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BY ELECTRONIC MAIL: peggywn@aol.com
and FIRST CLASS MAIL

Carlisle Board of Appeals
56 Westford Street
Carlisle, MA 01747

RE: 100 Long Ridge Road

On behalf of Horsley Witten Group, Inc. and for the neighbors and abutters to the 100 Long Ridge Road development project ("Project"), I have reviewed the proposed plans, supporting documents, and the proposed Groundwater Impact Analysis prepared by NGI dated September 15, 2014 for the Project. I offer the following comments:

1. Nitrogen Loading Analysis: The proposed nitrogen loading analysis will utilize an oversimplified dilution model by aggregating all of the nitrogen sources in the development and dividing by total amount of recharge on the property. This will estimate an average nitrogen concentration if all of the groundwater underlying the property were evenly mixed (which it will not be) but will not identify nitrogen concentrations at specific locations downgradient of the property including the neighboring private drinking water wells. DEP's nitrogen loading policy also identifies nitrogen sensitive areas where there are private wells. This requires a more detailed computation of nitrogen concentrations at the downgradient property boundary rather than average (fully mixed) conditions. This analysis requires a more specific flow-net analysis that includes only that groundwater recharge that mixes with the wastewater effluent (and other nitrogen sources) before it reaches the downgradient property line.

   This same concern was identified in the Coventry Woods 40B proceedings and was addressed by the town's consultant, James Vernon of ENSR. In his April 19, 2007 Memorandum (copy attached), Dr. Vernon questioned the applicants' consultant's analysis - "is it reasonable to assume that infiltrated wastewater will fully mix with groundwater before exiting the site?" (page 3 of Memo).

2. Pathogens Analysis: The proposed study identifies fractured rock wells as a component of the study. The attached Table 1 summarizes hydrogeologic data on 19 wells in the vicinity that show an average depth of 9.5 feet to bedrock and shallow depths to groundwater (5-12 feet in several cases). It is our understanding that the drinking water

wells in the neighborhood are predominantly bedrock wells. Groundwater flow through fractured bedrock is significantly more complicated than the proposal suggests. Groundwater flow rates and pollutant transport rates can be considerably faster in fractured rock flow than compared to flow in porous media such as sand and gravel. To accurately predict the direction and rate of groundwater flow and probable transport routes for pollutants the orientation and location of fractures need to be identified. This can be accomplished through fracture trace (lineament) analysis or the use of tracers such as dyes. The proposal does not provide any information about how this type of flow and fractured rock will be evaluated or accounted for.

This same concern was identified in the Coventry Woods 40B proceedings and was addressed by the town's consultant, James Vernon of ENSR. In his April 19, 2007 Memorandum, Dr. Vernon recommended "elements for hydrogeologic assessment including a bedrock analysis that included "lineament analysis, tracer tests, and the use of fluorescent dyes to assess the hydraulic connections between the site and the homeowner's bedrock wells" (pages 2-3 of the Memo).

Coincidentally, I consulted for the neighbors and abutters to the proposed Coventry Woods project in 2006-2007, and am familiar with the details of that proposal. The groundwater protection issues presented in the Coventry Woods application are substantially the same as are presented here. In my opinion the Board was correct to accept Dr. Vernon's proposed scope of study and to impose it as a condition on the Coventry Woods project. In my opinion, that scope of study should be applied in substantially the same form here. There would be no scientific justification to apply a different testing protocol here as the factual circumstances are not materially distinguishable.

3. Private Well Impacts from Groundwater Withdrawals: The proposed Quantity Wells analysis (item #2) proposes to test wells within 500 feet of the proposed well. This analysis could be expanded to additionally locate all private wells within 500 feet of the downgradient side of the subject property. This would allow for a more meaningful nitrogen and pathogen impact study. The applicant should also document groundwater flow directions throughout the property to identify downgradient areas.

4. Groundwater Mounding: The proposed groundwater mounding analysis should incorporate the cumulative effects of both stormwater infiltration and wastewater disposal. These effects are additive and cumulative. Stormwater mounding should incorporate both long-term (steady state) and short term, rainfall event based impacts, both of which should be added to the mounding that will result from the wastewater disposal.

This same concern was identified in the Coventry Woods 40B proceedings and was addressed by the town's consultant, James Vernon of ENSR. In his April 19, 2007 Memorandum Dr. Vernon which states, "as suggested by the Horsley Witten Group (letter to Carlisle ZBA dated 12/18/06), effects due to stormwater infiltration should also be considered" (page 3 of the Memo).

Please call me with any questions regarding these comments.

HORSLEY WITTEN GROUP, INC.

Scott W. Horsley
Principal

MEMORANDUM

TO: Carlisle Zoning Board of Appeals
FROM: James H. Vernon, Ph.D., ENSR Corporation
DATE: 4/19/07
SUBJECT: Coventry Woods Septic System C - Recommended "Hydrogeologic Assessment"

INTRODUCTION:

ENSR's approach to the Hydrogeologic Assessment for Coventry Woods Septic System C is based on the question: Will the proposed septic system have adverse impacts on abutters' water supply wells?

Three key factors make this situation unique and lead ENSR to conclude that site-specific hydrogeologic investigations are required that may be more stringent than those that are considered standard in order to address this question. The factors are:

- Two domestic wells (Epstein/Stone and Breuing/Kummer) are located on abutting properties proximal to the proposed leach field.
- ENSR's understanding is that the wells are completed in bedrock, and thus potential impacts are more difficult to predict than for receptors located in overburden.
- There is no Town water system to which the homes could be connected in case the wells are negatively impacted. This places an extra burden on hydrogeologic studies intended to predict the impact on the wells. This may make it more critical to demonstrate that the wells are "safe".

NOTES:

1. These recommendations are derived from the Massachusetts Department of Environmental Protection (DEP) "Guidelines for Title 5 Aggregation of Flows and Nitrogen Loading" (Guidelines) and what ENSR has learned to date regarding the Coventry Woods site.

2. ENSR has reviewed a report entitled "Hydrogeologic Evaluation – Sewage Disposal System C" by Stamski and McNary dated March 9, 2007 (report). ENSR provided a review of the report in a Memorandum to the Carlisle ZBA, dated 3/28/07. The Memorandum enumerated Major Concerns, Minor Concerns, and Conclusions.

3. ENSR also has received certain letters, memoranda, and other documents submitted by the Board of Health, Scott Horsley, and others between November 27, 2006 and March 12, 2007, which are pertinent to these recommendations. The Carlisle Board of Health has issued a number of specific recommendations and has stated its anticipated requirements should it review a Title 5 permit application for Septic System C. The Board of Health has indicated clearly that more data are needed and that a hydrogeological analysis should be performed.

RECOMMENDED ELEMENTS FOR HYDROGEOLOGIC ASSESSMENT:

I. Borings/Shallow Monitoring Wells/Shallow Groundwater Flow Direction Determination – Drill borings at Septic System C site and describe the drilling samples; construct a minimum of 3 shallow, screened, and developed monitoring wells (screens below or at the water table); estimate saturated thickness in overburden and depth to bedrock (may require a drilling method that can penetrate glacial till); survey the wells (determine elevation of a measuring point on the well casing); measure water levels and convert to sea level elevation; plot results on map and estimate flow direction. A geologist or hydrogeologist should be on site during the boring; he/she should collect and describe drilling samples in order to characterize subsurface geology.

CMG (letter to Carlisle ZBA dated 11/27/06) also advised that monitoring wells be installed and used to determine ambient groundwater flow direction. Current information is inadequate to resolve conflicting interpretations regarding the ambient groundwater flow direction.

This geologic information should be synthesized with test pit information provided in the Stamski and McNary report, published soils mapping, and published surficial geologic mapping.

II. Basic Bedrock Study – Desktop analysis, plus one field visit will provide basic geologic information on the bedrock in the area. The following tasks should be included.

- Compile and assess published bedrock geologic mapping;
- Conduct airphoto lineament analysis (must be performed by an experienced analyst) on stereo pairs of at least two different dates and scales of air photographs;
- Perform on-site geologic reconnaissance and bedrock outcrop fracture measurement (strike, dip, morphology – must be performed by a qualified bedrock geologist), analyzing the results and synthesizing with the published information and air photo work;
- Try to obtain drilling records and pump setting information for abutters' wells.

These elements are critical, assuming the homeowner wells are completed in bedrock and are receiving their water from bedrock fractures. The only **exception** to the need for such a basic bedrock study, in ENSR's opinion, would occur if an areally-extensive clay layer is found in the overburden, located above the bedrock, but below the proposed leach field for Septic System C.

III. Soil Evaluation in accordance with Title 5 Requirements – This has been done using existing test pit data provided in the report. Results could be confirmed or expanded based on the results from the boring descriptions in item I.

IV. Determination of Seasonal High Groundwater in Accordance with Title 5 Requirements – This has been done using existing test pit data (report). Note that the test pit data used for this determination are not suitable for mapping groundwater contours or determining groundwater flow direction.

V. Determination of Aquifer Parameters Sufficient for Calculation of Mounding Potential – Specific data gathering needs depend on the type of mounding analysis to be conducted. The usefulness of the model results depends, among other things, on the reliability of the aquifer parameters that are input. In general, the following items will be needed:

- *K estimate:* The report provides hydraulic conductivity estimates based on published soil mapping. These estimates may be sufficient. However, if the proposed mounding calculation has more stringent requirements, additional methods for determining hydraulic conductivity may be required. Results of sensitivity analyses for the selected mounding analysis should indicate whether existing hydraulic conductivity estimates are sufficient.
- *Saturated thickness of the "aquifer":* This can be estimated from item I, above. If the sandy loam and loamy sand soils on site (per the report) are seasonally unsaturated, then the borings will have to be installed deep enough to characterize the subsurface "aquifer". (Saturated thickness estimates provided in the report should not be used for the mounding analysis, as these were estimated based on soil mottling and not on observed groundwater at any given time and as discussed in ENSR's 3/28/07 Memorandum.) It is possible that year-round saturated thickness above the bedrock is zero.
- *Conceptual hydrogeologic model:* This will govern the general model setup, boundary conditions, etc. The conceptual hydrogeologic model should be developed from information in the report and from new information gathered during the Hydrogeologic Assessment tasks outlined above.
- *Water level measurements:* Water levels measured in surveyed monitoring wells (item I) will be needed to calibrate the model.

ENSR notes that the Hydrogeologic Assessment should be used to guide the other elements of a "Site-Specific Mass Balance Analysis" (Guidelines, p. 8). The Coventry Woods proposed Septic System C meets the criteria for which the Mass Balance Analysis may be required unless the Hydrogeologic Assessment clearly indicates that sensitive receptors (in this case, homeowner wells) will not be affected. In addition to the Hydrogeologic Assessment, the following elements are part of a Mass Balance Analysis:

- **Mounding Analysis** – not presented in report; should be performed and presented; in addition to presenting the results, the applicant should clearly explain the method or model used and the assumptions involved; in light of the site conceptual hydrogeologic model developed as part of the Hydrogeologic Assessment, the degree to which the method assumptions are violated should be discussed, along with the implications. The Carlisle Board of Health (Memo dated 1/26/07 to ZBA) anticipates requiring such an analysis. Further, the Board of Health (Memo to ZBA dated 3/1/07) anticipates requiring a three-dimensional model for the analysis.

  As suggested by the Horsley Witten Group (letter to Carlisle ZBA dated 12/18/06), effects due to storm water infiltration should also be considered. If the ambient groundwater has a component of flow from Septic System C toward an existing homeowner well, the mounding analysis should include an estimate of the water level increase to be expected at the location of the existing well, as suggested by the Horsley Witten Group (12/18 letter).

- **Nitrogen Analysis** – the report contains a nitrogen analysis. The analysis itself follows the Guidelines. The applicability of the analysis assumptions to the site should be discussed. For example, is it reasonable to assume that infiltrated wastewater will fully mix with groundwater before exiting the site?

- **Groundwater Monitoring Program** – see below.

WHAT WILL THE RESULTS MEAN, AND WHAT ARE THE NEXT STEPS?

The results of this investigation may indicate that an adverse impact is likely, that it is uncertain whether there will be an adverse impact, or that an adverse impact is unlikely. Depending on those results, one or both of the following additional steps may be taken:

- **Advanced Bedrock Study** – To augment the Basic Bedrock Study (item II, above), the next step would be to assess whether there is a hydraulic connection between the site of proposed Septic System C (in the overburden) and the homeowners' bedrock wells. This could be done with injection tests and water level monitoring or with tracer tests and water level monitoring. (There are also other possible approaches.) For the tracer tests, nested pairs (one in overburden and one in bedrock) of monitoring wells should be drilled along the property line for sampling and water level measurements during the test (to avoid risking saline water or fluorescent dyes reaching the homeowner wells during the testing, even though these are non-toxic). It may also be prudent to try to evaluate travel time of groundwater (and possible pathogens) through bedrock, as recommended by Horsley Witten Group (letter to Carlisle ZBA dated 12/18/07).

- **Long-Term Monitoring** – To mitigate risk that may remain even if the above studies do not indicate a clear threat, long-term monitoring could be required as a permit condition. Nested pairs of monitoring wells could be installed along the property line between Septic System C and the homeowner wells also suggested by CMG, 11/26/06 letter to Carlisle ZBA; Horsley Witten Group, 1/11/07letter to Carlisle Board of Health). Water levels could be monitored with data loggers, and water samples could be collected periodically. These results could be used to verify predictions of the mounding and nitrate analyses, as well as to sample for bacteria and viruses. The wells could serve as sentry wells that might provide a warning before contamination reached the homeowner wells.

Conduct of long-term monitoring implies that actions would be taken if monitoring demonstrates or

predicts an adverse impact to nearby homeowner wells. ENSR notes that since there is no existing public water system to which the homes could be connected and since it is unknown whether a replacement well that meets all setback requirements and is not adversely impacted can be sited if necessary, options would be limited. ENSR recommends that a contingency plan be developed in case of adverse impact to a homeowner well.