November 3, 2011

Mr. Raymond Frigon
Remediation Division
Bureau of Water Protection and Land Reuse
State of Connecticut Department of Energy and Environmental Protection
79 Elm Street
Hartford, CT 06106-5127

Subject: Post-Remediation Groundwater Monitoring Plan
Non-Public Properties, Newhall Street Neighborhood (SRD-128)
Hamden, Connecticut

Dear Mr. Frigon:

On behalf of Olin Corporation, AMEC Environment & Infrastructure (AMEC) is submitting this letter which presents the Post-Remediation Groundwater Monitoring Plan for the Non-Public Properties of the Newhall Street Neighborhood in Hamden, Connecticut (Figure 1). This letter is an update to the original July 27, 2010 Monitoring Plan to address DEEP verbal comments. Development of the Post-Remediation Groundwater Monitoring Plan was requested in the Connecticut Department of Energy and Environmental Protection (DEEP) letter to Olin *"Documentation of Compliance with RSR Criteria for Fill and Request for Alternative PMC and DEC Criteria"* dated July 6, 2010. Within the referenced letter the DEEP requests the following:

> *In accordance with paragraph B.3.f of Consent Order SRD-128, within 30 days of the date of this letter, Olin must submit a plan for post-remedial groundwater monitoring for the Commissioner's review and approval, and a schedule for performing the approved monitoring. Since compliance with the applicable groundwater and surface water criteria has been demonstrated prior to the remedy construction, the purpose of the post remediation groundwater monitoring will be to demonstrate the trend in groundwater quality following cleanup of waste fill.*

The remainder of this letter presents the proposed approach to the requested groundwater monitoring, including monitoring wells to be sampled, analyses, frequency of sampling, analysis of trends in analyte concentrations, reporting, and the proposed schedule.

Monitoring Wells

The monitoring wells proposed for sampling under the post-remediation groundwater monitoring program are the five downgradient wells used to demonstrate Pollutant Mobility Criteria in the letter *"Documentation of Compliance with RSR Criteria for Fill and Request for Alternative PMC and DEC*

Criteria" submitted to DEEP by Olin on May 20, 2010. The five monitoring wells, located in Blocks H, L, and T are:

H2003S
H2003D
L2002S
T2002S
T2003S

Figure 2 shows the location of these five monitoring wells and the interpretive direction of groundwater flow. These wells will be re-developed prior to the first sampling event, and if any of these wells are damaged, they will be replaced in a location near the existing well.

Sampling and Analysis

Before sampling groundwater, water levels will be measured in all five monitoring wells. The monitoring wells will be sampled in accordance with DEEP standards using low-flow (<300 milliliters/minute) submersible pumps to minimize sample turbidity with the goal of achieving less than five NTUs and less than one-foot of water level drawdown. During well purging and sampling, the groundwater will be analyzed in the field for turbidity, pH, temperature, dissolved oxygen and specific conductance. Well sampling purge wastewater will be containerized and characterized for proper off-site treatment/disposal at an Olin-approved location.

Specific methodologies for collection of groundwater measurements and groundwater sampling are presented as Attachment A (taken from the Final Quality Assurance Project Plan, Malcolm-Pirnie, Inc., Revised May 2004).

An evaluation of analytes in groundwater for substances in fill material that exceed the existing PMC was presented in the letter "Documentation of Compliance with RSR Criteria for Fill and Request for Alternative PMC and DEC Criteria" submitted to DEEP by Olin on May 20, 2010. The proposed groundwater monitoring program uses the list of analytes in Table 4 of the referenced letter as guidance in proposing that the following analytes be analyzed for in post-remediation groundwater samples:

<u>Semivolatile Organics (Method 8270C)</u>

2,4-Dinitrotoluene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(ghi)perylene
Benzo(k)fluoranthene
Carbazole
Chrysene

Dibenz(a,h)anthracene
Dibenzofuran
Fluoranthene
Indeno(1,2,3-cd)pyrene
N-Nitrosodiphenylamine
Phenanthrene
Pyrene

Metals, Total and Dissolved (Method 6010B)

Antimony
Lead
Nickel

Petroleum Hydrocarbons (Method CT ETPH)

Extractable Total Petroleum Hydrocarbons (ETPH)

Groundwater samples will be analyzed for these parameters by a Connecticut Department of Public Health (CTDPH) approved laboratory.

The following table presents the containers, preservatives, and holding times for the sample fractions:

Parameter	Container	Preservative	Holding Time
SVOCs	(2) 1 L glass w/Teflon-lined cap	Cool to 4ºC	7 days extraction, analysis 40 days
Metals	1 L Polyethylene or Glass	HNO_3, pH < 2	6 months
ETPH	(2) 1 L glass w/Teflon-lined cap	Cool to 4ºC	7 days

Data Validation

Data validation procedures will be conducted as specified in Section 4.0 of the *Final Quality Assurance Project Plan*, dated August 2009.

Duration and Frequency of Sampling

The proposed frequency of the baseline sampling is once every three months for a period of two years, which equates to 8 total rounds of quarterly groundwater sampling. After the two year period, Olin would end groundwater monitoring for wells or analytes based on the following criteria:

After 2 years, if the data have either demonstrated compliance with the Remediation Standard Regulations (RSRs) Groundwater Protection Criteria (GWPC) or have established a trend in some or all wells for some or all analytes, terminate monitoring in those wells for those analytes that are in compliance with the GWPC or have an established trend.

If wells are still in the program after two years, Olin would monitor them semi-annually for up to an additional three years.

For the wells still in the program after two years, if at any time the data either demonstrate compliance with the GWPC or establish a trend, Olin would then terminate monitoring in those wells.

Because there are other source areas in the NPP that are outside Olin's responsibility, Olin's groundwater monitoring would have a maximum duration of five years total. After that period of time, DEP or others under DEP direction would assume responsibility for conducting the groundwater monitoring program.

Trend Analysis

Statistical analysis will be conducted to assess the concentration trends of selected analytes detected in groundwater. Data from wells with at least four sampling events, of which at least half are greater than the respective reporting limit, will be statistically evaluated using the Mann-Kendall non-parametric test for trends, as described below or by other appropriate methodology determined at the time of evaluation.

The Mann-Kendall test is a statistical method commonly used to assess time-ordered chemical concentration data for statistically-significant trends (Gilbert, 1987). It was specifically developed for use with environmental sampling concentration data by various geo-statistical researchers, and regulatory agencies commonly use and accept the Mann-Kendall test to evaluate statistical trends. This trend analysis method is a preferred method for environmental data because the method does not require a set time period between sample events, the data need not conform to any particular distribution, and non-detect values can be used by assigning a value of less than the reporting limit. The Mann-Kendall test for trends is a nonparametric statistical evaluation that uses only the relative magnitudes of the data rather than the actual data values to evaluate the probability that a trend exists. The data are ordered by time, and each data point is compared to data points corresponding to earlier sampling dates. The number of earlier data points that are higher or lower than each evaluated data point is used to calculate the Mann-Kendall statistic (S). The statistic is used in conjunction with the total number of data points (n) to look up the probability that a trend (positive or negative) exists.

The Mann-Kendall statistic will be calculated using the Monitoring and Remediation Optimization System (MAROS) software tool (AFCEE, 2004). MAROS categorizes Mann-Kendall trends as increasing, probably increasing, stable, probably decreasing, decreasing, or no trend. If the Mann-Kendall statistic demonstrates a steady or decreasing or probably decreasing trend to groundwater contaminant concentrations in a well, monitoring will be discontinued in that well prior to the end of the 2-year baseline monitoring period.

Reporting

Following completion of groundwater monitoring, a report will be prepared summarizing the groundwater elevation measurements, sampling, analytical data, data validation, and trend analyses.

Schedule

Groundwater monitoring will be initiated following completion of remedial activities within the Non-Public Properties. Within four months of the final round of sampling, a Draft report of findings will be issued to the DEEP for review.

Well Abandonment

The remaining wells in the NPP not included in this monitoring program will be abandoned prior to the completion of the removal of fill in the NPP area. The 5 remaining wells where trend monitoring is to be performed will be left in place for DEP or others to continue monitoring if needed and abandonment of those 5 wells will be the responsibility of DEP or others under DEP direction.

Based upon recent discussions, we also are documenting the mutual agreement that completion of the scope of work described herein fulfills Olin's post-remedial monitoring obligations under the consent order.

Please do not hesitate to contact me at (207) 775-5401 should you have any questions or concerns regarding this work plan.

Sincerely,

AMEC Environment & Infrastructure

Nelson Walter, P.E.
Project Manager

Rod Pendleton, P.G
Principal Scientist

Enclosure

cc: David Share (Olin)
Curt Richards (Olin)
Carrie Hunt (Olin)
Alan Elia (Sevenson)
Rob Bell (DEEP)
Pat Bowe (DEEP)

DOCUMENT CERTIFICATION

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I have personally examined and am familiar with the information submitted in this document and all attachments thereto, and I certify, based on reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, that the submitted information is true, accurate and complete to the best of my knowledge and belief. I understand that any false statement made in the submitted information is punishable as a criminal offense under §53a-157b of the Connecticut General Statutes and any other applicable law.

David M. Share, Director, Environmental Remediation

~~Chief~~ Executive ~~Officer~~ (or duly authorized representative)
Olin Corporation

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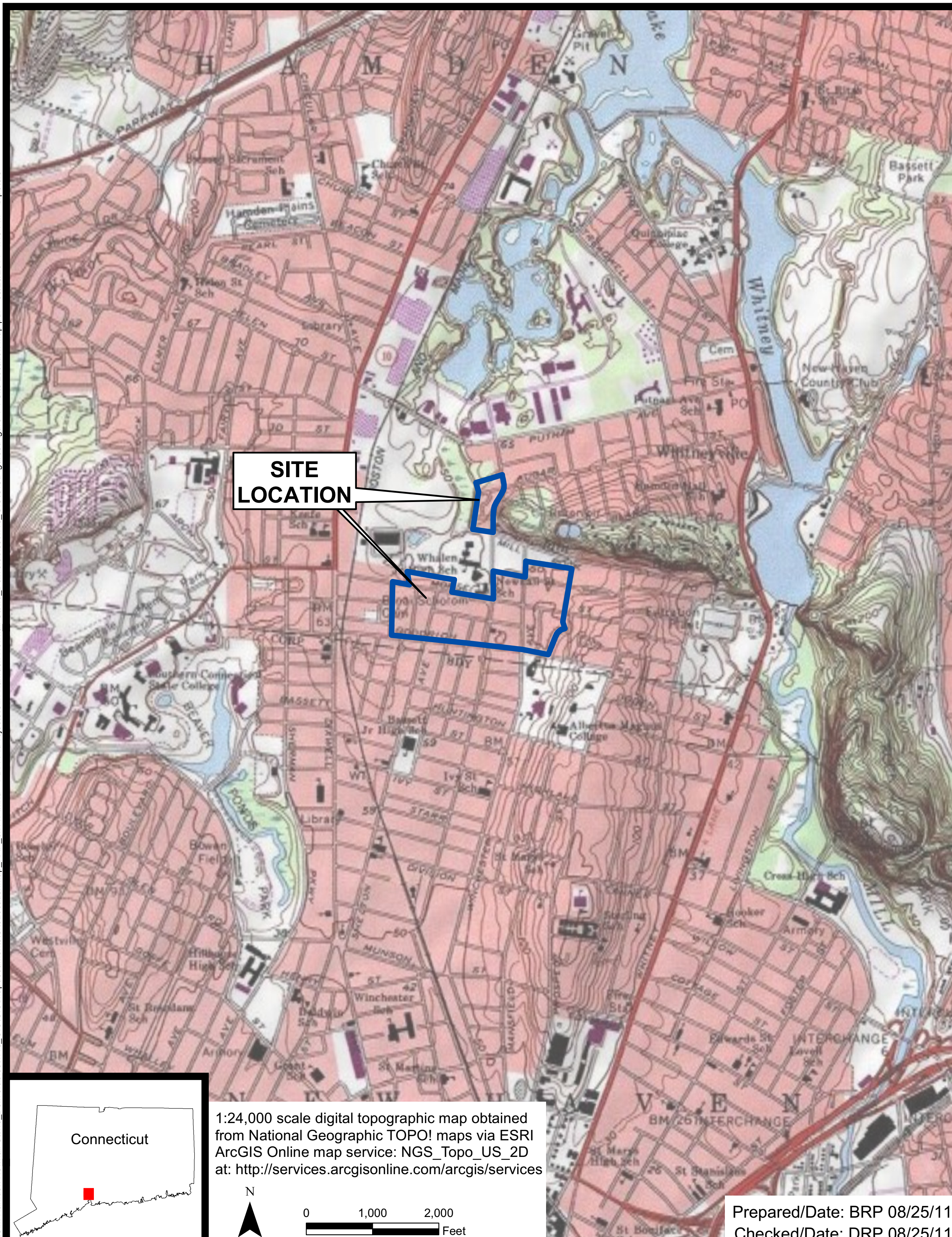
Nelson Walter, Project Manager

MACTEC Engineering and Consulting, Inc.

FIGURES



1:24,000 scale digital topographic map obtained from National Geographic TOPO! maps via ESRI ArcGIS Online map service: NGS_Topo_US_2D at: http://services.arcgisonline.com/arcgis/services

N

0 1,000 2,000 Feet

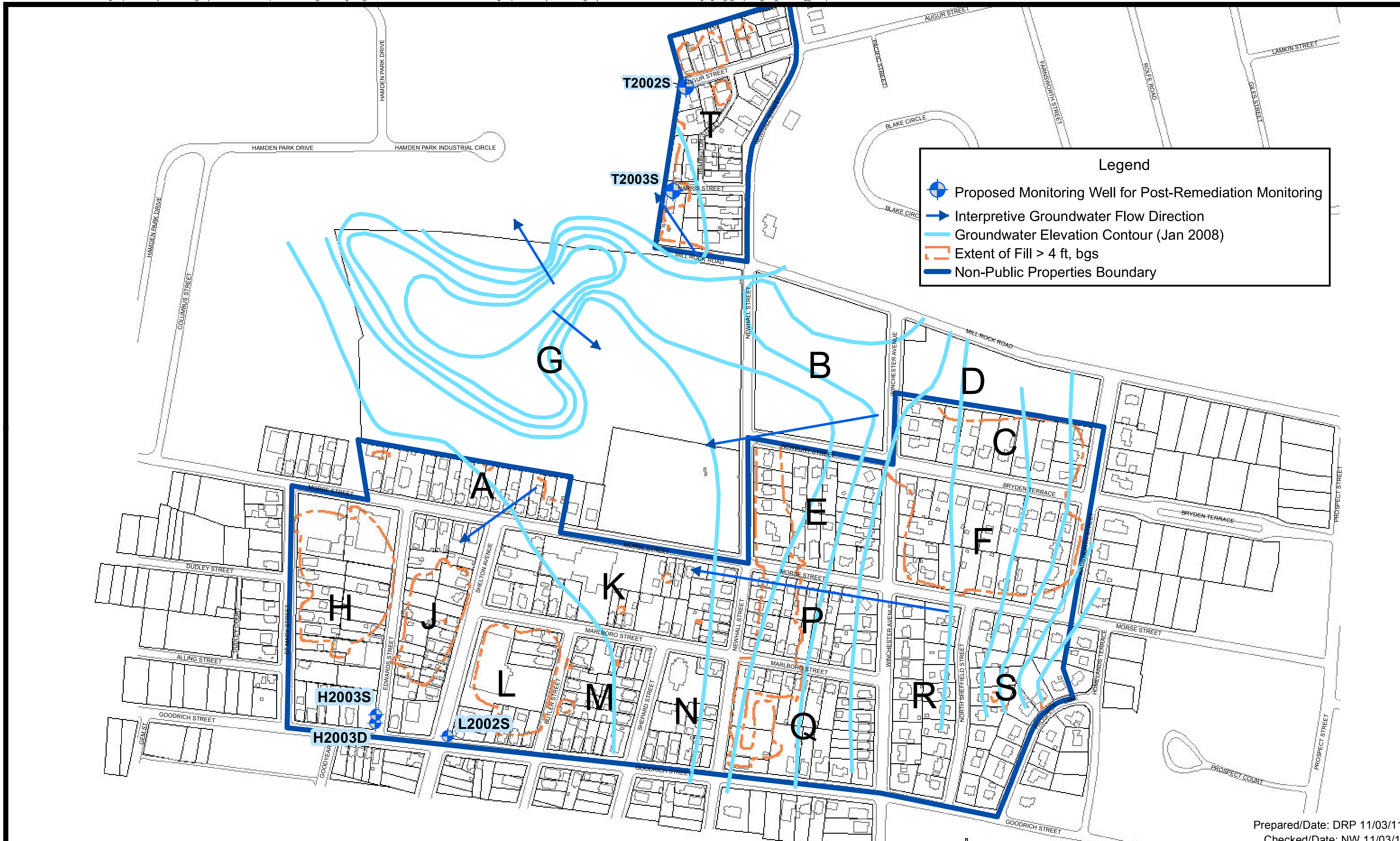
Prepared/Date: BRP 08/25/11
Checked/Date: DRP 08/25/11

Property Specific Remedial Action Plan
Newhall Street Neighborhood
Hamden, Connecticut

amec

Figure 1
Site Location Map

Document: C:\Documents and Settings\drpendleton\My Documents_Projects\Hamden\GIS\Mapdocuments\GW_Monitoring Plan_Nov2011.mxd PDF: C:\Documents and Settings\drpendleton\My Documents_Projects\Hamden\Groundwater Monitoring\Figure_2_Proposed_GW_Monitoring_Locs.pdf 11/03/2011 3:42 PM DRPendleton



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0 75 150 225 300 600 900 Feet

Olin Corporation
Newhall Street Neighborhood
Hamden, Connecticut

Proposed Groundwater Sampling Locations
Post-Remediation Groundwater Monitoring
Project 6107-11-0004 Figure 2

ATTACHMENT A

Groundwater Level Measurement Procedures

1.0 OBJECTIVE

The objective of these guidelines is to provide general reference information and technical guidance on the measurement of groundwater levels.

2.0 LIMITATIONS

These guidelines give overall technical guidance only and could be modified by specified requirements of project-specific plans for measuring groundwater levels in wells.

3.0 DEFINITIONS

Water table -- The surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure.

Piezometric (potentiometric) surface – An imaginary surface representing the total head of groundwater in an aquifer that is defined by the level to which water will rise in a well screened at and/or beneath the water table.

4.0 GUIDELINES

4.1 General

In measuring groundwater levels, there should be a clearly established reference point of known elevation, which is normally the top of the PVC well casing. The field notes recorded should clearly describe the reference used. To be useful, the reference point should be tied in with the USGS benchmark or a local datum. An arbitrary datum could be used for an isolated group of wells if necessary. (All groundwater level measurements shall be made and recorded to the nearest 0.01 foot.) After the groundwater observation standpipe has been installed or the cased borehole completed and left open, the initial depth to the water should be measured and recorded. The date and time of the reading should also be recorded. Information related to precipitation should be included in the data. The depth of the groundwater should be entered.

Appropriate remarks describing the history of the groundwater standpipe or open-cased borehole should be recorded along with the name of the individual who has read the groundwater levels in a monitoring well.

Readings should be taken regularly, as required by the field team leader. Groundwater standpipes or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart; the frequency of such readings should be established by the site geologist.

4.2 Equipment

Electronic Water level Indicator

This instrument consists of a spool of graduated, small-diameter cable and a probe attached to the end. When the probe comes in contact with the water, the circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact. Pen light batteries are normally used for a power source.

4.3 Groundwater Level Measuring Techniques

Procedure

1. Ensure well is at equilibrium with atmospheric pressure (see note below).
2. Check operation of equipment above ground.
3. Record well number, top of casing elevation and surface elevation if available. Water levels should be taken from top of the protective casing or a reference point at the ground surface for borehole measurements. The distance between the top of the protective casing and inner casing should be recorded.
4. Record water level to the nearest 0.01 foot.
5. Measure depth to bottom of well to the nearest 0.01 foot. Compare results to well installation log. Record evidence of obstructions or siltation, odor, and other pertinent observations in the field logbook.
6. Record the time and day of the measurements.

Note: In flush-mounted wells with air tight plugs, or wells without vents, the hydraulic head may not be the same as in an open or vented well. Remove well cap and allow sufficient time for the well to equilibrate with atmospheric pressure. Several measurements may be needed to ensure equilibrium has been reached. This is especially important for deep wells.

When there is oil on the water, high specific conductance, water cascading into the well, or a turbulent water surface in the well, measuring with an electric sounder may be difficult. Before lowering the probe into the well, the circuitry can be checked by dipping the probe in water and observing the indicator. The probe should be lowered slowly into the well and once the buzzer sounds, slowly raised and lowered until it just ceases sounding. At this point the depth to water is read directly from the graduated cable at the reference point and recorded to the nearest 0.01 feet.

Low Flow Groundwater Sampling Procedures

1.0 OBJECTIVE

Low flow sampling is the purging and sampling of groundwater at low flow rates to collect groundwater samples that are representative of the formation from which they are being withdrawn. Sampling pump flow rates are set to minimize water level drawdown within the well so that the majority of the groundwater withdrawn from the well is entering horizontally from the geologic formation. There are three primary benefits to collecting groundwater samples in such a manner. First, using a low flow rate during sampling promotes laminar flow, which minimizes turbulence and the disturbance of sediment at the bottom of a well. Thus, groundwater samples are less turbid, which reduces the need to filter. Second, the amount of groundwater withdrawn from the sampling well is significantly reduced, minimizing investigation derived waste. Third, there is less opportunity to aerate the sample, which helps preserve the chemical quality of the groundwater sample.

2.0 LIMITATIONS

Low flow sampling can be used to collect groundwater samples from any well to be analyzed for any contaminant, geo-chemical parameter, or biological parameter. These procedures give overall technical guidance only and may be modified by specific requirements of project-specific plans for groundwater sampling.

3.0 PRE-SAMPLING PROCEDURES

Prior to any sampling or purging, measure the depth to water surface (Dws) with an electronic water level indicator according to "Groundwater Level Measurement" procedures.

Measure the length (L) and inside diameter (D), in meters, of the tubing used in the sampling pump assembly. Calculate tubing volume using the following equation:

Volume, mL = $L \times \pi D^2/4 \times 10^6$ mL/m^3. For example, 10 mm diameter tubing has a volume of approximately 80 mL for every meter in length.

4.0 SAMPLING PROCEDURES

1. Prior to lowering sampling equipment into a well, and if field conditions permit, clean plastic sheeting should be spread and used as a ground cover around the well. This "good housekeeping practice" will minimize the potential for contamination caused by contact of the ground with the equipment.
2. Install the pump by slowly lowering the pump assembly and tubing into the well. Lower the pump intake below the water surface and pump at a fast enough rate to displace all air or other water from the pump discharge line. Then, decrease flow rate and lower pump to zone of maximum flow through the formation, if known, or to the center of well screen, if

unknown. The pump should be set to the appropriate depth with the intake being a minimum of two-feet above the bottom of the well to prevent disturbing and re-suspending any sediment at the bottom of the well.

3. Monitor water level while pumping. Begin purging the well at a rate of 250 to 500 milliliters per minute (ml/min). Pump at as slow a rate as possible to avoid lowering the water level by more than 0.3 feet, if possible. Measure flow rate using a graduated container and stopwatch. The flow rate should be monitored and adjusted accordingly to meet these criteria. Any adjustments that are made should also be recorded.

4. Monitor field parameters using a calibrated instrument with flow-through cell. Field parameters (pH, conductivity, temperature, redox potential, DO, and turbidity) and water level should be monitored after purging the equivalent of one tubing volume. The well is considered stable and ready to be sampled once the field parameters are within the following limits over three consecutive readings:
    - Turbidity (10% for values greater than 1 NTU)
    - DO (10%)
    - Specific conductance (3%)
    - Temperature (3%)
    - pH (+/- 0.1 standard units)

   The pump should **not** be removed or shut off between purging and sampling.

5. **Sample Collection:** If necessary, reduce the flow rate to 100 to 250 ml/min to reduce turbulence while filling sample containers during sample collection. Where wells are purged at a flow rate less than 100 ml/min, maintain the same flow rate during sample collection. Disconnect the inflow line from the flow-through cell and collect the groundwater sample. Groundwater samples should be collected in order of importance, according to the project requirements. Clean gloves should be worn and the container caps kept clean when filling the sample containers. The sample bottles must be labeled with the proper identification number. When filling the various sample bottles, care should be taken to minimize sample aeration by lowering the pumping rate if necessary. Some of the sample containers and bottles may contain a measured amount of chemical preservative. Consequently, the containers and bottles are not rinsed with sample water before filling. Care must be taken to avoid overfilling and diluting the preservative. Good technique includes filling the sample bottles one at a time and recapping before filling the next bottle.

6. **Remove Pump:** Once sampling is complete, slowly remove the pump assembly and tubing from the well. If the tubing is dedicated to the well, disconnect the tubing from the pump, re-insert the tubing into the well, and secure the tubing so it is easily accessible.

7. **Secure Well:** Secure the top of the well casing with a locking cap or compression plug and close the well. In the case of a stick-up, lock the outer casing.

5.0 DECONTAMINATION

After the pumps are removed from a well, they should be rinsed and the sampling lines should be purged with clean water. Collect one equipment blank each survey for all required parameters after completing this clean water purge procedure. Record which wells were sampled before and after collection of the equipment blanks. Then pump out any remaining water left in the pump and tubing before proceeding to the next well. Use dedicated tubing for each well, when feasible.

6.0 POTENTIAL PROBLEMS/TROUBLESHOOTING

Insufficient yield, cascading, field parameters failing to stabilize, and aerating the groundwater sample are potential problems when trying to use low flow protocols to collect representative groundwater samples.

6.1 Insufficient Yield/Cascading

A low yielding well that cannot sustain a low flow purge rate may eventually go dry. The sampler should take care not to dewater the well below the top of the well screen to prevent cascading of the sand pack. Therefore, pumping a well dry should be avoided in all situations. If a well should go dry, the groundwater sample should be collected as soon as there is sufficient recharge to collect the sample. If the well has not recharged sufficiently within 48 hours, then the well should not be sampled.

A low yielding well that consistently demonstrates that it cannot sustain a low flow purge rate of 250 ml/min or less should not be sampled using low flow protocols. This is because the resultant groundwater sample is representative of the stagnant groundwater within the well and the surrounding sand pack, and not representative of the formation. In addition, in this circumstance, sample turbidity is typically high, which can bias the analytical results of groundwater samples being analyzed for organic compounds and metals.

6.2 Key Field Parameters Fail to Stabilize

If any key parameters fail to stabilize within four hours of purging, then the following alternatives should be considered:

1. Continue purging until you reach stabilization.
2. Stop purging, do not collect a sample, and document the activity.
3. Stop purging, collect a sample, and document the activity
4. Stop purging, secure the well, and try again the next day.

The key parameter for samples being analyzed for VOCs is dissolved oxygen (DO). The key parameter for all other samples is turbidity. These also happen to be the two parameters that typically take the longest to stabilize.

Turbidity failing to stabilize can sometimes be avoided. Periodically, sediment gets trapped in the Cell during purging, which causes turbidity readings to fluctuate and prevents turbidity from stabilizing. To avoid this, the sampler should visually compare the turbidity of the groundwater in the Cell with the groundwater entering the Cell. If the groundwater entering the Cell is clearer, then disconnect the inflow line, drain the turbid groundwater from the Cell, and reconnect the inflow line. Turbidity readings should then begin to stabilize. Repeat as needed.

DO failing to stabilize can sometimes be avoided. Periodically, air bubbles will form in the Cell or sample tubing, which causes DO readings to fluctuate and prevents DO from stabilizing. To avoid this, the sampler should ensure that the Cell and inflow line to the Cell are sealed tightly. Once tightened, groundwater coming into the Cell will displace the air from the Cell and DO readings should then begin to stabilize.

6.3 Aerating the Sample

To prevent inadvertently aerating the groundwater sample, the flow rate should be set so that pump suction is sustained, and positive groundwater flow through the sample tubing is maintained. To ensure this occurs, the sampler should minimize the length and diameter of the sample tubing. It is recommended that either six or ten millimeter inner diameter tubing be used.

Where centrifugal pumps are being used to collect a groundwater sample from a deep well, preventing aeration and sustaining a low flow rate becomes problematic. These issues can be minimized if an impeller is removed from the pump. This allows the pump to run at a lower flow rate, which reduces the potential for aerating the groundwater sample. There is also concern with heating the groundwater sample when using a centrifugal pump. However, the groundwater temperature rarely increases by more than two degrees Celsius during sampling.