Nobis
Engineering a Sustainable Future

February 20, 2015
File No. 89220
Via Email and U.S. Mail

Town of Carlisle, Zoning Board of Appeals
ATTN. Steve Hinton
66 Westford Street
Carlisle, MA 01741
shinton@mindspring.com

Re: Phase 1 Report
Independent Hydrogeologic Study
100 Long Ridge Road, Carlisle, MA

Dear Mr. Hinton:

Nobis Engineering, Inc. (Nobis) is pleased to present this Phase 1 Report to the Town of Carlisle Zoning Board of Appeals ("Town") as part of an independent hydrogeologic study of potential impacts related to a proposed 40B housing development on the Brem property located at 100 Long Ridge Road (site; a.k.a. "The Birches") in Carlisle, Massachusetts ("Site"). (See Figure 1.) The Site is Carlisle tax lot 1-72-33K (with the recent subtraction of a lot for a new home at 90 Long Ridge Road). This Report is the primary deliverable item for Phase 1 of the project under Nobis' contract with the Town, dated January 13, 2015 and signed by the Town on January 14, 2015 (Town of Carlisle ZBA document # BREM_151 01.14.2015). The Scope of Work is included in the contract.

Nobis understands that the Site is proposed for development by a private owner (Jeffrey Brem of Lifetime Green Homes) and that the Town's concerns include potential impacts of proposed, on-Site, wastewater disposal systems on proposed on-Site and existing off-Site drinking water wells, and potential interference (yield and water level) effects between the new wells and the existing abutter wells. Also, potential interference effects between the proposed new wells are a concern.

1.0 BACKGROUND

Lifetime Green Homes, LLC (LGH) submitted a 40B housing approval application ("LGH application"; BREM_001 07.03.2014) to the Town on July 2, 2014. Nobis has received an updated Site plan from the Town (prepared by LGH, dated November 14, 2014; BREM_127 12.08.2014) which depicts 19 proposed residences and one existing residence to be served by a septic system consisting of three septic disposal areas and eleven drinking water wells (Figure 2). The Site plan also depicts an existing drinking water well (shown on Figure 1) on abutting property, located at 132 Long Ridge Road, west of the Site; earlier maps reviewed by Nobis and provided by the Town indicate that at least one other existing drinking water well is present on an abutting lot, located at 200 Long Ridge Road, southwest of the Site. Additional wells on abutting and nearby properties are discussed below.

Nobis understands that the Town has retained Nitsch Engineering of Boston and GeoHydroCycle, Inc. (GHC) of Newton as peer reviewers for the LGH application and related submittals. The Town provided to Nobis GHC's reviews (including BREM_082 10.21.2014; BREM_107

Nobis Engineering, Inc.
18 Chenell Drive
Concord, NH 03301
T (603) 224-4182

11.24.2014; BREM_139 12-24-2014; BREM_152 01.14.2014) of the application and related submittals. Nobis further understands that Site property abutters retained Hill Law of Cambridge and the Horsley Witten Group of Sandwich to review the LGH application and related materials. The Town provided Horsley's reviews (including BREM_076 10.03.2014 and BREM_081 10.17.2014) of the application and related materials to Nobis. LGH has retained Northeast Geoscience, Inc. (NGI) of Clinton as a hydrogeologic consultant, and some information prepared by NGI (e.g. BREM_080 10.14.2014) is also available on the Town's website. Numerous other documents related to the project are available on the Town's website (see below).

Nobis understands that the objectives of the independent hydrogeologic study include the following:

- Assessment of potential impacts of the proposed Site septic system on proposed Site and existing drinking water wells at abutting Site properties
- Assessment of potential impacts of proposed drinking water wells on existing drinking wells at abutting properties;
- Assessment of potential impacts of proposed drinking water wells on each other, and,
- Evaluation of actions intended to reduce the impacts or risks of impacts to acceptable levels.

Specific objectives of Phase 1 include an assessment of existing information, identification of data needs, a reconnaissance site visit, performing initial "desktop" hydrogeologic investigations (including a photolineament analysis), preparing a Phase 1 report, providing cost estimates for filling data and analysis needs, and providing technical support at a meeting. All objectives except the last are addressed in this Phase 1 report. Additional technical objectives may be developed during the course of the project and will be addressed in Phase 2 or subsequent Scopes of Services.

2.0 PHASE 1: BACKGROUND INFORMATION REVIEW AND SITE WALK -- RESULTS

The results of Nobis work on Phase 1 follow, organized by the tasks as numbered in our January 13 proposal.

Task 100: Obtain and Review Background Information

Nobis has assessed hydrogeologic information provided by the Town or available on the Town's project website regarding the Site septic system and the location of proposed and existing drinking water wells. This information includes submittals by the applicant (LGH), the Town's peer reviewers, and the abutters' consultants. Many of the items consist of plans and recommendations for work yet to be done; relatively few hydrogeologic or geologic results are contained in the Town's files as of February 13, 2015.

A letter, dated October 2, 2014 (BREM_072 10.02.2014; this report, Attachment A), from the Carlisle Board of Assessors (BOA) to Jeffrey Brem defines abutters as owners of properties within 300 feet of the Site lot lines and lists 21 such abutters. One of these is the Town of Carlisle; the other 20 abutters (shown on Figure 1) are presumed to have homes with domestic water supply wells. Because impacts due to the proposed wells and septic system disposal areas could

other 20 abutters (shown on Figure 1) are presumed to have homes with domestic water supply wells. Because impacts due to the proposed wells and septic system disposal areas could possibly extend beyond 300 feet, Nobis will not necessarily limit our assessment to wells on the 20 official abutters' properties.

Nobis has also reviewed existing records on abutters' wells and other wells in the area, provided by the Carlisle Board of Health (BOH) and in a letter report by NGI entitled "Groundwater Impact Analysis" and dated September 15, 2014 (BREM_080 10.14.2014). All of the wells known in the area are drilled into bedrock, with casing extending through the overburden and several feet into bedrock. The total depths of the wells are between 110 feet and 710 feet, with depth to bedrock (overburden thickness) ranging between 4 and 25 feet in the area. Because outcrops are present (see Task 300 results), overburden thickness is zero in some places, so the overall range is 0 to 25 or more feet.

Accurately characterizing overburden thickness is critical for permitting the septic system and for assessing the potential impacts of the proposed septic disposal areas. For example, the saturated thickness is a required parameter for mounding calculations and nitrate dilution. Locations where the saturated thickness may only be a few feet thick may have groundwater mounds that are unacceptable or that provide insufficient nitrate dilution. Analysis of logs for test pits already installed (BREM_146 01.08.2015 and BREM_147 01.08.2015) and logs for borings already installed or to be installed will allow a more detailed mapping of overburden thickness, a critical parameter for achieving project objectives.

Reported well yields in the area are relatively high for most of the wells, and the yields range from 0.75 gallon per minute (gpm) (35 Suffolk Lane in a report at the BOH) to 100 gpm (148 Stony Gate, per Table 1 in the 9/15/14 NGI report (BREM_080 10.14.2014)). Reported yields of 10 – 20 gpm are common, suggesting that the bedrock in the area is generally sufficiently fractured to transmit significant quantities of water, leading to drilling success. One exception appears to be 35 Suffolk Lane, located east of the site (Figure 1); two drilling attempts were apparently needed to obtain a well with sufficient water. The first well was drilled to 710 feet and produced only 0.75 gpm. A second well was drilled to 200 feet and obtained 10 gpm. This also illustrates the high degree of local variability in the bedrock and its ability to transmit and produce water. Nobis notes that yields reported in domestic well drilling records are typically airlift yields conducted by the well driller for up to an hour immediately following drilling. Pumping tests to determine sustainable yield are rarely performed on domestic bedrock wells. The sustainable yield for such a well is nearly always significantly less than the reported airlift yield. Also, it is unknown whether any of the existing wells interfere with each other.

Water quality information is available for some of the wells in the area, and elevated concentrations of dissolved iron in the water are fairly common. Elevated iron levels are generally considered an esthetic concern, not a health concern.

Most of the wells in the area are located on a map (dated November 4, 2014 (BREM_105 11.3.2014) and revised January 8, 2015) provided by LGH to Nobis during the site walk (see below). Nobis notes that the January 8 updated version (not on Town website or available to Nobis in electronic form) lists 8 (not 20) abutters. Well locations provided on the January 8 map are shown on Figure 1.

The existing well on the site is rated at 20 gpm and is 150 feet deep, with the depth to bedrock 8 feet. This well currently serves the existing home on the site, but this well has been proposed to be used for irrigation, and 11 new wells are shown on the November 14, 2014 map (BREM_127

12.08.2014), to serve the existing home and the 19 proposed homes. Most wells will serve two homes each, with two of the wells only serving one home each. Nobis also understands that the Carlisle Fire Department has requested that an additional well be installed, for the purpose of providing water to a proposed fire cistern.

Estimated design flows for the proposed septic disposal areas (LGH "Computation of Sewage Flows" document dated January 5, 2015 (BREM_145 01.05.2015)) are estimated by LGH at 1980 gallons per day (gpd) each for the three proposed septic disposal areas (Attachment B). (Nobis understands that the Carlisle Board of Health (BOH) may stipulate that the design flow for the septic system should be 165 gpd per bedroom, as opposed to the design flow of 110 gpd per bedroom used by LGH. This increases the design flow for each proposed septic disposal area to 2970 gpd.) The existing home is assumed by Nobis to remain on its existing septic system, whose design flow is unknown, but is probably 660 gpd, based on 4 bedrooms at 165 gpd per bedroom. Nobis notes that because neither BREM_145 01.05.2015 (Attachment B) nor the "Plan & Profile and Utility Plan (BREM_128 12.08.2014) show the existing home (#20) as connected to the new septic system, LGH apparently intends to keep the existing home on its existing septic system. Not including the septic system for the existing home, proposed septic disposal areas 1 – 3, designed to serve the 19 new homes, will have a combined design flow of 5940 gpd (8910 gpd using BOH design flow). If 660 gpd is added for the existing home, the total design flow for the new and existing septic systems, combined, could be as high as 9570 gpd. Presumably, combined withdrawals from the 11 proposed wells (not including the existing well, proposed to be used for irrigation and therefore not discharging to a septic system and not including a well to supply the firefighting cistern) should equal at least this amount, although the wells intended to serve only one home will require lower design flows than the wells designed to serve two homes. It is assumed that most of the water pumped from the wells (except water used for watering lawns or gardens) will be discharged to the septic systems.

A new well was drilled in 2014 to serve a new home immediately to the southeast of the site, at 90 Long Ridge Road (Figure 1). The new well is reported, by LGH, to have been an overflowing artesian well when drilled. Fill was emplaced to raise the wellhead, and additional casing was added to stop the overflow. The well is located behind the new home, in the topographically lower portion of the lot. The overflowing condition indicates that the hydraulic head in at least one of the fractures that supplies water to the well is greater than the original wellhead elevation. This indicates that the fracture(s) obtain water from a topographically higher recharge area and that vertical groundwater gradients at that location are upward.

Nobis has obtained and reviewed existing published maps that are available as Geographic Information Systems (GIS) layers from the public domain database, MASSGIS. Such maps include bedrock geology, overburden geology, soils, wetlands, and tax maps. Working copies of these maps can be found in Attachment C. This map information provides the basis for a conceptual hydrogeologic model of the Site and vicinity. The conceptual hydrogeologic model should constantly be updated as the project proceeds and more information is gained. The model will form the basis for understanding the flow of groundwater beneath the Site and vicinity, the transport of wastewater discharged from the septic systems, and possible interference effects between proposed and/or existing wells.

Mapped soils (Attachment C1) for the site include Charlton-Hollis Rock Outcrop Complex, Rock Outcrop Hollis Complex, and Woodbridge Fine Sandy Loam. Two of these three soil types suggest that bedrock may be near the surface. Thus, for septic system design and mounding and nitrate analyses, it will be important to determine whether saturated overburden is present at all three proposed septic disposal are locations and down-gradient of these. The thickness of

saturated soil and the depth to the seasonal high water table beneath the proposed septic disposal areas and downgradient of the septic disposal areas will be crucial in estimating the height of groundwater mounds that are anticipated beneath the septic disposal areas. The saturated thickness will also be crucial in nitrate loading and transport models. The soil types will also strongly influence infiltration rates and the heights of groundwater mounds that are anticipated to form above the proposed septic disposal areas.

Surficial geologic mapping (Attachment C2) shows much of the site as "abundant outcrop and shallow bedrock", with swamp deposits along the northern boundary. The "abundant outcrop" mapping does not mean that outcrops are actually present where mapped, but raises a concern that bedrock may be shallow (see below). It must also be remembered that the GIS layers have been downloaded from statewide GIS and cannot be expected to be accurate on the Site scale. Rather, this mapping is useful in identifying possible concerns and focusing field investigations. GIS wetland mapping (Attachment C3) shows wetlands along the northern edge of the site (similar location as the mapped swamp deposits) and in the far southeastern corner of the site. On-Site mapping by LGH (BREM_127 12.08.2014) shows that these two wetlands are connected by a brook that flows southward and then southeastward and is flanked by a narrow strip of wetlands.

Bedrock mapping (Attachment C4) shows two primary lithologies in the area. Nearly all of the Site (and all of the area for the proposed development) is underlain by mafic rocks. Mafic rocks are dark rocks rich in magnesium and iron that may have had a volcanic origin, although they have since been metamorphosed (see more description below). Granite is mapped beneath the extreme southeastern corner of the Site; granite is a quartz-rich igneous rock. The bedrock lithology is important because lithology can influence fracturing (and thus transport pathways in the rock) and groundwater quality in the bedrock (and in drilled bedrock wells). Nobis proposes additional investigation of these considerations in Phase 2.

Task 200: Project Base Map

Nobis received existing GIS mapping (electronic data layers) for roads, tax maps and existing wells as mapped by the Massachusetts Department of Environmental Protection (MADEP) from the Carlisle ZBA for the project site and abutting properties. See Figure 1. Nobis has added mapped information and data layers obtained under Task 100 and shown in Attachment C. In those cases where electronic (GIS or CADD) files were unavailable to Nobis, Nobis located proposed septic disposal areas, proposed wells, existing borings, and test pits from paper maps or other information as available. Should electronic information become available, these key features can be more accurately located for analysis.

Task 300: Site Walk

Nobis conducted a reconnaissance visit in the vicinity of the Site on January 23, 2015 with Steve Hinton of the Town ZBA. We were accompanied on site by Jeffrey Brem and his consulting hydrogeologist, Joel Frisch of NGI. An agreement obtained by the Town with LGH permitted the accompanied site walk and "scraping the dirt", but no digging or collecting samples. Subsequently, we were accompanied for a greater neighborhood reconnaissance by Thornton Ash, an abutter.

While at the Site, Nobis observed boulders throughout and one small, possible bedrock outcrop (may be a boulder) near the western edge of the property. In the northwestern corner of the property, where septic disposal areas 2 and 3 are planned (Figure 2), the area is cleared for

horseback riding, and excavation has removed several feet of soil and overburden to create a cleared, level area. Boulders are visible in the cut banks. In the "lower turnout" area of the property, a monitoring well, presumably screened in overburden, extends to a depth of 24 feet, as reported by NGI. Several monitoring wells, former and recent test pits, and wooden stakes to be used as staff gauges in the stream or wetland are present around the property. Test pit logs are available (BREM_146 01.08.2015 and BREM_147 01.08.2015), but Nobis has not received boring logs. The existing well that serves the existing home on the site is located immediately beside the proposed new entrance road for the development and has been tested by NGI and reportedly has "plenty of water."

A wetland is present near the northern edge of the property, and wetland flagging was observed during the site walk. The wetland drains southward via a slow moving, reportedly ephemeral, brook that leads to another broad wetland in the extreme southeastern corner of the property. (See Attachment C3.) This brook/wetland complex transects the eastern portion of the Site and lies immediately east of the proposed development. A low, but steep ridge parallels the brook on the east side of the brook and is characterized by a long series of ridge-like bedrock outcrops. The outcrops trend northeastward (estimated to trend 30 to 40 degrees east of true north (N30-40E)) and are characterized by near vertical metamorphic foliations (layers) of the same trend. Some of these foliations appear to be fractured. Cross-cutting fractures are present but not common or prominent. Nobis did not collect any samples or take any measurements of the bedrock fractures or foliations. The rock appeared to be an amphibolite schist, consistent with the lithologic mapping illustrated in Attachment C4.

During a tour of the neighborhood, two more bedrock outcrops were observed (Figure 1). One is on the west side of Long Ridge Road, across the road from 50 Long Ridge Road. Some portions of the outcrop were schistose and appeared similar to the on-Site outcrop described above. Metamorphic foliations appear to strike northeastward and are steep. Other portions of the outcrop contained more massive, possibly granitic rock. A second outcrop was observed on the north side of Nowell Farme Road, at the intersection with Long Ridge Road. This rock was more fractured than the rock in the previous outcrop, but did not appear to be foliated. Additional study of the bedrock lithology and fracturing will enhance our understanding of potential groundwater flow in the fractured bedrock.

On the neighborhood tour, Nobis and Steve Hinton were accompanied by Thornton Ash, an abutter. We drove portions of Long Ridge Road, Garnet Rock Lane, Suffolk Lane, and Suffolk Lane extension. From the car or by walking the various neighbors' yards, we located wells for most of the homes in the area (Figure 1), with the help of the LGH map updated on January 8, 2015. Most of the wells were located where shown on the LGH map, but the well for 29 Suffolk Lane is mislocated. We found this well in a bush at the edge of the yard, northwest of the house, but much closer to the house than shown on the LGH map.

Task 400: Photolineament (Fracture Trace) Analysis

The proposed wells are to be drilled into fractured bedrock, and all known existing wells in the area are drilled into bedrock. Therefore, an understanding of the bedrock geology as well as the overburden geology in the Site vicinity is needed in order to achieve the project objectives. For this task, Nobis obtained public domain aerial photographs, available as stereo pairs from the USGS' Earth Explorer website. Nobis examined the six pairs of photos stereoscopically; the photos range in scale (for a 9'x9" print) from approximately 1:24,000 to 1:80,000 and in date from

1957 to 1995; some are black and white photographs and some are color infrared photographs. The photos examined are listed in Attachment D.

A photolineament is a more or less linear feature observed on an aerial photograph or other image that may represent a steeply dipping bedrock fracture zone. Nobis traced the photolineaments on Mylar overlays and digitized the lineaments for superimposition on project GIS maps. (See Attachment D for photocopies of the airphotos with overlays showing photolineaments (potential fracture traces)). All photolineaments interpreted for this study are shown on a map in Attachment D; photolineaments on the Site and abutters' properties are shown on Figure 3. Each photolineament was interpreted as strong, intermediate, or subtle. Linear features on air photos can be mistakenly interpreted as fracture traces when they are actually human-made features such as property lines or utility corridors. Therefore, photolineaments that are observed and interpreted as fracture traces on more than one set of air photos are considered more likely to represent bedrock fracture zones than are those that are observed on only one set of air photos. Also photolineaments of the same orientation as fractures measured in nearby bedrock outcrops are interpreted more confidently as fracture traces than lineaments that do not correspond to outcrop fracture orientations. Depending on the scale of the air photo from which the lineament was transferred, the location of the lineament as shown on Figure 3 is approximate and meant as an indication that a bedrock fracture zone may be present in the area shown.

The results show that few strong or intermediate lineaments are present in the area (map in Attachment D) and that all the lineaments that occur on Site or on abutters' properties are subtle (Figure 3). The most common lineament orientation is northwest to southeast (NW/SE), although a north-northeast (NNE) trending lineament is present near the eastern edge of the Site. This lineament probably coincides with the brook, wetland, and northeast-trending outcrop in that location and may indicate that a steeply dipping bedrock fracture zone is present in this area. Such a fracture zone can potentially receive recharge from the overburden and soils that overlie it and can serve as a migration pathway for groundwater, possibly connecting bedrock wells with each other or with groundwater discharged at a septic disposal area.

Figure 3 shows photolineaments on the Site and the abutters' properties, superimposed on a map of the Site and vicinity with existing and proposed wells and the proposed septic disposal areas. Because these lineaments may represent bedrock fracture zones, they may be pathways for groundwater flow and contaminant transport. It must be remembered that photolineaments are not guaranteed to be fracture zones, and their location, especially from high altitude photographs, is only approximate. Nonetheless, Figure 3 can serve to focus investigations on some proposed wells and existing abutters' wells that may be of more concern than others. For example, northwest-to-southeast (NW-SE) trending lineaments project southeastward from the site (yellow and red dashed lines on Figure 3) may indicate that future studies should include detailed assessments of wells to the southeast of the Site.

Nobis also notes that there is not sufficient hydrogeologic information available, at the present time, to assign risk to any particular locations or wells. The nature of the overburden and soils, overburden groundwater flow direction, fracturing in the bedrock (in general and at particular wells), and the hydraulic connection between overburden and bedrock (or lack of connection) have yet to be characterized.

Figure 3 does not show any photolineaments directly passing through any of the three proposed septic disposal areas. However, a NW-SE photolineament traverses the area just northeast (topographically downhill) from proposed septic disposal areas #2 and #3. Although the groundwater potentiometric surface ("water table") in the overburden and the groundwater flow

direction have yet to be mapped, the groundwater gradient and flow direction appear to be directed to the northeast from proposed septic disposal areas #2 and #3, based on topographic contours obtained from MASSGIS (Figure 2). Overburden groundwater flow direction in the vicinity of proposed septic disposal area 1 is less clear, based on available topographic contours, but is probably to the SW, S, and SE (Figure 2). The surface contour map and groundwater contour map to be developed by LGH (BREM_148 01.09.2015) will aid greatly in predicting overburden groundwater flow directions in the vicinity of the proposed septic disposal areas. Even with this information, however, possible flow paths to the proposed and existing bedrock wells will not be predictable with confidence.

3.0 DATA REQUIREMENTS

In general, a sound and detailed Conceptual Site Model (CSM) that integrates overburden and bedrock hydrogeology is needed for the Site and vicinity in order to achieve the objectives described above. At present, the overburden hydrogeology is partially characterized by LGH and its consultant, and test pit logs are available (BREM_146 01.08.2015 and BREM_147 01.08.2015); Nobis has not received boring logs, which will provide much more information on the overburden hydrogeology. Nobis also understands that LGH plans additional investigations to characterize the overburden. Future "Hydrogeologic Study Testing and Analysis" that LGH will perform is listed in Exhibit A of a letter by LGH's attorney to the Town dated 1/9/15 (BREM_148 01.09.2015). However, it appears that the bedrock hydrogeology is not characterized, except for information on existing bedrock wells (BREM_080 10.14.2014) and the photolineament analysis contained in this report. Finally, the potential interactions between overburden and bedrock groundwater do not appear to be characterized at all, at the present time.

Groundwater flow direction and gradients are needed for several of the required analyses. As described above, groundwater contour maps and flow in the overburden will be achieved by investigations proposed by LGH (BREM_148 01.09.2015 and BREM_080 10.14.2014).

Nobis also points out, however, that groundwater flow through fractured bedrock depends on particular pathways along individual fractures. Determining exactly where (along which fractures) the water that supplies the existing and proposed wells in the vicinity comes from cannot be predicted with a high degree of confidence and likely differs for each individual well. Therefore, it may be reasonable to identify those wells or areas within the Site and neighborhood that appear, based on preliminary characterization, to be more susceptible to impact from the septic systems or from pumping the new, proposed wells. These areas and wells could receive increased focus and study. Such an approach will not reduce the risk of impact to zero, but when combined with an escrow account to replace impacted water supplies may provide a defensible approach. If the Town agrees with this approach, Phase 2 work will be focused on identifying locations and wells that need more focused characterization.

In the remainder of this section, Nobis itemizes some elements needed to characterize the overburden and bedrock hydrogeology, and most importantly, to integrate these aspects to produce a CSM and accomplish the particular analyses that are needed. The CSM should be continuously updated as the investigations proceed. A topical list of data needs follows.

Future "Hydrogeologic Study Testing and Analysis" that LGH will perform is listed in Exhibit A of a letter by LGH's attorney to the Town dated 1/9/15 (BREM_148 01.09.2015). LGH has also proposed to conduct 24-hour pumping tests on each of the proposed new wells (BREM_060

09.12.2014). Nobis has compared the list of investigations and analyses proposed by LGH to those recommended below and to recommendations by GHC. (Note: Additional agreements by LGH to perform investigations are reported by GHC in their November 14, 2014 letter (BREM_107 11.14.2014) and their December 30, 2014 letter (BREM_139 12.24.2014_ and appear to have been orally communicated to GHC. Nobis has not seen these agreements in writing from LGH.) For the present, Nobis assumes that LGH will be willing to share all its technical information in a timely manner. Nobis understands that existing data obtained from LGH or other source will be used when feasible and obtainable in a timely manner, but that Nobis will conduct independent investigations for data needs that will not be provided by LGH or that will not be provided as soon as it is needed, or for which the Town may wish an independent check.

Nobis notes three elements that have been discussed by LGH, GHC, and others regarding studies proposed for this project: one is the length of pumping tests to be conducted on the new wells (24 vs. 48 hours); the second is whether or not to use dye tracing studies to establish hydraulic connectivity (or lack thereof) between wells and proposed septic disposal areas; the third is the duration of post-development monitoring (2 years vs. 5 years). Nobis believes that a decision on the third item should depend on the results of the investigations described below. The first two items both involve establishing whether or not there is hydraulic connectivity from one location or well to another (or to a septic disposal area).

There are several potential methods for establishing hydraulic connectivity or lack thereof. These include pumping tests, recovery tests, dye tracing, and others. Pumping tests, with water level monitoring in other wells, have already been agreed to. One of the most sensitive ways of establishing a hydraulic connection between wells is to look for a response in water levels in one well immediately after shut down of pumping in another well. This can easily be done during the tests that are already agreed to by extending the monitoring periods for an hour following pump shut down and by programming pressure transducers (used to monitor water levels) at an appropriate frequency. Careful data analysis can then establish whether there is evidence of a hydraulic connection. Nobis believes that recovery monitoring is likely to be more important than the duration of the pumping phase of the tests. Decisions as to pumping duration should be determined on a test-by-test basis, and Nobis recommends that the parties remain flexible and work cooperatively as to the specific designs of the tests.

Dye tracing studies can be difficult to execute and interpret. Nobis recommends that this technique should only be considered after the pumping (with recovery monitoring) tests are completed and the Conceptual Site Model is more fully developed. Pumping and recovery tests will likely establish definite hydraulic connections in some instances and definite lack of connection in other cases. If ambiguous, but critical, situations remain, other approaches such as dye tracing may be considered.

Overburden Hydrogeologic Characterization:

- Topographic contour map for site ***-- Proposed by LGH, using "GIS mapping, and other mapping with site information"; will probably be adequate, although more information as to how the map will be made would be helpful. This map is crucial to many analyses and needs to be available ASAP.***
- Test pit and boring logs with soil and overburden description ***– LGH-proposed test pits and borings will likely be adequate, pending adequate coverage and timely performance and submittal of logs.*** Depth to water and saturated thickness ***–It is not clear whether LGH is proposing a synoptic round of water level measurements, but this presumably will be done and will be adequate.***

- Potentiometric surface contour map and groundwater flow direction ***– Proposed by LGH and probably adequate if done in a timely manner.***
- Hydraulic conductivity from slug test results and/or sieve analyses ***-- Proposed by LGH and probably adequate if done in a timely manner.***
- Is there evidence of a clay or peat layer that might cause locally confining conditions? ***-- If LGH borings extend to bedrock and there is sufficient aerial coverage, this information should be adequately available from boring logs. Possible need for additional or deeper borings will be assessed during Nobis Phase 2.***
- Is there a dense basal till that might hydraulically separate bedrock from overburden? ***See above.***
- Percolation test (infiltration rate) results ***– Already done for proposed septic disposal area 1; presumably will be done for proposed areas 2 and 3.***
- Groundwater flow velocity/ time of travel analysis ***-- Proposed by LGH and should be adequate; should be checked by an independent consultant. (Note: this will apply to groundwater flow in overburden only.)***
- Groundwater Monitoring Plan ***– Recommended by GHC and reportedly (per GHC) agreed to by LGH; GHC recommends 5-year monitoring duration; LGH reportedly has agreed to 2 years. Nobis believes there is not yet enough information to specify the monitoring plan details.***

Bedrock Hydrogeologic Characterization:

- Yield and drawdown characteristics for existing neighborhood wells (pre project) – ***Proposed by LGH; should be adequate, assuming LGH does not reduce the number of abutters' wells monitored from the "official" list by the BOA without the Town's agreement. Also, as recommended by GHC, LGH and the Town should agree, prior to existing well testing, how unacceptable loss of well yield will be defined/determined.***
- Water quality characteristics for existing neighborhood wells (pre project) ***– Proposed by LGH; should be adequate, assuming LGH and Town agree on abutters list.***
- For new wells drilled for project, drillers log (depth to bedrock, casing length, total depth, driller's airlift yield, depth of water-bearing fractures, water level) ***– Should be available after drilling and requested from LGH.***
- For new wells drilled for project, results of pumping tests (length to be determined), including pumping rate, yield, drawdown, and evidence of interference with other wells monitored ***– LGH has proposed a 24-hr pumping test for each new well; water level monitoring should continue at least one hour after pumping ceases; wells selected based on increased vulnerability as may be indicated by the conceptual site model and initial investigation results might need to be pumped for a longer period of time.***
- Bedrock outcrop fracture orientations measurements (to compare to photolineament results) ***– Proposed by Nobis.***
- Possible hydraulic connection between proposed septic systems and existing wells – ***Not directly addressed by any proposed LGH investigation (although "Nutrient loading and pathogens" study (BREM_080) will be relevant; timing of this study is uncertain; pumping, recovery, and other interconnectivity tests should be considered following pumping/recovery tests.***
- Possible hydraulic connection between proposed septic disposal areas and proposed wells ***– Proposed pumping tests by LGH should address this, if water levels are monitored in monitoring wells or non-plugged test pit pipes in each proposed septic disposal area.***

- Possible hydraulic connections between proposed wells and existing wells – ***Proposed pumping tests by LGH should address this; water level monitoring should continue for at least one hour after pumping ceases. Other interconnectivty tests can be considered following pumping tests if needed.***
- Groundwater Monitoring Plan – ***See above.***

Groundwater Mounding Analysis: (note that some items overlap with items listed above)

- Proposed septic systems' dimensions and daily loading volume for each system – ***Provided by LGH.***
- Hydraulic conductivity (from slug test or sieve analysis) – ***Slug tests proposed by LGH, and probably adequate if done in a timely manner.***
- Saturated thickness (from water levels and boring logs) -- ***Proposed by LGH, and probably adequate if done in a timely manner.***
- Specific yield (estimated from soil/overburden type) – ***Can be estimated from published information.***
- Groundwater mound analyses for each of the three proposed septic disposal areas – ***Proposed by LGH; will be checked by independent consultant; Nobis recommends that an analysis for areas 2 and 3, combined should be conducted.***

Nitrate Loading Analysis

- Groundwater contour and flow analysis -- ***Proposed by LGH and probably adequate if done in a timely manner.***
- Saturated thickness -- ***See above.***
- Hydraulic conductivity – ***See above.***
- Proposed nitrogen loading due to septic systems and fertilizer application – ***Proposed by LGH; timing uncertain.***
- Mass balance analysis for total Site – ***Proposed by LGH; timing uncertain.***
- Specific plume analyses for each proposed septic disposal area (#2 and #3 should be combined into a single analysis) – ***"Analytical solute transport model" proposed by LGH (BREM_148) may or may not be adequate; more details of planned modelling needed.***
- Predicted nitrate results at key receptors (proposed on-site wells, existing neighbors' wells, down-gradient property lines) – ***Not proposed by LGH; Nobis recommends modelling for overburden; modelling probably not feasible for bedrock.***

4.0 PROPOSED PHASE 2 SCOPE OF WORK AND COST RANGES

Phase 2: Initial Field Investigations and Hydrogeologic Analysis

As presented in our January 13, 2014 proposal, the Scope of Services for proposed Phase 2 activities depend on the results of Phase 1 (including identified data needs), Site access, and the quality and extent of data and field investigation results that may be submitted by LGH, including more recent promises by LGH, specifically, BREM_080 and Exhibit A of BREM_148. Some or all of the tasks listed below may be undertaken in Phase 2. Following review by the Town and discussion between Nobis and the Town, Nobis will prepare a proposal for agreed-upon Phase 2 items.

Task 600: Overburden Hydrogeology and Groundwater Flow Direction Assessment

- Use existing test pit data to characterize soils and potentially recommend new test pits if needed to fill data gaps; no direct field test pitting by Nobis is anticipated;
- Use existing boring logs to characterize soils and overburden geology and determine saturated thickness and depth to bedrock or compact till; recommend new borings if needed to fill data gaps; no direct field test boring by Nobis is anticipated;
- Review surveying and synoptic (water levels in all wells and non-clogged test pit pipes on the same day) water level data to be provided by LGH to contour the potentiometric surface and establish overburden groundwater flow directions;
- Review the results of slug tests on selected Site/abutter monitoring wells, conducted by LGH, in order to estimate hydraulic conductivity for comparison with published and expected values.
- Review groundwater velocity and time of travel estimations by LGH.
- ***Estimated cost range: $800 - $1,500***

Task 700: Develop Hydrogeologic Conceptual Site Model for Overburden and Bedrock

- Measure orientations of fractures and other features that appear capable of groundwater flow in two nearby, off-site bedrock outcrops observed during Phase 1 site visit. If permission is obtained, measure fractures on on-site outcrop observed during Phase 1 site visit;
- Integrate these results with the photolineament analysis in Phase 1 to assess location of potential steeply dipping bedrock fracture zones and areas or wells that may be connected with proposed septic disposal areas, downgradient nitrate plumes therefrom, or proposed on-site wells and that therefore may warrant more detailed study;
- Integrate detailed information on neighbors' bedrock wells with the other bedrock data obtained and display on a map of the Site and vicinity;
- Synthesize overburden hydrogeologic information from Tasks 100 and 600 with bedrock hydrogeologic information to develop a coherent, conceptual hydrogeologic model for the site and vicinity.
- ***Estimated cost range: $2,000 - $3,000***

Task 800: Mass Balance and Groundwater Mounding Analyses

- Perform mass balance nitrate analysis for comparison with LGH analysis;
- Conduct Site specific groundwater mounding analyses for each of the three proposed septic disposal areas using the Hantush (1967) Method and the best available input parameters (depending on accessibility to the site and/or availability of on-site data gathered by others); include a scenario that combines septic disposal areas 2 and 3;
- ***Estimated cost range: $500 - $1,500***

Task 900: Nitrogen Loading/Dilution/Plume Analysis

- Review analytical solute transport model for nitrates to be performed by LGH;
- *Optional:* Perform analytical (groundwater dispersion) analysis for comparison with LGH analysis; pending results, a numerical groundwater flow model might be considered, but is not included at present; ***note that these models can predict future nitrate concentrations in <u>overburden groundwater</u> at the locations of bedrock wells, but***

the models cannot predict the concentrations of nitrates in the bedrock groundwater or the wells themselves.

- ***Estimated cost range: $500 - $2,500***

Task 1000: Phase 2 Report

Nobis will prepare a report summarizing Phase 2 investigations and results. As appropriate, paper and/or digital appendices will include results of field investigations (e. g. boring logs), analytical models, etc. The report will also present recommendations for additional studies and/or actions that may be needed to address the LGH application.

Estimated cost range: $2,000 - $4,000

Task 1100: Project Management and Meetings

- Ongoing project management and planning;
- Communications with the Town
- One to three meetings/presentations to Carlisle ZBA.
- ***Estimated cost range: $1,000 - $4,000***

We look forward to continuing to work with you and the Town on this project. Thank you for the opportunity to be of service. If you require additional information, please do not hesitate to contact us at (603) 224–4182.

Very truly yours,

Nobis Engineering, Inc.

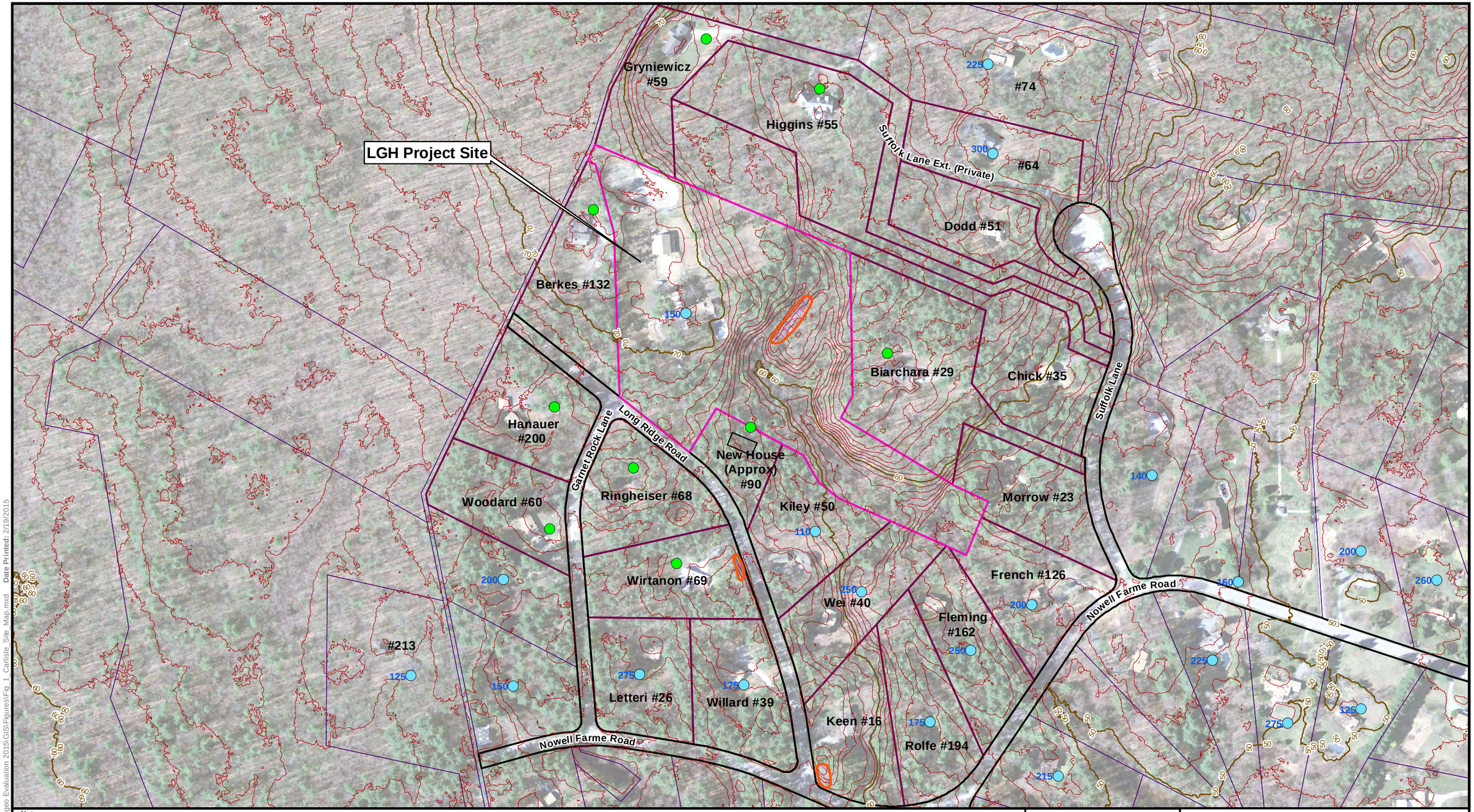
James H. Vernon, Ph.D., P.G.
Senior Hydrogeologist

Figures:

Figure 1. Site Map with Existing Wells
Figure 2. Proposed Septic Disposal Areas and Wells
Figure 3. Combined Well/Septic/Photolineament Map

Attachments:

Attachment A. Carlisle BOA List of Abutters
Attachment B. Septic System Design Flows
Attachment C. Map Information from Mass GIS
Attachment D. Airphotos with Interpreted Lineaments



Notes:

1. Non DEP locations from LGH map updated 1/8/15 and from Nobis site visit 1/23/15.
2. Assessor's parcels are from the Town of Carlisle. Contours are from MassGIS. Aerial photography provided by ESRI. Lot line for #90 Long Ridge Road is approximate.
3. Abutters identified by Board of Assessors (10/2/14 letter).
4. Elevations based on a relative datum, not sea level.
5. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

- Existing Well Observed by Nobis, 1/23/15
- 185 DEP Well Locations with Depth
- LGH Project Site
- Abutters with Owner Name and Address
- Other Properties
- Bedrock Outcrops
- 10 Foot Contour
- 1 Foot Contour

0 100 200 400
Feet
1 inch = 250 feet

N

Nobis
Engineering a Sustainable Future
Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T(978) 683-0891
www.nobiseng.com
Client-Focused, Employee-Owned

FIGURE 1

SITE MAP WITH EXISTING WELLS
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: FEBRUARY 2015

Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\Figures\Fig_1_Carlisle_Site_Map.mxd Date Printed: 2/19/2015

Proposed Septic Disposal Area 3

Proposed Septic Disposal Area 2

Proposed Septic Disposal Area 1

Suffolk Lane Extension

Suffolk Lane

Garnet Rock Lane

Long Ridge Road

Nowell Farme Road

A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11

?

Notes:

1. Proposed well and septic locations from Brem_127_12.08.2014.

2. Assessor's parcels are from the Town of Carlisle. Aerial photography provided by ESRI. Lot line for #90 Long Ridge Road is Approximate.

3. Elevations are to a relative datum, not sea level.

3. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

A1 Proposed Well with LGH # (Location Approximate)

Preliminary Groundwater Flow Estimate

Proposed Septic Disposal Area

LGH Project Site

10 Foot Contour

1 Foot Contour

0 100 200 400

Feet

1 inch = 200 feet

N

Nobis

Engineering a Sustainable Future

Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T(978) 683-0891
www.nobiseng.com

Client-Focused, Employee-Owned

FIGURE 2

PROPOSED SEPTIC DISPOSAL AREAS AND WELLS
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: FEBRUARY 2015

Date Printed: 2/19/2015

Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\Figures\Fig. 2_Carlisle_Septic_Wells.mxd

LGH Project Site
Gryniewicz #59
Higgins #55
#74
#64
Dodd #51
Berkes #132
Biarchara #29
Chick #35
Hanauer #200
New House (Approx) #90
Ringheiser #68
Woodard #60
Kiley #50
Morrow #23
Wirtanon #69
Wei #40
French #126
Fleming #162
Letteri #26
Willard #39
Rolfe #194
Garnet Rock Lane
Long Ridge Road
Suffolk Lane Ext. (Private)
Suffolk Lane
Nowell Farme Road
225
300
150
110
140
200
250
160
260
125
275
175
215

Notes:

1. Non DEP locations from LGH map updated 1/8/15 and from Nobis site visit 1/23/15.
2. Assessor's parcels are from the Town of Carlisle. Contours are from MassGIS. Aerial photography provided by ESRI. Lot line for #90 Long Ridge Road is approximate.
3. Elevations are based on a relative datum, not sea level.
4. No "Strong" photolineaments noted on site or abutters; see small scale map in Attachment D.
5. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

- Non-DEP Well Locations
- 185 DEP Well Locations with Depth
- 10 Foot Contour
- Proposed Septic Disposal Area
- LGH Project Site
- Abutters
- Other Properties

Photolineament Source

- NAPP 1995
- NHAP 1995 CIR
- NHAP 1985 B&W
- VESC 1981

Photolineament Strength

- Intermediate
- Subtle

0 100 200 400
Feet
1 inch = 250 feet

N

Nobis
Engineering a Sustainable Future
Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T(978) 683-0891
www.nobiseng.com
Client-Focused, Employee-Owned

FIGURE 3

COMBINED WELL/SEPTIC/
PHOTOLINEAMENT MAP
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: FEBRUARY 2015

Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\Figures\Fig. 3 Carlisle_Combined.mxd Date Printed: 2/19/2015

Town of Carlisle

Office of
BOARD OF ASSESSORS

66 WESTFORD STREET
CARLISLE, MASSACHUSETTS 01741
PHONE (978) 369-0392 FAX (978) 318-0098

Brem-073_10.02.2014

October 2, 2014

RECEIVED
OCT 02 2014
TOWN CLERK
CARLISLE, MASS.

Mr. Jeffrey Brem
100 Long Ridge Road
Carlisle, Massachusetts 01741

RE: PARCEL 1-72-33K (REVISION)

Dear Mr. Brem:

Abutters are within 300 feet of any requested parcel's lot lines. We hereby certify that the enclosed list, taken from Real Estate property files, as per recorded deeds as received up to August 31, 2014 includes the names addresses of all parties; interest under MGL 48A, as amended to the best of our knowledge and belief.

This abutter's list will not satisfy legal requirements for notices; if ninety days have elapsed from date of request.

Required information if these properties are abutting the Town of Carlisle properties sent to:

Board of Selectmen
66 Westford Street
Carlisle, MA 01741

If any property is listed as Massachusetts State properties include the following, Commonwealth of Massachusetts notices regarding abutter activity should be sent to:

Office of the Commissioner Management
Department of Environmental Management
251 Causeway Street #600
Boston, MA 02202

Department of Environmental
Region Two Headquarters
PO Box 829
Carlisle, MA 01741

Sincerely,

Melissa M. Stamp, Principal Assessor

Enclosure

BREM 073-10-02 2014
1-72-33K -300 FT

Abutters List

ParcelID	Location	Owner	Co-Owner	Mailing Address	City	State	Zip
10-6-3	51 SUFFOLK LN	DODD SUSAN S		51 SUFFOLK LANE	CARLISLE	MA	01741
10-6A-4	64 SUFFOLK LN	SUNTHARALINGAM VYSHNAVI	LATHROP NATHANIEL G	64 SUFFOLK LANE	CARLISLE	MA	01741
10-6D-2A	55 SUFFOLK LN	HIGGINS COLIN J TRUSTEE	HIGGINS CAROLYN E TRUS	55 SUFFOLK LANE	CARLISLE	MA	01741
10-6E-1A	59 SUFFOLK LN	GRYNIEWICZ JOHN	GRYNIEWICZ JOANNE	59 SUFFOLK LANE	CARLISLE	MA	01741
1-67-29K	60 GARNET ROCK LN	WOODARD ANN		430 CYPRESS DRIVE	LAGUNA BEACH	CA	92651
1-68-30K	200 LONG RIDGE RD	HANAUER MICHAEL		200 LONG RIDGE ROAD	CARLISLE	MA	01741
1-69-0	OFF LONG RIDGE RD	TOWN OF CARLISLE		66 WESTFORD STREET	CARLISLE	MA	01741
1-71-32K	132 LONG RIDGE RD	BERKES JUDITH		2160 SW BRADFORD PLACE	PALM CITY	FL	34990
1-72-A	90 LONG RIDGE RD	G GARDNER CONTRACTING LLC		28 ENDLEIGH AVENUE	BILLERICA	MA	01821
1-73-26K	68 GARNET ROCK LN	RINGHEISER DAVID A		68 GARNET ROCK LANE	CARLISLE	MA	01741
1-74-25K	69 LONG RIDGE RD	WIRTANEN EDWARD F	WIRTANEN ANN C	69 LONG RIDGE ROAD	CARLISLE	MA	01741
1-76-24K	39 LONG RIDGE RD	WILLARD DAVID G	WILLARD JUDITH G	39 LONG RIDGE ROAD	CARLISLE	MA	01741
1-77-34K	50 LONG RIDGE RD	KILEY CHRISTOPHER		50 LONG RIDGE ROAD	CARLISLE	MA	01741
1-78-35K	40 LONG RIDGE RD	WEI YU-FENG		40 LONG RIDGE ROAD	CARLISLE	MA	01741
1-80-37K	194 NOWELL FARME RD	ROLFE NORMAN F	ROLFE JOAN M	194 NOWELL FARME ROAD	CARLISLE	MA	01741
1-81-38K	162 NOWELL FARME RD	FLEMING ERIC	MONAGLE JULIE	162 NOWELL FARME ROAD	CARLISLE	MA	01741
1-82-39K	126 NOWELL FARME RD	FRENCH PETER N	FRENCH SHEILA F	126 NOWELL FARME ROAD	CARLISLE	MA	01741
1-83-40K	23 SUFFOLK LN	MORROW GLENN S	BOWLING-MORROW DEBOF	23 SUFFOLK LANE	CARLISLE	MA	01741
1-84-50K	29 SUFFOLK LN	BAJRACHARA MAX		29 SUFFOLK LANE	CARLISLE	MA	01741
1-85-51K	35 SUFFOLK LN	CHICK RICHARD W	CHICK KATHLEEN K	35 SUFFOLK LANE	CARLISLE	MA	01741
9-15-0	OFF STEARNS ST	TOWN OF CARLISLE		66 WESTFORD STREET	CARLISLE	MA	01741

End of Report

Attachment B
Brem_145_01.05.2015

The Birches 1/5/2015

Computation of Sewage Flows

165 gpd/br ↓ 110 gpd/br ↓ Proposed Well (See Figure 2)

Septic System 1:

Unit	1	3 BR	495	330	GPD	A11
	2	3 BR	495	330	GPD	A10
	3	3 BR	495	330	GPD	A10
	4	3 BR	495	330	GPD	A1
	5	3 BR	495	330	GPD	A1
	6	3 BR	495	330	GPD	A2
			2970	1980	GPD	

Septic System 2:

Unit	7	3 BR	495	330	GPD	A2
	8	3 BR	495	330	GPD	A3
	9	3 BR	495	330	GPD	A3
	10	3 BR	495	330	GPD	A4
	18	3 BR	495	330	GPD	A8
	19	3 BR	495	330	GPD	A9
			2970	1980	GPD	

Septic System 3:

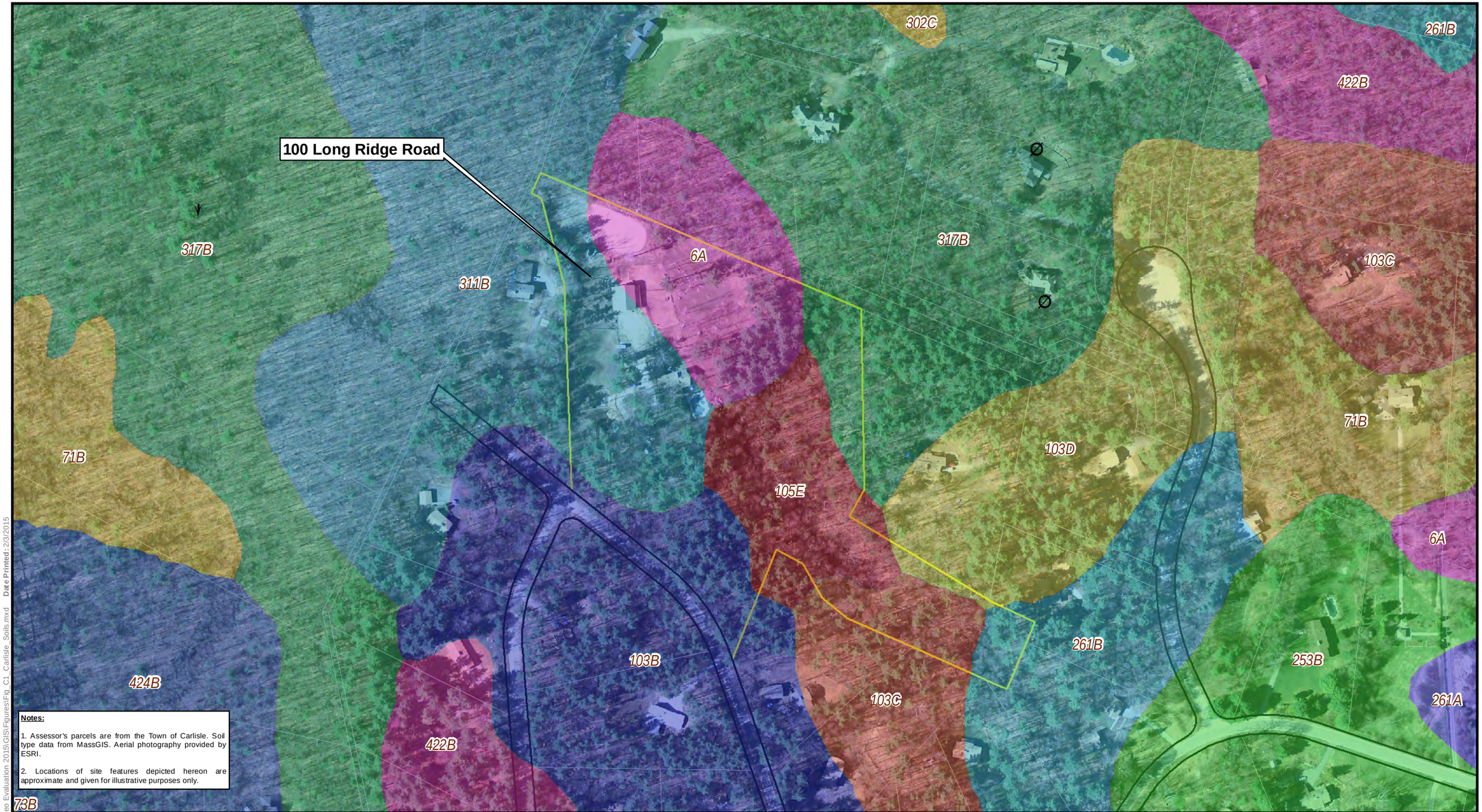
Unit	11	2 BR	330	220	GPD	A4
	12	2 BR	330	220	GPD	A5
	13	3 BR	495	330	GPD	A5
	14	3 BR	495	330	GPD	A6
	15	3 BR	495	330	GPD	A6
	16	3 BR	495	330	GPD	A7
	17	2 BR	330	220	GPD	A8
			2970	1980	GPD	

20 (existing home) ? A9 (see below)

Annotations by Nobis 2/13/15 (Well info from "Neighborhood Well and Septic Exhibit" by LGH, dated 11/4/14, updated 1/8/15)

Notes: ① number of bedrooms for existing home unknown, so flow (design) to existing septic system unknown. Assume 4 bedrooms; 660 gpd

② LGH assumed 110 gpd / bedroom; Carlisle BOH considering 165 gpd / bedroom



Notes:

1. Assessor's parcels are from the Town of Carlisle. Soil type data from MassGIS. Aerial photography provided by ESRI.

2. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Soil Type

103B	Charlton-Hollis-Rock outcrop complex, 3 to 8 percent slopes	105E	Rock outcrop-Hollis complex, 3 to 35 percent slopes	302C	Montauk fine sandy loam, 8 to 15 percent slopes, extremely stony	424B	Canton fine sandy loam, 3 to 8 percent slopes, extremely bouldery
103C	Charlton-Hollis-Rock outcrop complex, 8 to 15 percent slopes	253B	Hinckley loamy sand, 3 to 8 percent slopes	311B	Woodbridge fine sandy loam, 3 to 8 percent slopes, very stony	6A	Scarboro mucky fine sandy loam, 0 to 1 percent slopes
103D	Charlton-Hollis-Rock outcrop complex, 15 to 25 percent slopes	261A	Tisbury silt loam, 0 to 3 percent slopes	317B	Scituate fine sandy loam, 3 to 8 percent slopes, extremely stony	71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony
		261B	Tisbury silt loam, 3 to 8 percent slopes	422B	Canton fine sandy loam, 3 to 8 percent slopes, extremely stony	73B	Whitman fine sandy loam, 0 to 5 percent slopes, extremely stony

0 100 200 400
Feet

1 inch = 200 feet

N

Nobis
Engineering a Sustainable Future
Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T(978) 683-0891
www.nobiseng.com

Client-Focused, Employee-Owned

ATTACHMENT C1

SOIL MAP
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: FEBRUARY 2015

Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\Figures\Fig_C1_Carlisle_Soils.mxd **Date Printed:** 2/3/2015

Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\Figures\Fig_C2_Carlisle_Surficial_Geology.mxd Date Printed: 2/3/2015

Notes:

1. Assessor's parcels are from the Town of Carlisle. Surficial Geology is from MassGIS. Aerial photography provided by ESRI.

2. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Surficial Geology

- Abundant Outcrop and Shallow Bedrock
- Swamp and Marsh Deposits
- Thin Till
- Outcrop Observed by Nobis on 1/23/15

0 100 200 400

Feet

1 inch = 200 feet

N

Nobis
Engineering a Sustainable Future
Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T(978) 683-0891
www.nobiseng.com
Client-Focused, Employee-Owned

ATTACHMENT C2

SURFICIAL GEOLOGY MAP
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: FEBRUARY 2015

Notes:

1. Assessor's parcels are from the Town of Carlisle. Wetland data from MassGIS. Aerial photography provided by ESRI.

2. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Wooded marsh

0 100 200 400

Feet

1 inch = 200 feet

N

Nobis
Engineering a Sustainable Future
Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T(978) 683-0891
www.nobiseng.com

Client-Focused, Employee-Owned

ATTACHMENT C3

WETLAND MAP
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: FEBRUARY 2015

Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\Figures\Fig_C3_Carlisle_Wetland.mxd Date Printed: 2/3/2015

Notes:

1. Assessor's parcels are from the Town of Carlisle. Bedrock Lithology is from MassGIS. Aerial photography provided by ESRI.

2. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Bedrock Lithology

- Granite
- Mafic Rocks
- Outcrop Observed by Nobis on 1/23/15

0 100 200 400

Feet

1 inch = 200 feet

N

Nobis
Engineering a Sustainable Future
Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T(978) 683-0891
www.nobiseng.com

Client-Focused, Employee-Owned

ATTACHMENT C4

BEDROCK LITHOLOGY MAP
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: FEBRUARY 2015

Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\Figures\Fig_C4_Carlisle_Bedrock_Lithology.mxd Date Printed: 2/3/2015

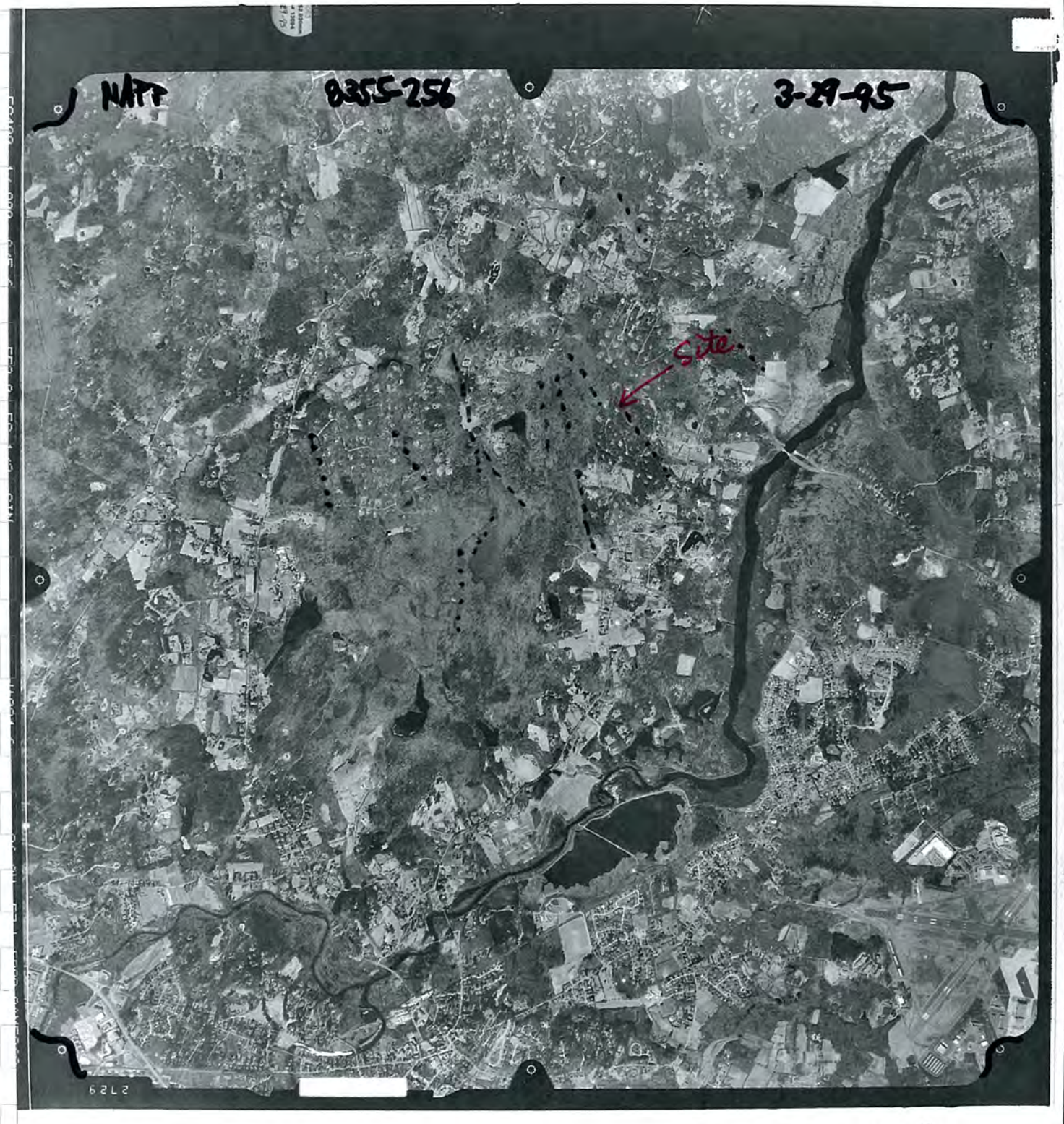
Phase 1 Report
Independent Hydrogeologic Study
100 Long Ridge Road, Carlisle, MA
Nobis Engineering
Feb-15

Attachment D: Airphoto Stereo Pairs Examined

Program	Date	Type	Scale	USGS Earth Explorer Website Photo #s	Comments
NAPP	03_29_95	B&W	1:40,000	N10NAPPW08355256 & 257	excellent quality; lineaments digitized
NAPP	04_29_15	CIR	1:40,000	NPONAPP002025005 & 004	excellent quality; lineaments digitized
NHAP	04_17_85	B&W	1:80,000	NB1NHAP850032224 & 223	blurry in study area; not digitized
NHAP	04_17_85	CIR	1:56,000	NC1NHAP850053184 & 183	good quality; lineaments digitized
GS-VESC	04_07_81	B&W	1:24,000	AR1VESC00060097 & 096	excellent quality; lineaments digitized
GS-VQU	04_22_57	B&W	1:24,000	AR!VQU000010005 & 006	blurry in study area; not digitized

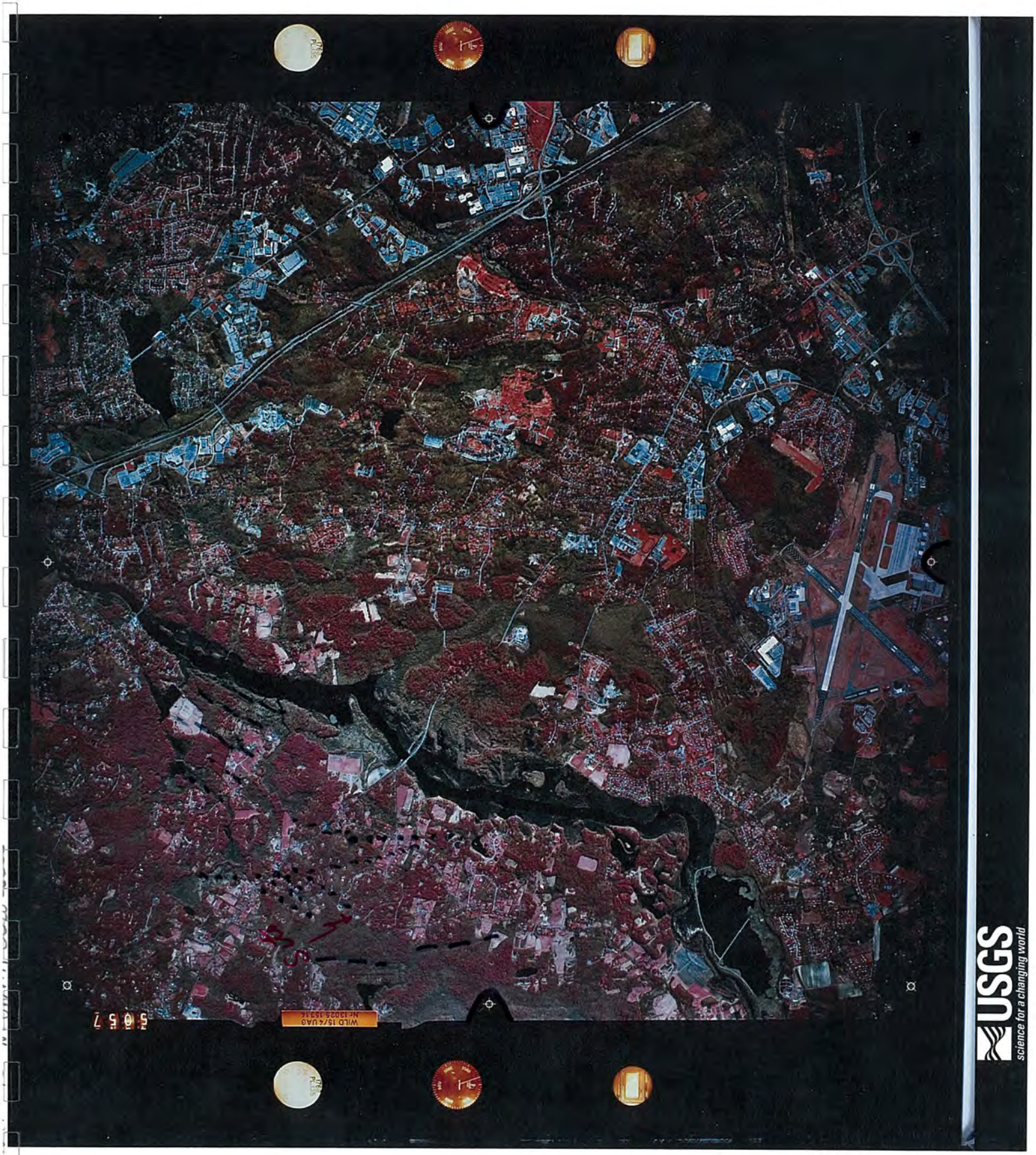
Notes

1. Scale is approximate for a 9x9 print
2. All photos examined were downloaded from USGS Earth Explorer website, printed, and examined stereoscopically.
3. CIR = color infrared
4. Copy of one member of each pair attached, with intrepreted lineaments, except VQU, not attached.



USGS
science for a changing world

Carlisle, MA
Boom project
JV 2/11/15

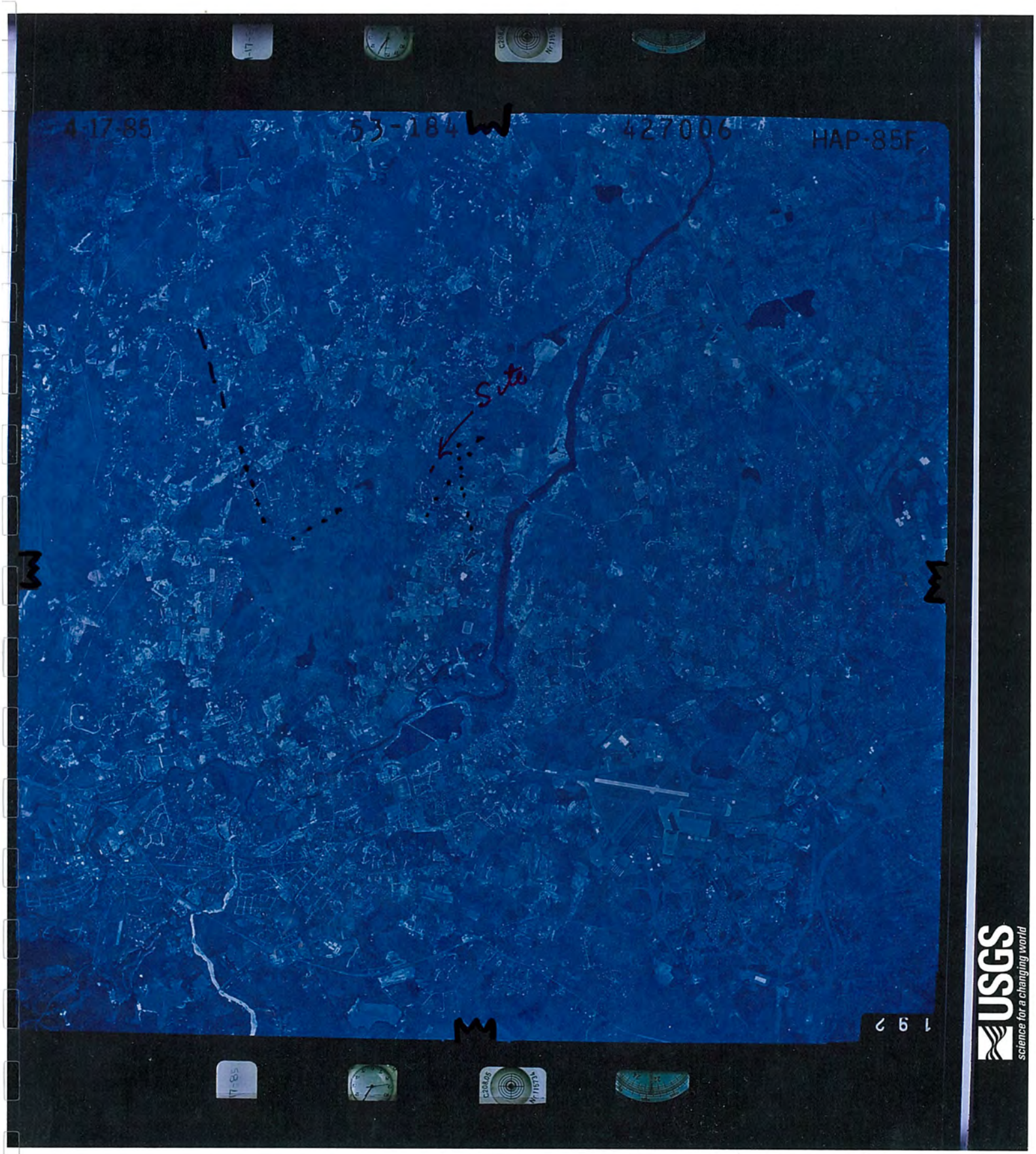


JV 2/11/15

Carlisle, MA
Brem Project

Earth Explorer Id NC1NHAP8500 53184

↑N



Carlisle, MA
JV 2/11/15

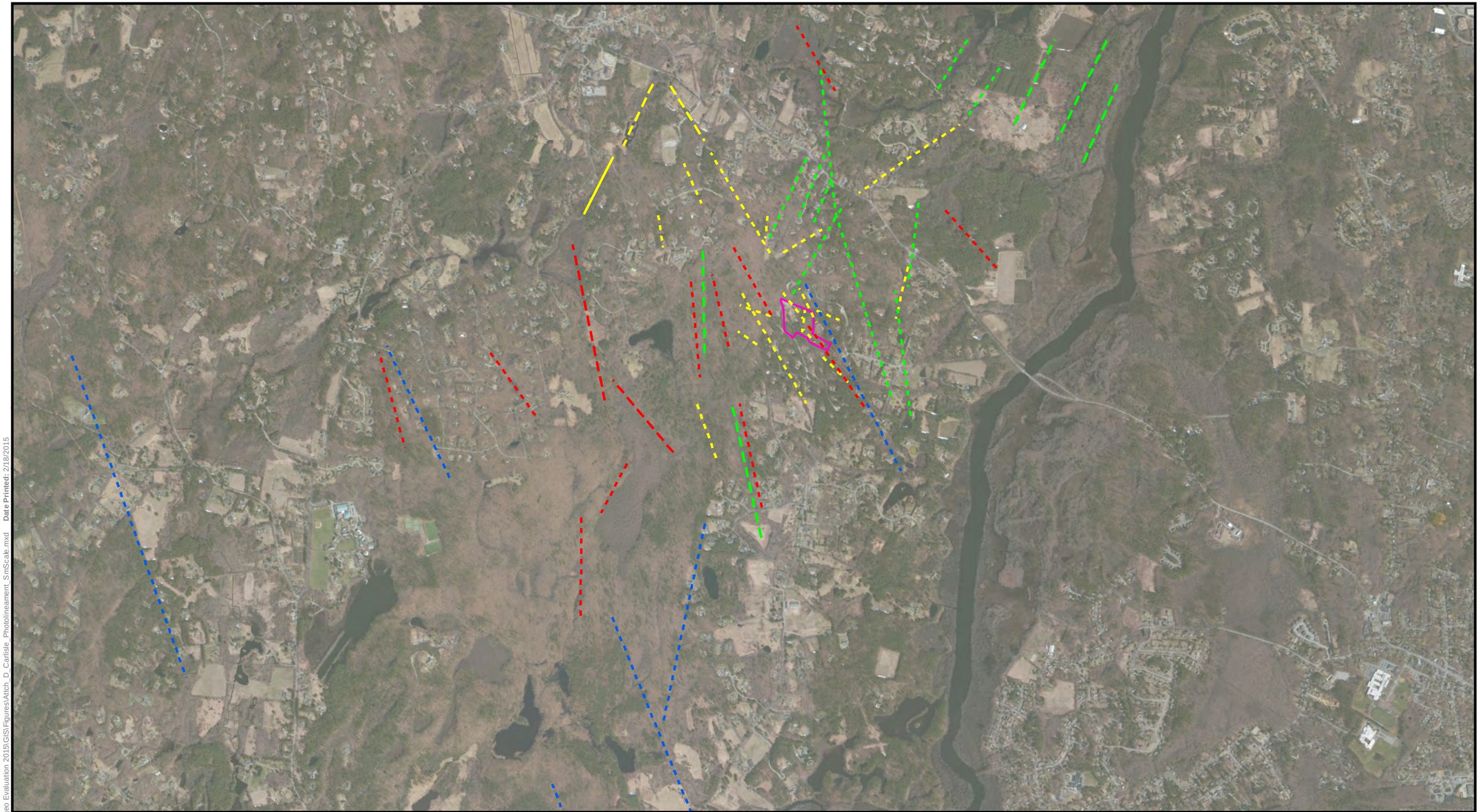
USGS
science for a changing world

EarthExplorer
id
NBINHAP
85003224

Carlisle, MA
JV
2/11/15

Earth Explorer id
ARIVESC00060096

Carlisle, MA
JV 2/11/15



Path: J:\89220.00 - Carlisle Hydrogeo Evaluation 2015\GIS\FiguresAttch_D_Carlisle_PhotolineamentSmScale.mxd Date Printed: 2/18/2015

Notes:

1. Assessor's parcels are from the Town of Carlisle. Contours are from MassGIS. Aerial photography provided by ESRI.

2. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

LGH Project Site

Photolineament Source	Photolineament Strength
NAPP 1995	Intermediate
NHAP 1995 CIR	Subtle
NHAP 1985 B&W	
VESC 1981	

0 1,000 2,000 4,000

Feet

1 inch = 2,000 feet

N

Nobis

Engineering a Sustainable Future

Nobis Engineering, Inc.
585 Middlesex Street
Lowell, MA 01851
T(978) 683-0891
www.nobiseng.com

Client-Focused, Employee-Owned

ATTACHMENT D

PHOTOLINEAMENT MAP
100 LONG RIDGE ROAD VICINITY
CARLISLE, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: JV
PROJECT NO. 89220.00	DATE: FEBRUARY 2015