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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 : February 28, 2014 Peter Garrett

Certified Ground Water Scientists and Professional Engineers
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PETER GARRETT
12/31/03

RE: **2013 Report of Groundwater Conditions in the Wards Brook Aquifer**
Background

In my last report, dated May 2011, I discussed the issue of baseflow in Wards Brook, which drains the Wards Brook Aquifer in which the Fryeburg Water Company (FWC)'s wells are located and out of which groundwater is withdrawn for both Nestlé Waters North America, Inc. (Nestlé) and the WE Corporation.

Baseflow is that portion of streamflow that is due to the relatively slow leakage of groundwater out of adjacent aquifers, in contrast to "quickflow" that is related to rainfall or snowmelt events. As noted in my 2011 report, baseflow in Wards Brook tends to be less variable than in many rivers due to the relatively large area of the Wards Brook watershed underlain by sand and gravel of the Wards Brook Aquifer.

This report focuses on climate variability and the possibility of droughts in the region because the unusually dry period from November 2012 through October 2013 raised some concerns about the long-term sustainability of the Wards Brook Aquifer, particularly in light of the atypical lowering of groundwater levels in the Fall of 2013. As noted below, dry years are recognized as a normal feature of climate systems and, therefore, were factored into the hydrologic modeling of the Wards Brook Aquifer (EGGI, 2005).

2012 and 2013 precipitation compared to previous periods

In order to compare the 2012 and 2013 precipitation amounts to previous years, I used 2012-2103 precipitation data collected at the Nestlé pumping station close to FWC's Wells 1 and 2 (Data was obtained from monthly reports submitted to Nestlé by Lutje Geologic Services (LGS)) and the Weather station for Fryeburg Airport[1] (Station KIZG). Average monthly data

[1] http://www.wunderground.com/history/airport/KIZG/2003/11/1/MonthlyHistory.html

was compiled from the Homefacts[2] website for Fryeburg, Maine (note that the historic data was compiled from a weather station in Brownfield, Maine) and Station KIZG.

The precipitation data compiled suggests that the monthly on-site precipitation for the period of November 2012 through October 2013 was below the historic annual average for Fryeburg (Table 1). Considerably lower precipitation occurred during the months of November 2012 and January, March, April and October 2013. Note that the summer months of May, June and July were somewhat wetter than average.

Table 1

Precipitation at FWC Wellfield
Compared to
Average Monthly Precipitation for Fryeburg, Maine.
November 2012 through October 2013

Month	Year	Average Monthly Precipitation*	On-Site Monthly Precipitation**	Difference
November	2012	4.34	0.84	-3.5
December	2012	5.21	5.76	0.55
January	2013	2.4	1.35	-1.05
February	2013	3.35	2.67	-0.68
March	2013	3.3	0.92	-2.38
April	2013	3.15	1.88	-1.27
May	2013	3.4	4.35	0.95
June	2013	4.12	5.37	1.25
July	2013	3.6	4.98	1.38
August	2013	5.07	4.47	-0.6
September	2013	3.33	3.59	0.26
October	2013	3.76	1.97	-1.79
Total		**45.03**	**38.15**	**-6.88**

* Data source: Homefacts

** Data source: LGS monthly reports

[2] http://www.homefacts.com/weather/Maine/Oxford-County/Fryeburg.html

Historic annual precipitation amounts were compiled to illustrate the year-to-year variability of precipitation (Table 2). These data demonstrate that total annual precipitation in Fryeburg has varied between 27.15 and 56.04 inches between 1999 and 2012. A two year drought extended from late 1999 through 2002. This drought period was followed by two years of about average precipitation (average is 45.03 inches), and then eight years during which precipitation totals were above average (except for 2006-2007).

Table 2
Total Annual Precipitation at Fryeburg Airport
for November through October in previous years

Year	Total Annual Precipitation (Rain and Snowfall) (inches)	% of Average Precipitation (45.03 inches)	Data Source
1999-2000	27.51	**61**	KIZG
2000-01	35.1	**78**	KIZG
2001-02	40.98	**91**	KIZG
2002-03	45.85	**102**	KIZG
2003-04	43.34	**96**	KIZG
2004-05	53.57	**119**	KIZG
2005-06	50.6	**112**	KIZG
2006-07	41.49	**92**	KIZG
2007-08	56.05	**124**	KIZG
2008-09	54.59	**121**	LGS
2009-10	51.34	**114**	LGS
2010-11	56.01	**124**	LGS
2011-12	49.19	**109**	LGS

By comparison, the total annual precipitation at the Nestlé project site during the 2012 to 2013 monitoring period (38.15 inches) was 85% of average. In fact, that 12-month period was the driest year since the FWC started to sell water to Pure Mountain Spring and lately to Nestlé, and since routine water level data collection throughout the Wards Brook Aquifer has been carried out by LGS.

Water Level Variations proximal to the FWC Wellfield

Groundwater level elevations determined from LGS's measurements of water levels in monitoring wells within the Wards Brook Aquifer and upgradient of the FWC Production Wells #1 and 2 are displayed in Figure 1. As would be expected, water level elevations in the monitoring wells higher in the watershed (MW-110 is highest) are higher than those in wells closer to the springs, which emerge in the vicinity of the FWC production wells at an elevation of about 388 feet.

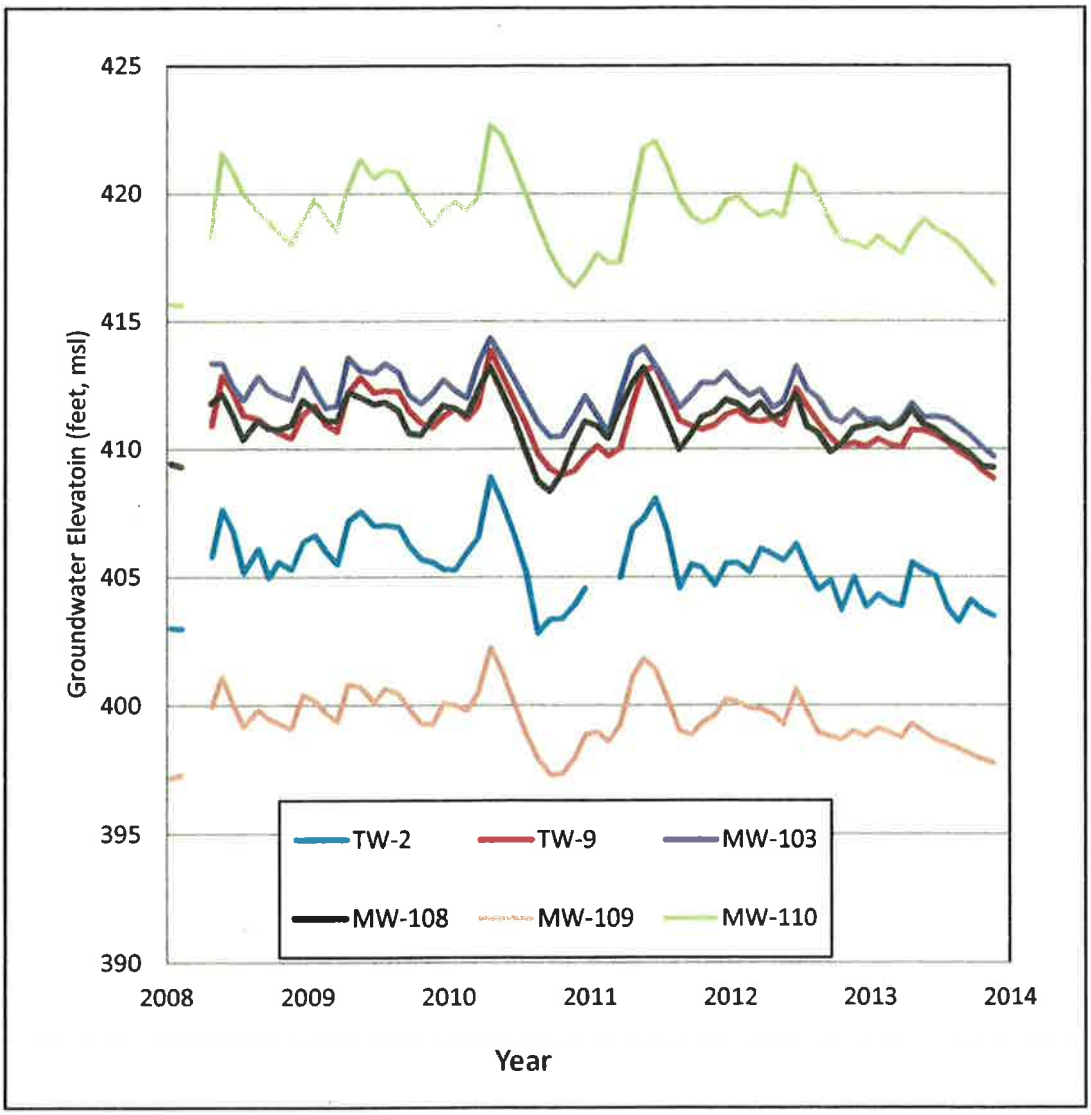

Figure 1: Groundwater Elevation Data Presented for 2/8/2008 to 11/20/2013

From Figure 1, it is clear that groundwater levels in monitoring wells vary seasonally by a few feet, and may change by as much as 5 or 6 feet during a dry spell such as was experienced during the summer of 2010. During most years, water levels rise during the Fall season due to a combination of factors, namely: 1) groundwater recharge from Fall rains, and 2) more recharge is available as evapotranspiration decreases due to falling temperatures and vegetation dies or becomes dormant. In the Fall of 2013, however, due to the lower than average precipitation, there was no seasonal rise in the water table. Instead, groundwater levels continued lower through November, as recorded in all monitoring wells.

Drought

The question these data, as presented, raises is: "Are we experiencing the start of another drought period?" Although the data of Figure 1 for the Fall season of 2013 appear to show the beginnings of a dry period following a dry year, climate and hydrologic conditions can quickly change. In fact, the plentiful rains and then snow of late November 2013 and other precipitation events throughout last winter will likely prove sufficient to recharge the aquifer once again. In other words, groundwater levels are likely to rise to more or less normal levels during the snow melt of Spring season, 2014. In summary, because of the variability of weather events, one cannot predict either the severity or duration of a drought period.

Another reasonable question arising out of this data set might be: "What would the effect of a prolonged drought be on groundwater levels in the Wards Brook Aquifer?" The answer to this question will depend on the amount of precipitation reduction and the duration of the period of low precipitation. Despite the fact that little or no data on water levels in the Wards Brook Aquifer is available for the period of the 1999-2002 drought, an answer to the question can be obtained through numerical modeling of the Aquifer, as conducted by EGGI (EGGI, August 2005)[3].

Groundwater flow models calibrated to known hydraulic conditions, such as those documented during EGGI's 2005 groundwater assessment, can be used to predict conditions that were not observed during the period of time for which the model was calibrated. The results of EGGI's drought assessment were presented and discussed in EGGI's 2005 report. These results suggest that groundwater resources sufficient to meets the needs of the FWC and the bottled water suppliers can be withdrawn from the Wards Brook Aquifer even during drought conditions. A summary of pertinent information concerning the model are presented below.

Conservative Assumptions Incorporated into EGGI's Groundwater Flow Model of the Wards Brook Aquifer

Two conservative assumptions built into the 2005 groundwater flow model are presented below, together with a recommendation supported by the model's conclusions. Insights gained since the model was created are presented in italics.

- **Assumption 1:** That water consumption by residents of Fryeburg would increase steadily from 110 million gallons per year (Mgy) in 2005 to a total of 134 Mgy by 2025. *Data collected by the Fryeburg Water Company show that water consumption has been steady at 110±7 Mgy since 2007 (when reliable data were first collected). FWC does not anticipate a significant increase in water consumption served by the public system given the Town's stable population.*
- **Assumption 2:** That a minimum flow in Wards Brook should be allowed to maintain ecological function in the Brook. *The flow we chose to evaluate this factor as an input for the model was the August baseflow for 2004. Subsequent observations have shown that this data point was slightly above average August flows.*

[3] Emery & Garrett Groundwater, Inc., August 2005, Groundwater Flow Model, Wards Brook Aquifer, Fryeburg, Maine.

- **Recommendation 1:** The model calculated that 804,000 gallons per day (gpd) could reasonably be withdrawn for trucking offsite for the bottled water industry in an average year. To insure continued adequate flows in Wards Brook even during low flow conditions, a 75% safety factor was incorporated into EGGI's 2005 water withdrawal recommendations. This safety factor reduced the maximum recommended withdrawal for bottled water to 603,000 gpd. *Actual groundwater withdrawals have been approximately half of that total since 2005(see Table 3 below). Furthermore, Nestlé has committed to maintaining their current groundwater withdrawals (approximately half of the 603,000 allowable) for the foreseeable future. This commitment was incorporated into their proposed long term contract with the FWC.*

Actual Water Withdrawals

The actual withdrawals by the two corporations that are currently withdrawing water for bottling, namely the WE Corporation and Nestlé, are presented in Table 3.

Table 3
Annual Water Withdrawals for Bottled Water
Data source: WE Corporation 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	95,737,026	98,957,126	296,279	49.1

*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 3 shows that groundwater withdrawn for bottled water has been more or less constant since at least 2007, and that total withdrawals from the aquifer are less than approximately 50% of the 603,000 gallons per day recommended by EGGI as an allowable amount for bottled water withdrawals.

Conclusions

The period from November 2012 through October 2013 was drier than had been observed in Fryeburg over the past 11 years. This resulted in groundwater levels in October and November of 2013 being lower than previously observed. This situation warranted a discussion of the effects of drought conditions on water levels in the Wards Brook Aquifer and a review of the conservative assumptions incorporated into EGGI's numerical model of the Wards Brook Aquifer and recommendations for sustainable withdrawals from the Aquifer. A review of actual annual withdrawals from the Aquifer for bottled water show that they remain close to 50% of the recommended allowable withdrawals for bottled water.

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.