations for "Next Steps"

3) Evaluate and develop additional groundwater resources in bedrock aquifers throughout the City of Dover (e.g., Day property) as soon as reasonably possible; and

4) Continue to pursue the development of Artificial Recharge in the Pudding Hill aquifer and potentially the Barbadoes Pond aquifer.

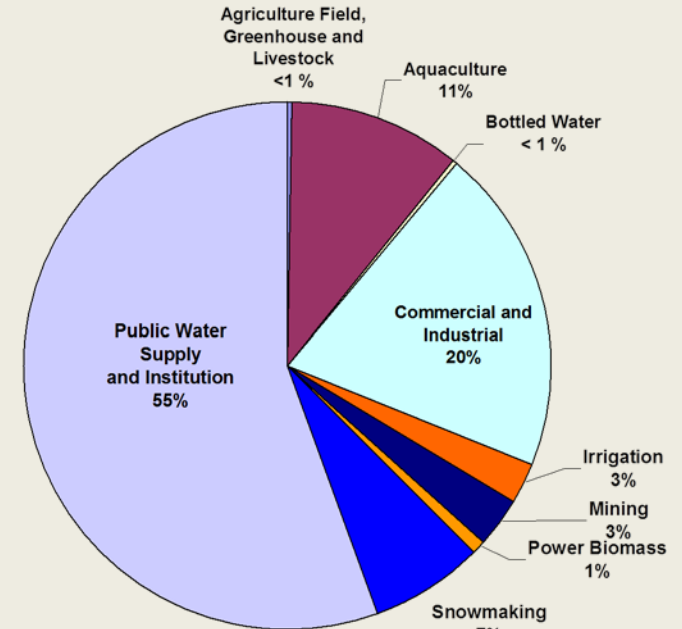
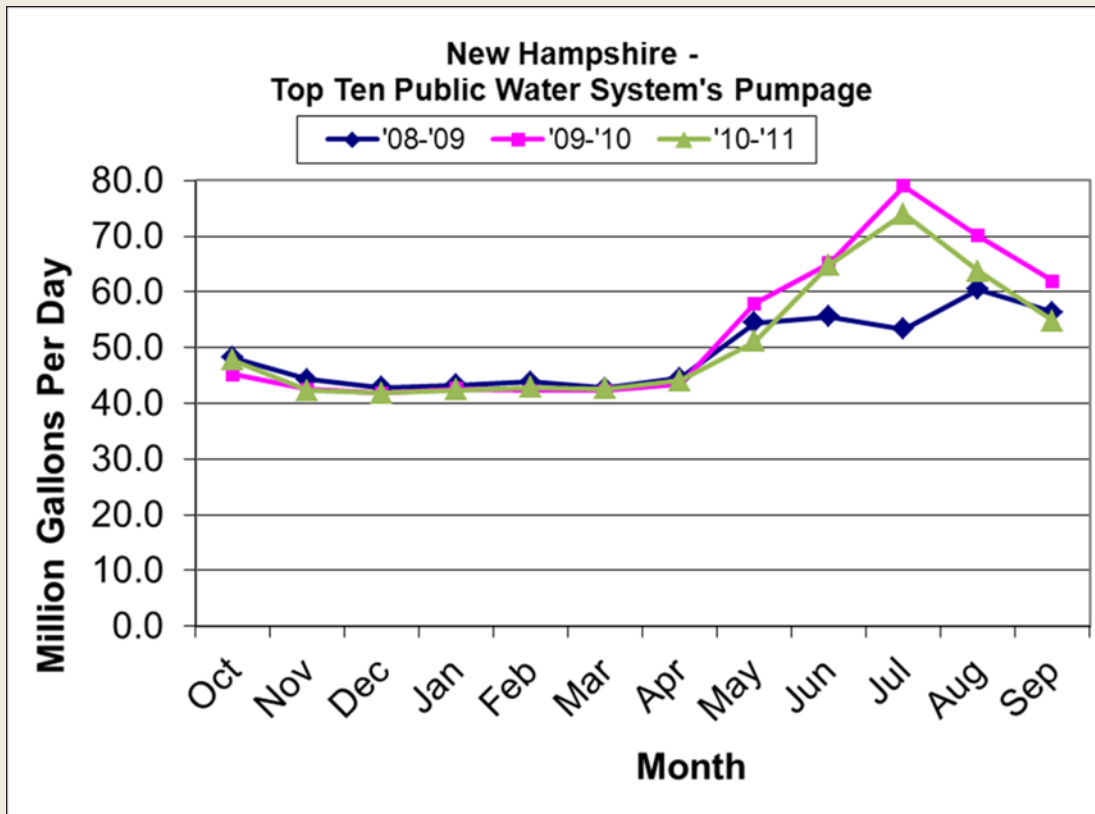
END



Emery & Garrett Groundwater Investigations, LLC



NHDES Drought Messaging and Communication



NH Daily Average Water
Withdrawals
163,350,642 gal

Public Notice and Enforcement

City of
Portsmouth
Department of Public Works



August 30, 2016

Portsmouth Water Supply Status

Overview

The following Portsmouth Water Supply Status Report provides the an assessment of the current water supply conditions. This report is on the City of Portsmouth's website at:
www.cityofportsmouth.com/publicworks - water

Odd/Even Water Use Restrictions

Customer Water Restrictions
N/A
None
Voluntary Measures
ODM/Even Watering
Two-Days per Week Watering
No Outdoor Use

Due to current supply and demand conditions, Water Use Restrictions began on August 16th. If drought conditions persist, additional restrictions or a ban may be required.

Odd/Even Water Use Restriction requirements as follows:

- Odd-numbered days – Outdoor watering from midnight and 10:00 AM;
- Even-numbered days – No Outdoor watering.

Water use restrictions are requested at this time due to drought conditions on the Seacoast. As the conditions show, the recent weather conditions continue to cause lower than typical reservoir levels, stream and groundwater levels.

Compliance with this water use restriction is required. Warning notifications and fines of \$100 per violation.

Additional updates and tips regarding water efficiency are available on the cityofportsmouth.com website or by calling the City of Portsmouth at: 603-766-7669.

CITY OF PORTSMOUTH



PRESS RELEASE

FOR IMMEDIATE RELEASE

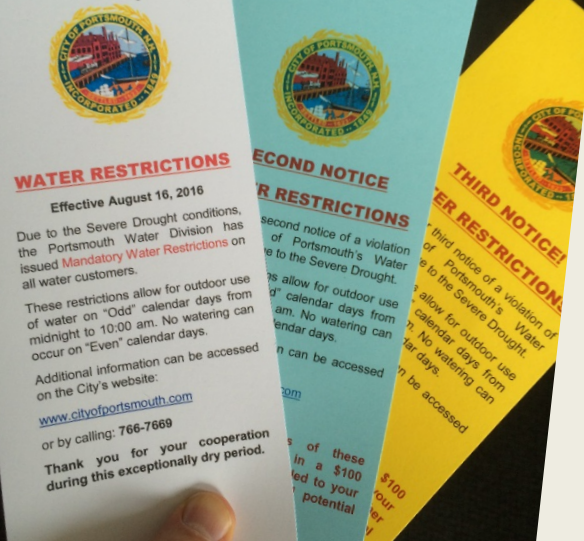
August 16, 2016

Portsmouth Water Division Enforces Water Restrictions

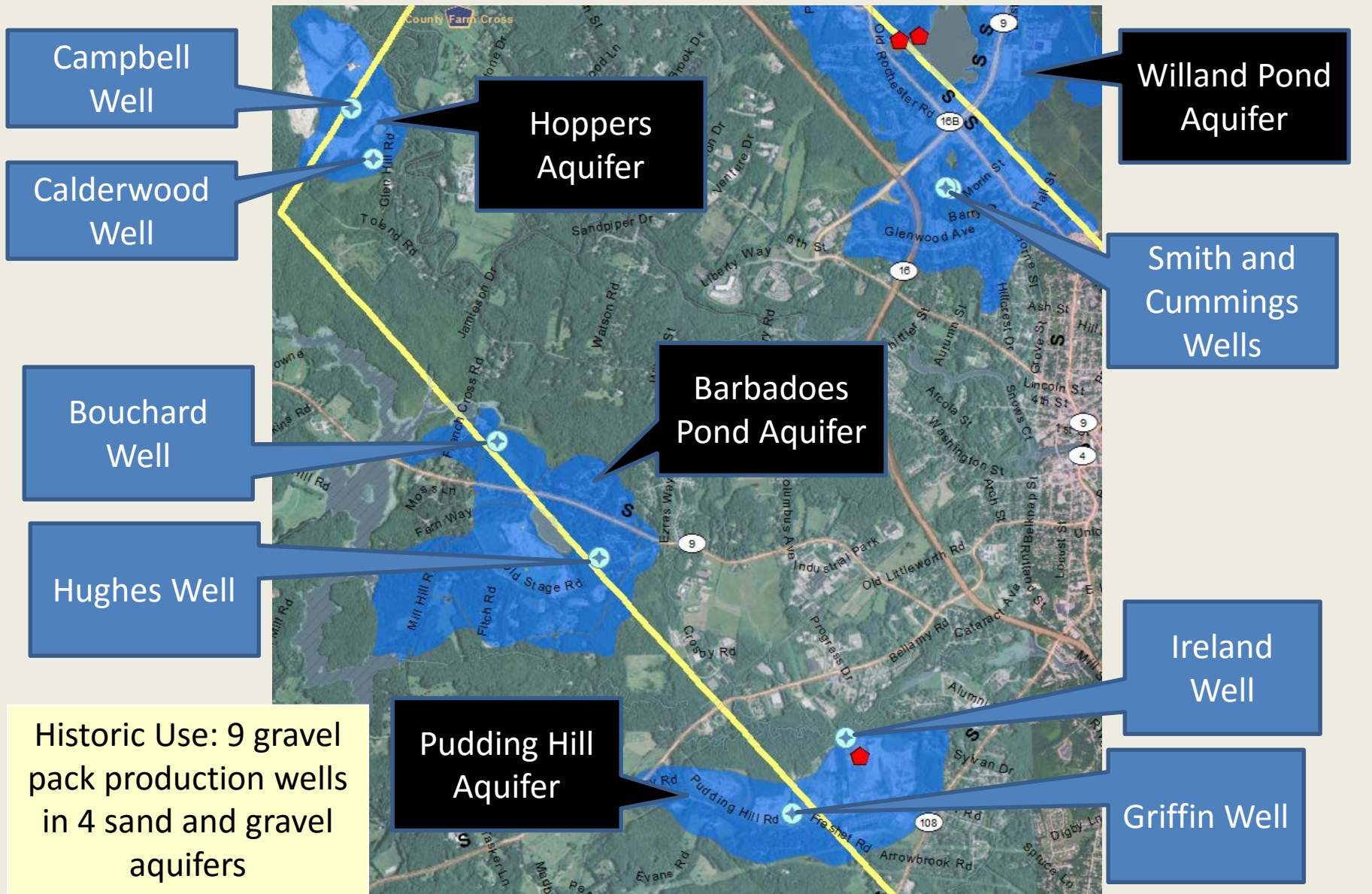
PORTSMOUTH, NH – Due to ongoing dry conditions, the Department of Public Works – Water Division will now be restricting irrigation use. The Water Division is requesting customers refrain from outdoor watering on even-numbered days, and to only water lawns and gardens on odd-numbered days from midnight to 10:00 a.m. (see attached Water Use Restriction sign).

"According to data tracked by the City's water operations staff, river levels are very low for this time of year and the reservoir is also lower than normal," states Brian Goetz, Deputy Director of Public Works. "This is an issue that has grown beyond the Seacoast. The entire state is now experiencing extremely abnormally dry to severely dry water conditions, according to New Hampshire's Department of Environmental Services. While we have experienced recent rain events, the amount will need to be substantial in order to recover from drought conditions. In turn, it is very important that our customers take this seriously and cooperate in being efficient with their water use." City staff will continue to monitor these conditions, but it is likely these measures will be in effect until substantial rainfall occurs and the Seacoast recovers from the current severe drought conditions.

Customers can read the full Water Supply Status Report and details behind the current status at www.cityofportsmouth.com/publicworks (click on "water"), and view current State conditions at <http://tinyurl.com/nhwatereban>. For more information, please contact Brian Goetz, Deputy Director of Public Works at 766-1420.



Groundwater Monitoring Program



Precipitation & Deficit (October 3, 2016)

County	Precipitation (6 months) (inches)	Deficit (6 months) (inches)	Precipitation (1 year) (inches)	Deficit (1 year) (inches)	Deficit (1 year) %
Belknap	14.96	-8.16	30.93	-14.28	32%
Carroll	17.43	-8.22	36.78	-14.00	28%
Cheshire	16.26	-7.72	31.30	-15.57	40%
Coos	20.55	-5.14	37.26	-10.08	22%
Grafton	19.71	-5.75	37.08	-10.89	23%
Hillsborough	13.72	-9.77	29.78	-17.19	37%
Merrimack	14.68	-8.88	30.80	-15.42	33%
Rockingham	12.78	-10.26	30.09	-16.48	35%
Strafford	13.02	-10.49	31.45	-15.76	38%
Sullivan	15.52	-8.11	30.23	-15.14	33%

River Flow

River Flow
Above Average
Average
Below Average
Low
Very Low
Drought

Portsmouth Water System operators track the USGS stream flow gauges in the Oyster River and Lamprey River to assess flow conditions. The monthly mean stream flow in the Oyster River at the USGS gauge was 0.37 cfs in September. This is 5.66 cfs (94%) lower than the 30-year September mean flow rate of 6.0 cfs. **This is the lowest average monthly flow measured for September over the 80-year historic record at this gauge.**

The monthly mean September stream flow in the Lamprey River at the USGS gauge was 5.3 cfs, which is 76 cfs (93.5%) lower than the 30-year September mean flow rate of 81 cfs.

At this time the current river flow rates are considered at **Drought** levels for this assessment. This condition reflect the absence of recharge to the Bellamy Reservoir from its tributaries.

Reservoir Level

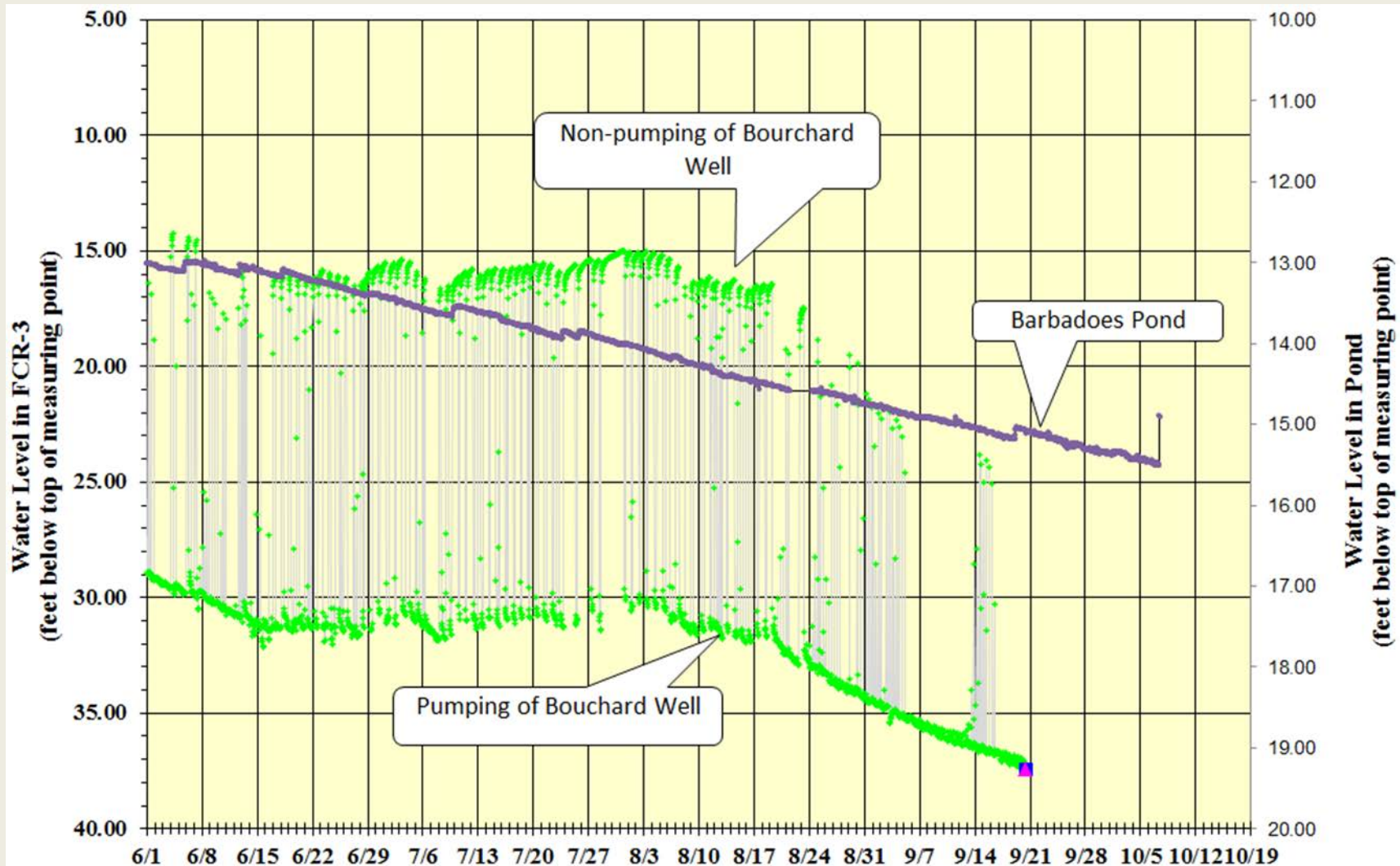
Reservoir Level
Above Average
Average
Below Average
Low
Very Low
Drought

The current stage of the reservoir is considered to be in **Drought** conditions for this time of year.

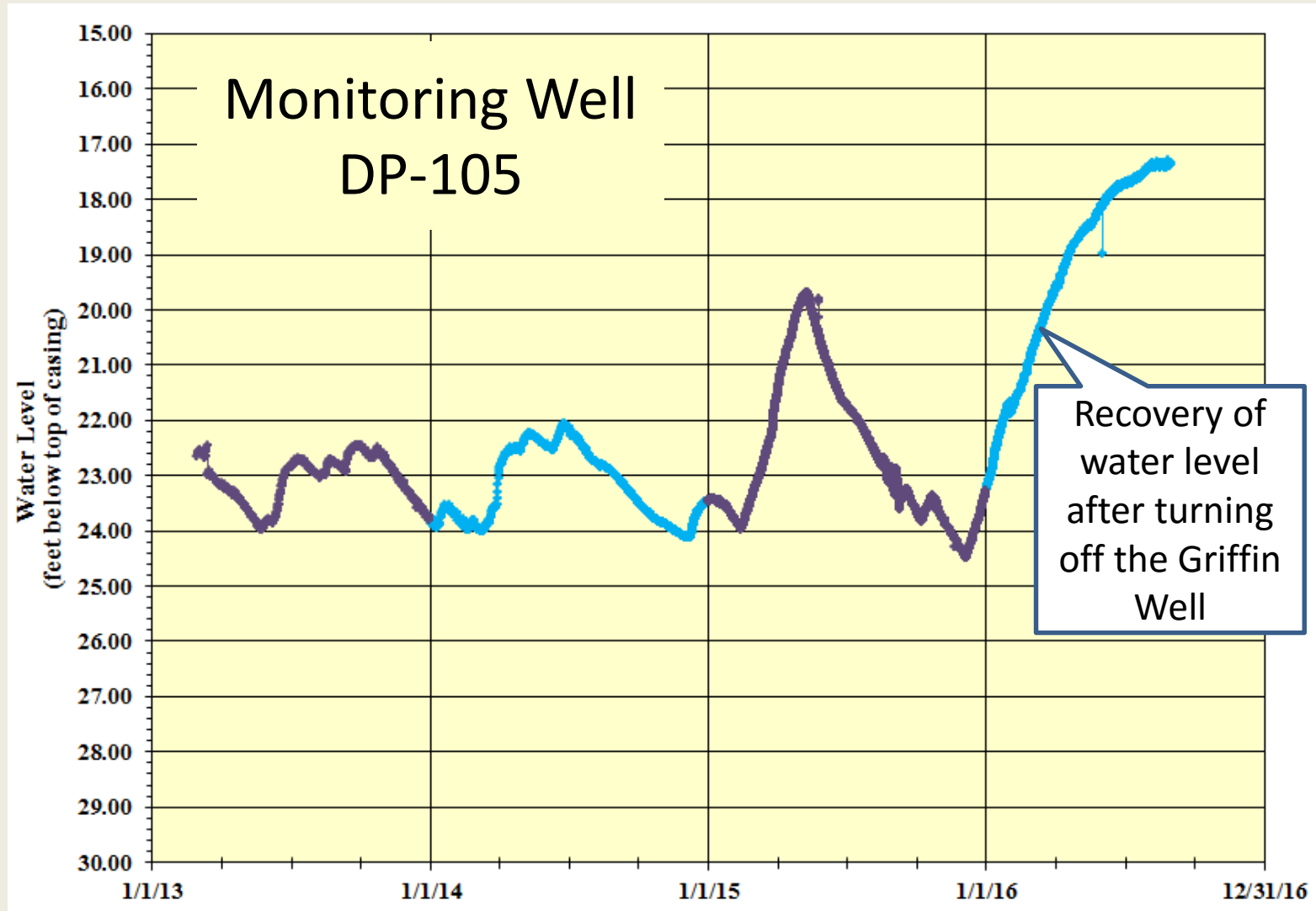
As the surface water source for the Madbury Water Treatment Facility, the Bellamy Reservoir is monitored to assess and predict the overall amount of water available for the Treatment Facility. Reservoir water levels are compared to typical monthly levels to assess the reservoir conditions.

The Bellamy Reservoir ceased flowing over the spillway during the last week of May. This typically occurs at the end of June or early July. This was a result of the deficit in precipitation over the winter and spring. Generally, recharge to the reservoir can occur with storm events that produce substantial runoff from the 22 square mile watershed. Currently the reservoir level is 3.6 feet below the spillway. However, this level is better than it was during the last drought in 2002 when the reservoir was 5 feet below the spillway. This is due to water operations staff reducing the surface water withdrawals and increasing use of groundwater in addition to the reduction in water demand due to the restrictions.

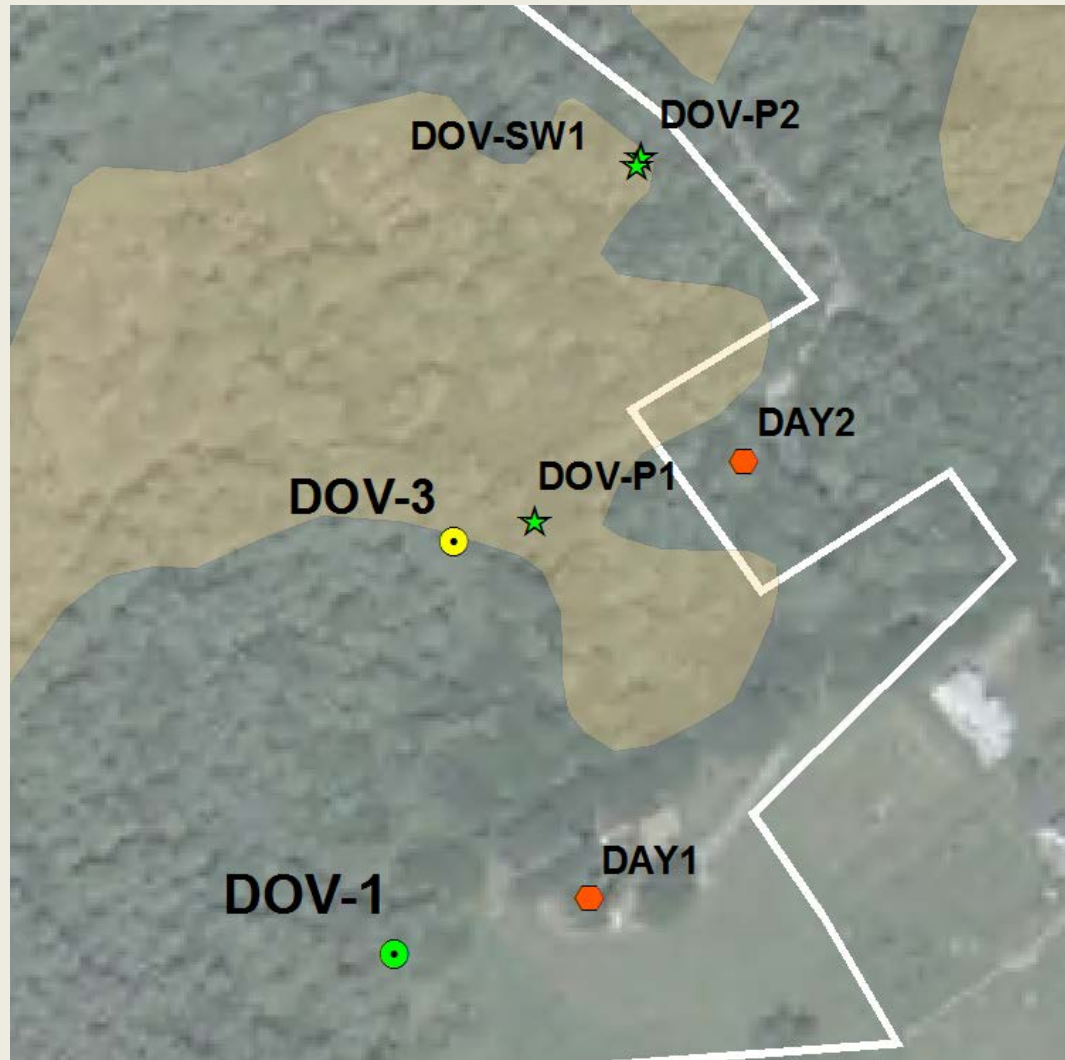
Water levels in Barbadoes Pond and Monitoring Well near the Bouchard Well



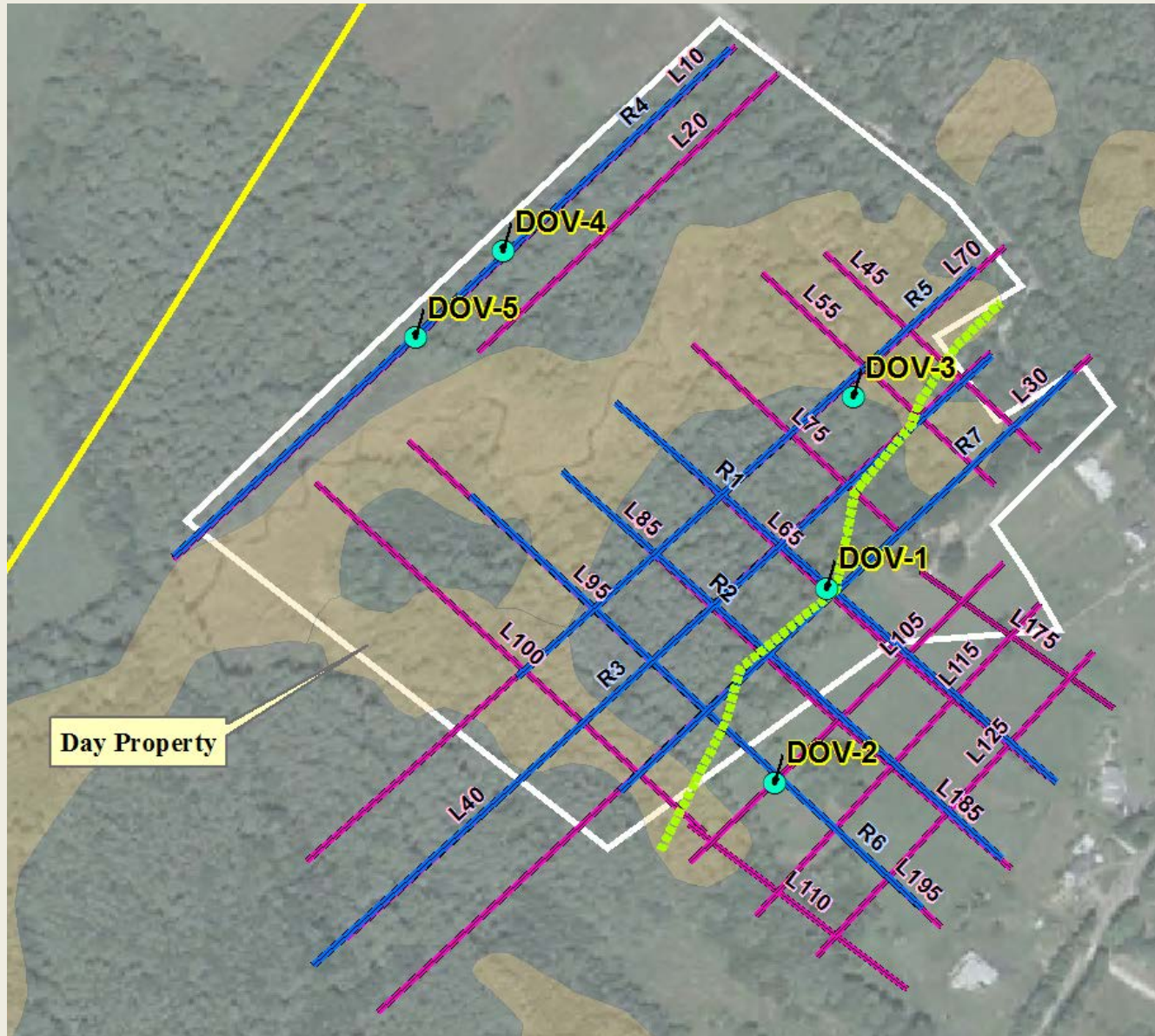
Annual water level variations in the Pudding Hill Aquifer and recovery of water level after turning off of the Griffin Well



Monitoring Sites for the DOV-3 Pumping Test



Geophysical Survey Lines



Geophysical Anomaly

