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October 17, 2008

Ms. Sherre Greenbaum, Chairwoman
Wayland Wellhead Protection Committee
161 Plain Road
Wayland, MA 01778

Re: **Capture Zones**
**Wayland Municipal Water Supply Wells**

Dear Sherre:

In accordance with your committee's authorization, we have completed the capture zone analysis of the Town's existing wells. The following briefly summarizes the methodology and results of our analysis. We are also including pertinent data as attachments, and three maps of the capture zones: one with a topographic base map, one with land use and one with zoning. A fourth map shows the surficial geology.

Records Reviewed

Earth Tech/AECOM collected and reviewed records of a hydrogeologic nature dating from the 1940s to the present. These included:

1. Pumping test records of all wells, except for Meadowview (which were not available). Pumping test data were analyzed to determine aquifer hydraulic characteristics, namely transmissivity and hydraulic conductivity.
2. Well drilling records. Test well drilling records were used to understand the stratigraphic conditions.
3. Consultant reports. These included reports completed by GZA, IEP, Anderson Nichols, D.L. Maher Co., and Geosphere. All of these reports, except for the D.L. Maher report, were available from the Wayland Water Department.
4. Masters Thesis, "The Groundwater Resources of Wayland, Massachusetts", by Richard L. Fortin, 1981.
5. Published U.S. Geological Survey surficial geologic mapping.
6. Other miscellaneous records.

Summary of Geologic Conditions

The Sudbury River is the predominant physiographic feature in Wayland. In general, the land surface slopes gently from the river valley along the Town's western boundary to a number of low hills in the eastern part of Town. The soils in Wayland are largely glacially derived. Whereas the eastern hills are largely underlain by glacial till and bedrock, the remainder of town is underlain by stratified drift consisting of layered sand, gravel, silt and clay. The glacial till and bedrock are typically viewed as

"non-aquifer areas", whereas the stratified drift is considered generally as "aquifer areas". The aquifer areas are made up generally of sandy or gravelly soils. However, nearest the Sudbury River and its flood plain, fine-grained soils, such as clay, silt and fine sand are present. These fine-grained soils may be discontinuous laterally, and may be present close to the surface but underlain by sand and gravel.

Based on the geologic and pumping test records, it appears that the Happy Hollow and Baldwin Pond Wells are located in areas where the soils consist largely of sand and gravel, with no significant overlying layers of fine-grained soils. Such aquifers are termed "unconfined aquifers" because flow of groundwater is not restricted vertically by a "confining layer" of clay or fine-grained soil. The Campbell Road well, in contrast, exists under confined conditions because a layer of fine sand and clay, approximately 50 feet thick, overlies the sand-and-gravel aquifer, which is only 15 feet thick or so. The Chamberlain well exists under partially confined conditions, as a few layers of clay are reported at the well, but in other areas nearby, no clay is reported.

Capture Zone Methodology

Capture zones were delineated largely using pre-existing data. Detailed groundwater elevation contours indicating groundwater flow were taken from IEP (1987, Aquifer Mapping Project, Town of Wayland, MA). These show that, in general, groundwater flows from the east to the west toward the Sudbury River. Earth Tech/AECOM analyzed existing pumping test records to determine aquifer transmissivity for all wells except Meadowview Well. Since we were not able to identify any pumping test records for Meadowview, we relied on the report of a previous consultant for a transmissivity value. Rather than assume Zone II pumping conditions, we assumed average pumping conditions for the period 2001 to 2007, as reported to us by the Wayland Water Department. For purposes of this study, average conditions are more realistic. For Zone II, one assumes that the well is pumped at its full capacity, 24 hours per day for 180 days with no rainfall recharge. As a result, the capture zones delineated under this study are considerably smaller than the Zone IIs.

We began the capture zone delineation process by determining the "downgradient stagnation point", which is the theoretical downgradient capture distance. The stagnation point is computed as follows:

$L = Q/2\pi Ti$, where

L = the downgradient stagnation point, in feet
Q = pumping rate, in $ft^3/day$
T = Transmissivity, in $ft^2/day$
i = groundwater gradient

For each capture zone analysis:

Q is the average pumping rate, 2001-2007
T was determined as described above, and
i was interpreted from the regional groundwater contour mapping completed by IEP (1987)

The downgradient stagnation point was plotted for each well. From the downgradient stagnation point, the downgradient boundary was extended north and south of each well through the aquifer area, then upgradient perpendicular to the groundwater contours.

Once the capture zone was delineated for each well, we checked the reasonableness of the size of the capture zone through a simple validation step, as follows. We first determined the area of the capture zone, A, in square miles. We then applied a rainfall recharge rate, R, of 0.8 million gallons per day per square mile (MGD/mi$^2$). Multiplying A by R, we computed the theoretical volume, V, of water recharged to the capture zone on a daily basis. This volume, V, should be roughly equal to the daily volume pumped, P, from each well.

Capture Zones

The capture zones are shown on three maps:

1. Topographic base map with groundwater elevation contours
2. Land Use base map
3. Zoning base map

Water Quality Issues – Happy Hollow Wells

There are a number of activities in the capture zone for the Happy Hollow wells that are cause for concern with respect to water quality:

1. The Wayland High School has a large septic system reportedly 530 feet from the wells. Aside from domestic wastewater, the septic system has received other wastes from the chemistry labs, photo-processing room, art room, and boiler room. The most recent water quality for Happy Hollow indicates a nitrate level of 2.5 mg/L. This is perhaps related to the school septic system as well as other septic systems to the east, including the Dudley Pond area. The drinking water standard for nitrate is 10 mg/L, however, DEP normally increases the frequency of monitoring when the nitrate level exceeds 5 mg/L.
2. The Massachusetts Department of Environmental Protection (DEP) requires ownership or control of all land within 400 feet of the well, known as Zone I. DEP requires that there be no activity in Zone I except for those related to water supply. We note several unrestricted activities in Zone I, including parking areas, recreational areas, and uncontrolled activities in the former gravel pit.
3. The High School has at least one underground fuel storage tank (UST) on site, installed in 1991. While the UST has the required alarms for detecting leakage, two consultant reports indicate that these are not in working order. A new football field has been constructed with artificial turf. The impact of the turf on water quality, if any, has not been examined.
4. The intermittent stream that passes directly to the north of the Happy Hollow wells receives drainage from unknown or uncontrolled sources. It is our understanding that this drainage is going to be re-routed outside of Zone I. Other road drainage from Route 126 is reportedly routed to catch basins in the capture zone for Happy Hollow.
5. The capture zone delineated for Happy Hollow represents a preliminary representation of the area that contributes most of the recharge to the wells.

6. In summary, there are a number of activities in the capture zone of the Happy Hollow wells, some in Zone I, which cumulatively degrade or threaten the quality of well water. In an ideal world, there would be no human activity in the capture zone. However, these wells were built decades ago, when the land was less congested and before widespread recognition of the vulnerabilities of groundwater supplies. Additional studies should be undertaken to define the capture zone with more precision and to evaluate potential sources of well contamination in more detail.

It has been a pleasure to assist the Wellhead Protection Committee on this important project.

Very truly yours,

Earth Tech|AECOM

Douglas DeNatale,
Project Manager/Senior Hydrogeologist

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| Well ID | Calculated Transmissivity ($ft^2$/day) | Hydraulic Gradient | Pumping Rate (gpm) | Computed downgradient stagnation point (ft, | Theoretical Contributing Area (sq. miles)* | Mapped Contributing Area (sq. miles) |
|---|---|---|---|---|---|---|
| Happy Hollow #1 | 13,800 | 0.017 | 234 | 31.2 | | |
| Happy Hollow #2 | 12,000 | 0.017 | 376 | 57.7 | | |
| Happy Hollow (Combined) | 13,200 | 0.017 | 610 | 85.1 | 1.10 | 0.75 |
| Meadowview | 6,685 | 0.001 | 82 | 350.5 | 0.15 | 0.15 |
| Baldwin #1 and #2 | | 0.005 | 145 | | | |
| Baldwin #3 | 19,750 | 0.005 | 165 | 54.1 | | |
| Baldwin (Combined) | 19,750 | 0.005 | 310 | 101.8 | 0.56 | 0.46 |
| Chamberlain | 9,320 | 0.012 | 185 | 53.2 | 0.33 | 0.30 |
| Campbell | 19,900 | 0.003 | 102 | 51.0 | 0.18 | 0.39 |

*Based on 0.8 MGD per square mile for areas underlain by sand and gravel.

**Average Pumpage from Wayland Wells 2001 - 2007**

| Well ID | Pumpage in MGY for the Year Shown 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Total | Years | Yearly Average MGY | Daily Average GPD | Daily Average GPM | Daily Average ft3/day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baldwin #1 and #2 | 84 | 90 | 62 | 71 | 74 | 0.1 | 0 | 381.1 | 5 | 76 | 208822 | 145 | 27917 |
| Baldwin #3 | 92 | 84 | 64 | 93 | 86 | 73 | 114 | 606 | 7 | 87 | 237182 | 165 | 31709 |
| Campbell | 42 | 84 | 52 | 53 | 8 | 48 | 88 | 375 | 7 | 54 | 146771 | 102 | 19622 |
| Chamberlain | 112 | 73 | 70 | 81 | 128 | 121 | 95 | 680 | 7 | 97 | 266145 | 185 | 35581 |
| Meadowview | 51 | 0.5 | 0.8 | 4 | 29 | 0.9 | 0 | 86.2 | 2 | 43 | 118082 | 82 | 15786 |
| Happy Hollow #1 | 124 | 149 | 127 | 83 | 108 | 129 | 142 | 862 | 7 | 123 | 337378 | 234 | 45104 |
| Happy Hollow #2 | 233 | 203 | 215 | 172 | 162 | 201 | 199 | 1385 | 7 | 198 | 542074 | 376 | 72470 |

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