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TO : Sharon Jackson, Town Manager, Fryeburg, Maine

FROM : Peter Garrett, Hydrogeological Consultant to the Town;
Emery & Garrett Groundwater Investigations, LLC (EGGI)

DATE : September 30, 2015

RE: **Report of Groundwater Conditions in the Wards Brook Aquifer in 2014**

In light of the unusually dry period from November 2012 through October 2013, I discussed climate variability and the possibility of droughts in the Fryeburg region in my last report (dated February 2014). As it turned out, there was an increase in precipitation during and after December 2013, such that the years of 2012 and 2013 were more or less normal years for precipitation and groundwater levels.

Therefore, no drought has been experienced in the Fryeburg area since that experienced in the period 1999-2002. That drought was not monitored in the Fryeburg aquifer because it preceded the period of detailed investigations and groundwater withdrawals by the Fryeburg Water Company (FWC), Pure Mountain Spring (PMS), Nestlé Waters North America, Inc. (Nestlé), and the WE Corporation (WE).

This memorandum focuses on the other end of the spectrum, namely heavy precipitation events and how they might affect water levels in the Wards Brook Aquifer in which the FWC's public water supply wells are located, and out of which groundwater is also withdrawn for sale offsite as bottled water by private companies. As it happens, a storm with exceptionally heavy rainfall was experienced across Maine as this memorandum was being finalized.

Climate Change and its effect on Precipitation

Climate change is considered by many people to be equivalent to "global warming". The impacts of climate change can include a variety of changes regionally and locally. As the average temperature of the earth rises, *regional* increases or decreases in both the average temperature and precipitation will occur.

The 2014 National Climate Assessment states that "between 1895 and 2011, temperatures in the Northeast increased by almost 2°F (0.16°F per decade), and precipitation increased by approximately 5 inches per year, or more than 10% (0.4 inches per decade). The Northeast has

experienced a greater recent increase in extreme precipitation than any other region in the United States. Between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events)... Though projections of precipitation changes are less certain than projections of temperature increases, the frequency of heavy downpours is projected to continue to increase as the century progresses."

Seasonal drought risk is also projected to increase in summer and fall seasons as higher temperatures will result in an earlier spring snowmelt as well as being associated with greater summer evaporation.

Many detailed research papers have been published recently regarding the historical and current trends of a) precipitation, b) wet days (days with the highest 5% of precipitation totals) and c) very wet days (those with the highest 1%). Brown and others (2010) show that for almost all weather stations from Pennsylvania through Maine there has been a very significant rise in all three categories during the period 1951-2005.

Weider and Bout (2010), in their analysis of New England climate anomalies from 1940-2010 note that "during wet periods (positive anomalies) ground water levels follow closely with streamflow and precipitation." However they note that a very different response of groundwater levels occurs during drought periods, with lower levels lagging as much as two years behind dry periods with low precipitation. The reason for this difference is likely due to the fact that during wet periods, aquifers discharge excessive precipitation into adjacent brooks, rivers and lakes. In contrast, during dry periods, the variation in groundwater levels is more muted due to storage of groundwater in the aquifer associated with reduced streamflow during and following droughts. This effect is very variable depending on the specifics of aquifer geometry and associated factors. No such analysis has been conducted on the Wards Brook Aquifer.

Precipitation in Fryeburg

No detailed historical record of precipitation in Fryeburg exists. The nearest weather stations with reasonably long records are East Hiram, Maine for the period 1967-2008, and North Conway, New Hampshire for the period 1975-2010. These records are not "long term" by any definition.

The two precipitation stations closest to Fryeburg, namely the on-site rain gauge located at the Fryeburg Water Company's spring site, and the Fryeburg Eastern Slopes Airport (known by the station initials KIZG), both have relatively short periods of record. For that reason the general conclusions about increased precipitation described above cannot be confirmed for Fryeburg, though it is likely that a similar pattern of precipitation has occurred and is occurring locally.

Average precipitation for Fryeburg according to www.homefacts.com is 45 inches per year. (The average for East Hiram and North Conway for the years those stations were operating was 49 inches.) The on-site gauge routinely registers several inches less precipitation per month than the gauge at KIZG. Precipitation in Fryeburg in 2014 was 43.62 inches at the on-site gauge

and 47.70 inches at the airport KIZG gauge. From this one can conclude that precipitation varies locally in the area surrounding the Wards Brook Aquifer. Higher elevations typically have higher rain and snow falls due to what is known as an orographic effect, and that appears to be true for the Fryeburg area.

Features of Groundwater Levels and Pumping Records, 2014

Groundwater level elevations have been determined on a monthly basis from measurements of water levels in monitoring wells within the Wards Brook Aquifer and surrounding area (Luetje, 2015). Groundwater elevations were within the seasonal limits as reported in previous years and require no additional comment.

Groundwater withdrawals by the two corporations currently withdrawing water for bottling, namely the WE Corporation and Nestlé, are presented in Table 1.

Table 1
Annual Water Withdrawals for Bottled Water
Data sources: WE Corporation* and Luetje reports for Poland Spring and Fryeburg Water Company

Year	WE Corp	Nestle/PMS	Total	gallons per day (gpd)	% of 603,000 gpd
2007		121,557,503	121,557,503	333,034	55.2
2008		109,994,052	109,994,052	301,354	50.0
2009	2,160,555	85,864,456	88,025,011	241,164	40.0
2010	2,444,317	98,919,123	101,363,440	277,708	46.1
2011	3,091,200	73,143,343	76,234,543	208,862	34.6
2012	2,855,800	92,615,024	95,470,824	261,564	43.4
2013	3,220,100	103,499,251	106,719,351	292,382	48.5
2014	4,284,700	97,477,530	101,762,275	278,801	46.2

*The WE Corporation bottles water locally and trucks it out of town.
Nestle trucks water purchased from the FWC out of Town in bulk.
Note that the FWC formerly sold to Pure Mountain Springs.

Table 1a
Water Company Withdrawals for Fryeburg

	gpd
2009	104,631,153
2010	106,278,707
2011	103,982,940
2012	111,686,881
2013	107,189,121
2014	106,278,707

Table 1 shows that groundwater withdrawn for bottled water continues to be less than 50% of the 603,000 gallons per day recommended by EGGI as an allowable amount for bottled water withdrawals. Table 1a shows that the total demand for water to serve domestic needs in Fryeburg has been more or less constant since at least 2009, the earliest date that Fryeburg Water Company figures are available. Emery & Garrett Groundwater's modeling of the Ward's Brook Aquifer (EGGI, 2005) considered withdrawals for the Town's uses to be separate from water withdrawn for bottling. Such withdrawals were not constrained by any limits (though an assumption was made that they would likely increase with time).

Conclusions

The Northeastern US has been experiencing climate changes that include increasing temperatures together with both increasing precipitation totals and the frequency of extreme precipitation events. Increased temperatures will likely be associated with summer and early fall drought periods due to increased evaporation.

Increased precipitation totals and extreme events will likely have little noticeable effect on groundwater levels in the Wards Brook Aquifer because excess groundwater will quickly drain out through Wards Brook. However, the Town should be aware that culverts, for instance beneath the Railroad, Route 113, the snowmobile trail and near the old mill site may require resizing in order to handle the largest storms without erosion of the roadways beneath which water is intended to flow.

Limitations

This report uses data collected by others and makes interpretations based on that data using generally accepted hydrogeological principles. Emery & Garrett Groundwater Investigations, LLC makes no warrantee regarding either data or interpretations.

Bibliographic references

Brown, P.J., R.S. Bradley and F.T. Keimig, 2010, "Changes in Extreme Climate Indices for the Northeastern United States, 1870–2005"; J Climate, Vol 23, p. 6555-6572.

EGGI, 2005, "Groundwater Flow Model, Wards Brook Aquifer, Fryeburg, Maine." Report to the Town, with Figures, Tables, Appendices and Plates.

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National Climate Assessment, 2014, http://nca2014.globalchange.gov/report/our-changing-climate.

Weider K. and D.F. Boutt, 2010, "Heterogeneous water table response to climate revealed by 60 years of ground water data"; Geophysical Research Letters, v 37, L24405.