May 22, 2014

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RE: Apex Oil Company, Inc.'s Response to Comments Regarding the LNAPL Component to the Conceptual Site Model, Hartford Petroleum Release Site, Hartford, Illinois

Ms. Kaysen and Mr. Turner:

On behalf of Apex Oil Company, Inc. (Apex), Trihydro Corporation (Trihydro) submitted the draft *Light Non-Aqueous Phase Liquid (LNAPL) Component to the Conceptual Site Model (CSM), Hartford Petroleum Release Site (Hartford Site), Hartford, Illinois* to the United States Environmental Protection Agency (USEPA) and Illinois EPA on February 21, 2014. The Hartford Working Group (HWG) provided comments regarding this first draft deliverable to the CSM on April 11, 2014; subsequently the USEPA and Illinois EPA (the Agencies) provided comments via correspondence on April 16, 2014. Trihydro appreciates all of the technical comments regarding the draft *LNAPL Component to the CSM*, as well as the Agencies' consolidation of their comments with those provided by the HWG.

The following provides a summary of Trihydro's response to the Agencies' comments. Trihydro has not responded to the HWG comments unless the Agencies consolidated those comments with their own comments. The *LNAPL Component to the CSM* has been revised where indicated in our response to the comments included herein. Where further clarification or revisions seemed necessary, Trihydro also has revised the *LNAPL Component to the CSM* to incorporate certain suggestions provided by the HWG. As noted by the Agencies in its April 18, 2014 comment letter, the *LNAPL Component to the CSM* is "only one component of the comprehensive CSM." Therefore, some of the comments provided by the Agencies and HWG may not be addressed within the revised *LNAPL Component to the CSM*; however these comments should be resolved within future components to the CSM including the dissolved phase, vapor phase, or comprehensive CSM deliverables.

GENERAL COMMENTS

USEPA General Comment No. 1: The Draft LNAPL Component to the CSM provided significant historical detail and background information but lacked in details concerning current site conditions or substantial comparisons thereof.

Trihydro Response to USEPA General Comment No. 1: As described in the *Comprehensive Conceptual Site Model Framework and Timeline, Hartford Area Hydrocarbon Plume Site* (*CSM Framework*, Trihydro 2013), "the CSM will integrate information previously collected at the Hartford Site with an emphasis on further analysis and visual presentation of the existing data. In addition, further investigation and monitoring activities will be proposed to resolve data gaps or update previous investigation findings as needed" (emphasis added). With regard to "existing data," the majority of activities related to assessment of the distribution, characterization, mobility, and recoverability of LNAPL performed at the Hartford Site were completed between July 2003 and May 2006, and previously reported within the *Active LNAPL Recovery System Conceptual Site Model* (Clayton 2005) and the *Active LNAPL Recovery System 90% Design Report* (Clayton 2006). Assessment activities performed over this timeframe included installation of: (1) 109 borings for cone penetrometer and laser induced fluorescence (LIF) testing (HROST-prefix), (2) 66 groundwater monitoring wells (HMW-prefix), (3) 17 piezometers (HP-prefix), (4) 271 multipurpose monitoring points (MP-prefix), and (5) 260 vapor monitoring probes (VMP- and VP-prefix). LNAPL recharge and recoverability tests were also performed in 19 wells via multiphase extraction and low-flow dual phase recovery between May and November 2005 (H2A 2006). After May 2006, the focus seems to have shifted from assessment to optimization of mitigation measures and further pilot testing of multiphase extraction within specific portions of the Hartford Site through installation of more than 75 soil vapor recovery wells (HSVE-prefix) and 5 multiphase extraction wells (MPE-prefix). The installation of an additional 66 multipurpose monitoring points (MP-prefix) and 3 groundwater monitoring wells (ASW-prefix) since May 2006, appear related to monitoring of the soil vapor extraction system and proposed pilot testing slated to be performed in Area A. Accordingly, because the principal purpose of the *LNAPL Component to the CSM* is to evaluate existing data, information was primarily obtained from historical assessment activities performed between July 2003 and May 2006.

This component to the CSM also incorporates more recent data collected since May 2006, including lithologic information from newly installed wells, LNAPL thickness measurements, and manual LNAPL skimming results. Additional LIF data collected in 2013 from 24 borings (UVOST-prefix) was presented in Section 4.5 of the draft *LNAPL Component to the CSM* to evaluate changes in the vertical and horizontal limits of the smear zone. The comparability of the LIF data collected in 2004 and 2005 using the rapid optical screening tool (ROST™) and the data collected in 2013 using the ultraviolet screening tool (UVOST™) are addressed in subsequent comments herein. Finally, this component of the CSM provides an explanation regarding the first phase of additional LNAPL recovery pilot testing performed beneath Area A in late 2011 and early 2012 that was reported in the *Light Non-Aqueous Phase Liquid Recovery Pilot Test Interim Report* (WSP 21012).

Several data gaps regarding recoverability, LNAPL composition, and source zone depletion were identified in Section 6.5 of the draft *LNAPL Component to the CSM.* As planned in the *CSM Framework*, these data gaps will be resolved in subsequent CSM deliverables to be submitted to the Agencies.

USEPA General Comment No. 2: In the *LNAPL Active Recovery System Conceptual Site Model* prepared for the Hartford Working Group by Clayton Group Services, Inc. dated December 15, 2005, Clayton Group produced an *LNAPL Characterization Figure 3-2* and a series of LNAPL Specific Thickness Figures for the Rand Stratum (3-4), the EPA Stratum (3-5), and the Main Sand (3-6). A series of figures or a 3D Model comparison of this historic data with more recent data would be helpful.

> ***Trihydro Response to USEPA General Comment No. 2:*** While it is not possible to prepare figures showing recent specific LNAPL thickness estimates for comparison to those provided within the *LNAPL Recovery System Conceptual Site Model* (Clayton 2005), as LNAPL saturation estimates via soil coring has not been performed since 2005. Trihydro has added several figures (referenced within Sections 4.2 through 4.5) depicting changes in the LNAPL thickness measurements within monitoring wells and multipurpose monitoring points installed within the hydrostratigraphic units beneath the Hartford Site.

USEPA General Comment No. 3: Has there been any attempt to estimate LNAPL volumes within each stratum or to differentiate between the potentially mobile component versus the residual component? To that end, why hasn't more narrative been provided to discuss and interpret transmissivity values, provided the utility of that metric to define hydraulically recoverable, mobile LNAPL?

> ***Trihydro Response to USEPA General Comment No. 3:*** Trihydro has not completed estimates of LNAPL release volumes due to the complexity of making such estimates within a highly heterogeneous setting such as the Hartford Site. There have been two previous estimates of LNAPL release volumes, which were reported within the *Innovations in Site Characterization, Streamlining Cleanup at Vapor Intrusion and Product Removal Sites Using the Triad Approach: Hartford Plume Site, Hartford, Illinois* (USEPA 2010). The first estimate was developed by Mathes (1979) based on apparent LNAPL thicknesses in wells and reported initial release volumes of approximately 10 million gallons. The second estimate was developed by the USEPA (2010) based on LNAPL porosities and saturations measured in six soil cores collected from the smear zone in 2005. The petrophysical results from the soil cores were compared to the LIF profiles form nearby borings and broad assumptions were made regarding LNAPL saturations. The USEPA estimated a release volume of 8 million gallons beneath the Hartford Site with an uncertainty of a factor of two or more. The uncertainty was reportedly attributed to the LNAPL saturation estimates made with data that had significant intra- and inter-core variability (although the inter-core variability is largely removed by the averaging used to estimate release volumes) that is further described in Section 5.1 of the revised *LNAPL Component to the CSM*. Also, uncertainty with the LNAPL saturation estimates attributed to potential fluid losses during collection of the soil cores may result in additional variability in the LNAPL release estimates.
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> While Trihydro is not proposing to collect soil cores across the Hartford Site for the purpose of estimating LNAPL saturations and refining the release volume estimates, we may estimate the volume of LNAPL-impacted soil as part of the *Comprehensive CSM* (if the data allow). The estimate of LNAPL impacted soil would be used to evaluate where the majority of the LNAPL mass is present and where remedial efforts should be focused.

Additional soil cores may be collected to supplement this analysis and to evaluate the LNAPL saturations and potential recoverability within areas proposed for future remedial efforts within the *Comprehensive CSM* deliverable.

Trihydro has added a discussion regarding LNAPL transmissivity estimates made using various tests over the past decade and the relative usefulness of these values for estimating LNAPL recoverability within Section 5.2 of the revised *LNAPL Component to the CSM*.

SPECIFIC COMMENTS

USEPA Specific Comment No. 1 (Section 1.1): Although the Agency acknowledges this component to the CSM is limited to potentially mobile LNAPL, a distinction should be made between hydraulically recoverable, mobile LNAPL and other phases of recoverable LNAPL. (See general comment above regarding transmissivity.)

HWG Specific Comment No. 4: Given the extensive direct (pilot testing, Tn testing, sustained recovery) and indirect (petrophysical properties, LNAPL properties, TPH/saturation data, LNAPL hydrogeologic condition data, etc.), it seems unlikely that recoverability is a significant data gap. If this statement is intended to refer only to the submerged LNAPL in the Village, then it should be revised accordingly.

Trihydro Response to USEPA Specific Comment No. 1: Two new sections have been added to the revised *LNAPL Component to the CSM*. Section 5.1 describes historical petrophysical results, saturation estimates, analytical modelling of LNAPL recoverability, and LNAPL specific thickness (Do) estimates. Section 5.2 provides a review of the LNAPL transmissivity estimates completed through 2012. In these sections, a distinction regarding LNAPL that is potentially mobile versus that which is present below residual saturation is provided.

USEPA Specific Comment No. 2 (Section 2.0): The description and site boundary as described in Section 2.0 and Figure 1, is not consistent with the site boundary as depicted in the Unilateral Administrative Order issued by the U.S. Environmental Protection Agency under Section 7003 of the Resource Conservation and Recovery Act, 42 USC § 6973. Docket No. RCRA-05-2010-0020.

Trihydro Response to USEPA Specific Comment No. 2: The Hartford site boundaries have been defined in the Unilateral Administrative Order as being bounded to the north by Rand Avenue, to the east by the railroad tracks parallel to Olive Street, to the south by Donna Drive and Hartford Park, and to the west by Illinois State Highway 3. The *LNAPL Component to the CSM* does not seek to redefine the legal boundaries of the Hartford Site; however, discussions provided in this and future components to the CSM will focus on the current extent of petroleum related constituents in soil, groundwater, and soil vapor. As such, references to the Hartford Site describe the area depicted on Figure 1 of the draft *LNAPL Component to the CSM*. The functional definition of the site boundary for the purpose of the CSM deliverables described in Section 2.0 have been revised accordingly.

USEPA Specific Comment No. 3 (Section 2.2): Can Apex demonstrate and quantify the impacts of skimming on LNAPL connectivity within the area of the well to support this statement? Furthermore, can Apex demonstrate the temporal and spatial effects of these impacts on potential future recovery efforts?

> **HWG Specific Comment No. 14:** Statement is not supported by data, there is no data documented here to state how far away from wells recovery efforts have been effective.

> > ***Trihydro Response to USEPA Specific Comment No. 3:*** Efforts to estimate the radius of capture for LNAPL skimming performed in the recovery wells (RW-prefixes) or manual skimming conducted in the groundwater monitoring wells or multipurpose monitoring points has not been performed via volumetric analyses, LNAPL tracer testing, or some other method. Charbeneau and Beckett (2007) suggest a radius of capture for LNAPL skimming between 10 and 30 feet. It is expected that the radius of capture for manual skimming efforts will be on the low end of the suggested radius of capture as a result of the methodology used. In general, field personnel would visit a location with more than 0.5 feet of LNAPL, conduct skimming, and then allow the LNAPL to recharge above this thickness before skimming again. This method would mean that drawdown in the monitoring well or monitoring point would only be maximized immediately after skimming, and would decrease over time until the next skimming event. Since drawdown was lower during recharge, this probably meant a lower radius of capture than would have been achieved with a dedicated skimmer (i.e., consistently maximized drawdown).
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> > An evaluation of the radius of influence of manual skimming and its effects on future remedial efforts may be considered in the *Comprehensive CSM*. This evaluation would compare LNAPL thicknesses and transmissivity estimates in monitoring wells and monitoring points where skimming has been performed to locations where manual skimming has not been performed. It should be noted that this comparison will not be a definitive indicator of the effects of skimming alone. It is possible that other factors, such as natural source zone depletion (which decreases LNAPL saturations over time) or continued smearing of LNAPL by piezometric surface fluctuations, could also reduce LNAPL thicknesses and transmissivities at locations where skimming has and has not been performed. Such an evaluation may help to determine if future LNAPL recovery, <u>in the zone of typical piezometric surface fluctuations,</u> would be low only adjacent to previously skimmed wells, or if low recovery might also be expected across the remainder of the smear zone footprint.

USEPA Specific Comment No. 4 (Section 2.2.1): The WSP recovery pilot test was the most recent attempt at hydraulic recovery; therefore, additional details should be included here. The test parameters, results and conclusions should be added. Also, it appears appropriate to include a discussion regarding the implications of the data presented in Tables 3 and 4. Please expand upon the significance of that data and the implications on hydraulic recovery of mobile LNAPL.

> **HWG Specific Comment No. 14:** Define what is meant by "not measurably improved" and provide parameters for the test - hours?, days?, weeks?, months? Percent change? Trend direction?
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> **HWG Specific Comment No. 20:** Again LNAPL recoverability, transmissivity, is not considered and low recoverability more so than technology could have been the reason for lack of recovery.

> ***Trihydro Response to USEPA Specific Comment No. 4:*** Section 2.2.1 has been revised to provide additional description of the methods, results, and conclusions of the additional LNAPL recovery pilot test performed by WSP in late 2011 and early 2012. In addition, Section 5.0 of the *LNAPL Component to the CSM* provides an explanation of the significance of the pilot test results on future LNAPL recovery efforts at the Hartford Site.

USEPA Specific Comment No. EPA 5 (Section 2.3.8): Apex has not discussed or presented the Main Silt's influence on LNAPL behavior. This information must be presented to support the exclusion of the Main Silt from the discussion on LNAPL recoverability.

> **HWG Specific Comment No. 25: I**t is true that the contact between the Main Silt and Main Sand is gradational and hard to differentiate. However, it should be differentiated from the Main Sand. The Main Silt can influence the extent of the LNAPL. In addition, it (and including saturated fine grained sands in the Main Sand) can act as a confining layer to LNAPL. The influence of the Main Silt on the LNAPL should not be minimized.

> ***Trihydro Response to USEPA Specific Comment No. 5:*** The *LNAPL Active Recovery System Conceptual Site Model* (Clayton 2005) previously considered the Main Silt “as being a portion of the Main Sand” and did not differentiate these units as separate aquifers nor did it consider the effects of the Main Silt with respect to LNAPL recoverability. Previous descriptions (Clayton 2005, Clayton 2006) of the extent of the Main Silt have been inconsistent due in part to the challenges in differentiating the stratum from over and underlying strata. The Main Silt has been described as compositionally similar to the North Olive and Rand strata, and although compositionally different from the Main Sand, the gradational contact between the Main Silt and Main Sand makes discerning the units difficult (Clayton 2005). The interpretation of the lateral extent of the Main Silt is presented on Figure 6 of the revised *LNAPL Component to the CSM* and is based on a review of historical isopach maps, geologic cross-sections, and lithologic logs from borings installed throughout the Village of Hartford.
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> Figure 6 also shows the aerial extent of the smear zone determined via LIF. Presence of the Main Silt stratum generally coincides with the southwestern limits of the smear zone. Two remediation areas (western portion of Area B2 and southwestern portion of Area C) were proposed in the *Active LNAPL Recovery System 90% Design Report* (Clayton 2006) within portions of the smear zone that intersects the Main Silt stratum. Multiphase extraction targeted a limited portion of the Main Sand overlain by the Main Silt in Area B2, with SVE being proposed in Area C.
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> A comparison of the groundwater and LNAPL elevation over time with respect to the Mail Silt contact are presented on Figure 19 of the revised *LNAPL Component to the CSM*. LNAPL is generally not observed at a high frequency nor at significant thickness within monitoring locations screened within the Main Silt (e.g., MP-038B and MP-048B) compared to locations screened in the Main Sand. This observation is consistent with vapor recovery being the sole remedial approach proposed within this stratum in the *Active LNAPL Recovery System 90% Design Report* (Clayton 2006).

There are locations where the Main Silt appears to have a confining effect on LNAPL thickness measurements; however, this is only reflected in the routine gauging results from a few locations such as monitoring point MP-038C. In other locations, the Main Silt does not appear to have any effect on apparent LNAPL thicknesses measurements, such as monitoring point MP-048C (where LNAPL thicknesses do not substantially change relative to the groundwater and LNAPL elevations) or monitoring point MP-049C (where the overlying fine grained unit appears to result in confined LNAPL and groundwater conditions but not the Main Silt). Further evaluation of the influence of the Main Silt with respect to proposed remedial approaches may be considered as part of the *Comprehensive CSM*.

USEPA Specific Comment No. EPA 6 (Section 2.4.4): Given the thickness of the Main Sand, the full range of conductivity should be presented and discussed within the context of LNAPL presence, saturation, and recoverability.

HWG Specific Comment No. 38: This is a complex hydrostratigraphic unit that generally fines upward across many tens of feet, and so any K value range should be qualified - is it the range of averages for the entire GWBU, an average range for the upper portion where the LNAPL typically occurs, or an average range for the lower portion where the production wells are screened, or something else?

Trihydro Response to USEPA Specific Comment No. 6: Hydraulic conductivity estimates for the Main Sand were made by the HWG in 2005 within the central portion of the Hartford Site using slug test results performed under unconfined conditions in wells screened across the upper portion of the hydrostratigraphic unit. The hydraulic conductivities were reported between 1.6E-02 and 3.1E-02 cm/s. Hydraulic conductivity estimates were also reported by Premcor via pump tests completed in the production wells installed along the refinery’s western boundary. Hydraulic conductivities were estimated as high as 1.0E-01 cm/s (Clayton 2005). Further estimates of the hydraulic conductivity determined via continuous pumping within the production well installed in Area A will be made after steady state drawdown is achieved as part of future pilot testing efforts.

USEPA Specific Comment No. EPA 7 (Section 2.4.4): Please provide the well screen interval depth.

Trihydro Response to USEPA Specific Comment No. 7: The two most recent groundwater production wells (No. 3 and No. 4) installed by the Village of Hartford have a total depth of approximately 105 feet below ground surface and were constructed with between 20 and 35 feet of screen.

USEPA Specific Comment No. EPA 8 (Section 2.4.4): Was this statement verified as currently accurate (have pumping rates changed)? The original statement was taken from *the LNAPL Active Recovery System Conceptual Site Model* prepared for the Hartford Working Group by Clayton Group Services, Inc. dated December 15, 2005. The original reference for this statement is; Farmayan, W.C. Nealville, M. Petkovsky and L. Drzewiecki. March 1998. *Groundwater Flow Model for the Shell Wood River Refining Company*.

> ***Trihydro Response to USEPA Specific Comment No. 8:*** Section 2.4.4 of the revised *LNAPL Component to the CSM* has been updated and states: "Natural flow of groundwater in the Main Sand aquifer has been locally altered beneath the Hartford Site due to pumping on the BP, Phillips 66, and Premcor facilities. In 2013, the pumping rate at the BP facility averaged 1,225 gpm, while pumping at the Premcor facility averaged 288 gpm with periods of pumping in excess of 500 gpm. Additional pumping wells located west and northwest of the Village of Hartford at the Phillips66 River Dock operated at rates between 6,300 and 7,100 gpm. In addition, groundwater production rates were reported between 3,000 and 3,800 gpm at the Phillips66 facility located northeast of the Village of Hartford (SJMA 2014)."

USEPA Specific Comment No. EPA 9 (Section 3.0): What LNAPL is this? Heavy range suggests something heavier than crude.

> ***Trihydro Response to USEPA Specific Comment No. 9:*** The "heavy-range" hydrocarbons generally corresponds to LNAPL with a higher proportion of diesel-range compounds than the light-range hydrocarbons which are comprised almost entirely of gasoline-range compounds (see Appendix A).

USEPA Specific Comment No. EPA 10 (Section 3.1): When comparing waveforms and chemistry, how comparable are the data sets? What are the limitations of comparing the ROST and UVOST waveforms to each other and to the LNAPL chemistry?

> **HWG Specific Comment No. 45:** GC data goes below C10, LIF data starts at C10. LIF data can only be compared to C10 and above. Also LIF represents the fluorescence fraction and not alkanes. The estimates given here are not the sole explanation.
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> > ***Trihydro Response to USEPA Specific Comment No. 10:*** Both the ROST™ and UVOST™ make use of fluorescence and data acquisition systems developed wholly or in part by Dakota Technologies. They differ primarily in the laser and associated wavelength used to excite polycyclic aromatic hydrocarbons (PAH) within the LNAPL (290 and 308 nanometer wavelengths, respectively). The PAH mixtures within the LNAPL emit photons of a distinctive wavelength irrespective of the excitation wavelength, although the intensity of the response may vary. By sampling the total fluorescence at different wavelength channels (which are nearly identical for both tools), a multi-wavelength waveform is generated. The waveform allows simultaneous description of the spectral and temporal qualities of the fluorescence with depth and can be used to identify different product types. The waveform data are referenced and displayed as a percent of the response compared to the calibration reference emitter (RE). The RE is similar to a calibration gas used in a flame ionization or photoionization detector, and is placed on the sapphire probe window before collecting fluorescence data at each boring. The same RE is used for the ROST™ and UVOST™ (that is to say, the RE produces the same multi-wavelength waveform). Fluorescence measurements generated in the borings are normalized to the RE measurements which allows for spatial and temporal comparisons of the fluorescence results despite changes in the optics, laser energy drift, window, mirror, etc.

Both the ROST™ and UVOST™ readily detect most light- to mid-range product types including diesel and gasoline. The fluorescence response for these product types are generally linear, with higher concentrations of PAHs within a given product type resulting in a greater percent response relative to the RE (excluding any matrix interferences described below). With respect to light-range LNAPL such as gasoline, ROST™ will potentially have an advantage over UVOST™ since its laser system produces a shorter wavelength. But much of this advantage may be normalized through comparison of the LIF results from ROST™ and UVOST™ to the same RE. This is generally observed in the waveforms for the ROST™ borings installed in 2004 and 2005 when compared to the UVOST™ borings installed at the Hartford Site in 2013. The fluorescence results from 24 collocated borings are presented as mirror images on the figures included in Appendix D of the draft LNAPL Component to the CSM and the scale for the total waveform from the ROST™ was adjusted in the horizontal direction (i.e., stretched or compressed) so the percent fluorescence response (%RE) was equivalent to that of the corresponding scale for the UVOST™ waveform.

This comparison of the ROST™ and UVOST™ waveforms is semi-qualitative and may be affected by changes in the distribution or weathering of the LNAPL within the hydrostratigraphic units due to groundwater fluctuations, remedial system operation, and natural smear zone depletion. These results are semi-qualitative as there are several sources of variation with respect to fluorescence response beyond the slight aforementioned differences in the ROST™ and UVOST™. For instance, only the relative fraction of LNAPL that is optically accessible at the sapphire window of the probe can contribute to the fluorescence response. Therefore, significant heterogeneities in the lithologic setting and LNAPL distribution within the soil matrix can affect the fraction of LNAPL present within a few centimeters of the window. In addition, the method used to install the borings (e.g., cone penetrometer, direct push) can result in differing physical response of the soils and LNAPL such that the diameter of probe, push speed, and other factors combine to influence how much LNAPL gets preferentially drawn towards or pushed away from the sapphire window. The semi-qualitative observations that were made by comparing the ROST™ and UVOST™ results and discussed in Section 4.5 of the draft *LNAPL Component to the CSM* will be further evaluated within subsequent CSM deliverables, which will consider changes (or lack thereof) in the dissolved and vapor phase conditions near the collocated LIF borings. These multiple lines of evidence will then be summarized within the *Comprehensive CSM.*

Screening of LNAPL collected from specific locations at the Hartford Site could further support the comparability of the historical and more recent LIF results, but this would depend upon the availability of the LIF results for screening performed on LNAPL samples using the ROST™ in 2004 and 2005. Alternatively, it has been suggested that a LIF boring could be advanced adjacent to a location where LNAPL samples have been collected for characterization purposes as a means to calibrate the LIF response to the product type. This calibration of the historical LIF results collected via ROST™ to LNAPL characterization results for samples collected in 2006 is described in Section 3.1 of the draft *LNAPL Component to the CSM*. Additional LNAPL samples will be collected at the Hartford Site during the next year, if the data allow and a similar calibration will be performed for the more recent LIF results collected using the UVOST™. Again, calibration of the LIF response allows semi-qualitative use of the LIF waveforms as an indicator of LNAPL type. These results will be provided in the *Comprehensive CSM*. Comparisons of the historical LIF results generated using the ROST™ to petrophysical data collected from six soil cores has previously been performed (USEPA 2010). The results were quantitatively used to estimate the volume of LNAPL present beneath the Hartford Site, as described in Trihydro's Response to USEPA Comment No. 3.

USEPA Specific Comment No. EPA 11 (Section 3.3): A comment on the magnitude of viscosities as it relates to mobility/recoverability would be germane here.

Trihydro Response to USEPA Specific Comment No. 11: The first paragraph included in Section 3.3 has been revised to relate viscosity to potential recoverability.

USEPA Specific Comment No. EPA 12 (Section 4.1): This discussion states "bottom" of the Main Sand, please clarify the depth interval that is being referred to.

HWG Specific Comment No. 45: Is this sentence correct? LNAPL "present at the bottom of the Main Sand stratum?" Then they go on to state LNAPL is present in the lower portion of the Main Sand. How deep are they seeing it? Do they mean upper portion of the Main Sand?

Trihydro Response to USEPA Specific Comment No. 12: Section 4.1 of the revised *LNAPL Component to the CSM* has been updated and states: "Specifically, LNAPL present within the lower portions of the smear zone in the Main Sand stratum (approximately 40 and 45 ft-bgs) within borings HROST-002 and HROST-003 was previously identified as a mid-range hydrocarbon.

USEPA Specific Comment No. EPA 13 (Section 4.1): What is meant by groundwater plume being "flatter" here? This is nonstandard jargon. I've never heard of dissolved plume being flat. Also, the use of "LNAPL plume" is probably a poor choice here—LNAPL body, as used elsewhere in the document, is probably a better choice.

Trihydro Response to USEPA Specific Comment No. 13: The use of the word "flatter" was intended to provide a description of LNAPL spreading across less permeable or saturated stratum. Based on the comment, the word choice is not helpful, and therefore the word "flatter" was removed from this sentence within the revised *LNAPL Component to the CSM*. The use of the word "plume" has also been removed from Section 4.1.

USEPA Specific Comment No. EPA 14 (Section 4.1): Is the "entirety of the smear zone" defined by LIF waveforms alone? The Agency is not comfortable with the absence of soil data in this CSM to define the saturations throughout the Village. The discussion and consideration of recoverability may be limited to mobile phase hydraulic recoverability for this component to the CSM; however, the non-mobile, residual phase recoverability will be expected in the forthcoming components. Updated soil data may be necessary for that purpose.

> ***Trihydro Response to USEPA Specific Comment No. 14:*** As discussed during the meeting between Apex and the Agencies on May 14, 2013, Trihydro is not planning to collect soil cores for petrophysical analyses to estimate residual and mobile LNAPL saturations across each of the hydrostratigraphic units beneath the Hartford Site. An estimate of LNAPL impacted soil may be completed to evaluate where the majority of the LNAPL mass is present and where remedial efforts should be focused. Following completion of this analysis and submittal of the *Comprehensive CSM*, soil cores may be collected and submitted for petrophysical analyses to support potential recoverability estimates within areas proposed for future remedial efforts prior to designing a final remedy. It is important to note that petrophysical results from soil coring can be highly variable over small lateral and vertical distances requiring installation of multiple borings and collection of multiple samples within each boring to allow for statistical averaging. Soil coring for LNAPL physical properties is even more sensitive to bias associated with subsurface heterogeneities (e.g., LNAPL distribution, lithology, etc.) due to limitations in collecting representative samples (e.g., intact pore structure and minimal loss of LNAPL and water during core recovery). There are a number of analyses that can be used to assess LNAPL saturations, with uncertainties associated with each method. Typically, each method yields different results. Analyses that may be considered for future coring includes: (1) direct measurement of LNAPL saturations (via total petroleum hydrocarbon analyses or LNAPL physical properties with subsequent centrifuge and estimation of residual saturations), (2) analysis of the air-water drainage curve and LNAPL interfacial tensions (with water and air) to estimate a LNAPL-water inhibition curve, and (3) analysis of a LNAPL-water drainage curve (to estimate the LNAPL saturation profile) and a LNAPL-water imbibition curve (to estimate the residual LNAPL saturation).

USEPA Specific Comment No. EPA 15 (Section 4.2): Has LNAPL been measureable in any wells screened within this stratum? What are the upper limits of LNAPL thickness, if so? How much do thicknesses vary seasonally? Is it confined/unconfined?

> ***Trihydro Response to USEPA Specific Comment No. 15:*** There are only two groundwater monitoring wells (HMW-013 and HMW-044A) and two monitoring points (MP-055A and MP-108B) screened within the North Olive stratum where LNAPL has been measured (thickness greater than 0.01 foot), with the most recent occurrence reported in monitoring point MP-108B in April 2011. LNAPL has only been measured 22 times in these four locations since gauging began in June 2003, with a maximum thickness of 0.82 feet in well HMW-013 in July 2008. LNAPL is only observed under unconfined conditions and there does not appear to be any correlation with seasonal variations and LNAPL occurrence within these four locations.

USEPA Specific Comment No. EPA 16 (Section 4.3): Some hydrographs to support this assertion would be germane. Also, reduced thicknesses could alternatively indicate continued spreading—lines of evidence of mobile LNAPL fraction stability.

> ***Trihydro Response to USEPA Specific Comment No. 16:*** A comparison of LNAPL thicknesses and groundwater elevations over time for select wells screened within the Rand Stratum has been provided as Figure 17 within the revised *LNAPL Component to the CSM*.

USEPA Specific Comment No. EPA 17 (Section 4.3): Has the impact of skimming on nearby LNAPL connectivity within the formation been evaluated? Skimming operations have collected significant product through the years and should be further evaluated within the context of a broader final remedial approach.

> **HWG Specific Comment No. 69:** The last sentence is speculation and the actual mechanism for decrease in thicknesses has not been supported. This is important when considering remedial effectiveness, it should not be based on speculative statements such as this.
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> > ***Trihydro Response to USEPA Specific Comment No. 17:*** Please refer to Trihydro's Response to USEPA Specific Comment No. 3.

USEPA Specific Comment No. EPA 18 (Section 4.4): Please define the vertical thickness and describe the confining and unconfining conditions.

> ***Trihydro Response to USEPA Specific Comment No. 18:*** The LNAPL smear zone in the Main Sand stratum occurs across the greatest vertical thickness, although this is variable, measuring less than one foot along the southern and western limits and as much as 29 feet within the central portions of the smear zone. LNAPL and groundwater in the Main Sand become confined when it vertically intersects less permeable overlying units such as the D Clay to the northeast, the C Clay within the central and eastern portions of the smear zone, and sometimes the Main Silt present in the western and southern portions of the Hartford Site. LNAPL and groundwater are considered unconfined when the elevation of the top of LNAPL surface is below these less permeable (confining) units.

USEPA Specific Comment No. EPA 19 (Section 4.4): Total LNAPL smear zone data is presented-mobile and residual. It's immaterial whether the residual is confined/unconfined. If it's mobile LNAPL being referenced here, it should be made clear in the narrative. What does appreciable means with respect to the apparent thickness? Clarify the language regarding LNAPL phase (mobile). Where is the data to support the LNAPL reduction via skimming claim (such as hydrographs)? Other factors could cause thicknesses to go down or confound this assertion: raising water table, change from confined to unconfined, etc. Please expand upon the significance of the final sentence.

> ***Trihydro Response to USEPA Specific Comment No. 19:*** Section 4.4 of the *LNAPL Component to the CSM* describes the distribution of LNAPL in the smear zone including both residual and mobile based on the historical LIF results. This section has been revised to include hydrographs showing LNAPL thicknesses within wells screened within the Main Silt, EPA, and Main Sand strata, as well as maximum LNAPL thicknesses measured in within groundwater monitoring wells and multipurpose monitoring points screened within the Main Sand Stratum over three time periods including 2003 through 2005, 2007 through 2009, and 2011 through 2013. These figures present the maximum LNAPL thickness measured within the monitoring locations over each two year span. On these three figures (Figures 22 through 24 of the revised *LNAPL Component to the CSM*), LNAPL thicknesses were only considered when the fluid levels were present within the screen interval of the monitoring location (representing unconfined conditions when LNAPL thicknesses were not

exaggerated). Finally, this section has been revised to identify mechanisms that could be contributing to reductions in LNAPL saturations within the deeper hydrostratigraphic units including mass recovery via manual LNAPL skimming, redistribution of LNAPL with fluctuating groundwater elevations, and natural smear zone depletion. Accordingly, the last sentence of this paragraph was removed.

USEPA Specific Comment No. 20 (Section 4.5): Is there a scientific basis for this scaling, if so, please reference it.

Trihydro Response to USEPA Specific Comment No. 20: Please see Trihydro's response to USEPA Specific Comment No. 10.

USEPA Specific Comment No. 21 (Section 4.5): To the extent that ROST and UVOST data are comparable this statement is true. Is there scientific literature to support this? If there is none, this comparison cannot be accepted as valid and probably should be omitted from the report.

Trihydro Response to USEPA Specific Comment No. 21: Please see Trihydro's response to USEPA Specific Comment No. 10.

USEPA Specific Comment No. 22 (Section 4.5.1): The Agency acknowledges that this component to the CSM doesn't cover the vapor phase; however, this statement is in contradiction to certain monitoring points throughout the Village where oxygen is depleted and hydrocarbon vapors persist. NSZD and aerobic degradation is likely taking place in various locations but that information must be fully presented and paired with those locations where anaerobic processes are present and hydrocarbon vapors are elevated (more appropriate for the vapor phase component).

HWG Specific Comment No. 80: The evidence in support of this should be presented herein or referenced if previously presented elsewhere. Otherwise this statement should be removed until such time as the evidence is available.

Trihydro Response to USEPA Specific Comment No. 22: Trihydro understands that natural smear zone depletion within the vadose and saturated portion of the North Olive stratum are not uniform processes and must be evaluated within future CSM deliverables. The final sentence in Section 4.5.1, has been revised to state, "Petroleum hydrocarbons within this shallowest hydrostratigraphic unit are being targeted for recovery using the SVE system. Natural smear zone depletion may also be occurring within the North Olive stratum via (1) volatilization and subsequent biodegradation within the vadose and (2) nutrient delivery within rainwater infiltrate and subsequent oxidation by petrophyllic bacteria in the saturated zone. Additional evaluation of the effects of the SVE system and natural smear zone depletion processes will be considered as part of future components to the CSM."

USEPA Specific Comment No. 23 (Section 4.5.2): In the absence of bacterial cultures, this appears to be conjecture. If they have been identified, present the data or mention that they have being identified. As LNAPL bodies age, the expectation is that natural attenuation rates diminish as the light-ends leave preferentially. Natural attenuation rates at a release of this age are questionable. However, these assumptions depend upon the validity of the ROST-UVOST comparison.

> ***Trihydro Response to USEPA Specific Comment No. 23:*** The discussion regarding natural smear zone depletion processes acting to reduce petroleum hydrocarbon mass within the deeper hydrostratigraphic units along the western and southern boundaries of the smear zone has been removed from this paragraph and will be considered within the forthcoming components to the CSM.

USEPA Specific Comment No. 24 (Section 4.5.2): Again, this is conjecture, if the LIF comparisons cannot be supported scientifically. Is the scaling valid?

> ***Trihydro Response to USEPA Specific Comment No. 24:*** Please see Trihydro's response to USEPA Specific Comment No. 10.

USEPA Specific Comment No. 25 (Section 4.7): What criteria will be used to choose "select dissolved and vapor analytical results"? In general, the parameters, assumptions and limitations of the 3D Model should be discussed further in this document.

> ***Trihydro Response to USEPA Specific Comment No. 25:*** The assumptions, limitations, and data used to generate the ground surface, lithology, and smear zone layers within the 3D visualization model is provided in Section 4.1 of the revised *LNAPL Component to the CSM*. Updates will be made to the model as part of the dissolved and vapor phase components to the CSM. For example, dissolved phase benzene results collected over several timeframes within the various hydrostratigraphic units may be incorporated into the model. Timeframes that could be considered include (1) 2003 through 2005, (2) 2007 through 2009, and (3) 2011 through 2013. Data would be evaluated for representativeness prior to being incorporated into the model (e.g., samples collected when the groundwater table was within the vertical extent of the well screen, LNAPL not present in the monitoring location). Fluid level results (groundwater and LNAPL elevations) may also be incorporated into the model including periods when the water table is elevated and confining conditions are present and periods when groundwater is seasonally low and unconfined conditions are present in the Main Sand stratum. The 3D model may also be updated to include select volatile petroleum related hydrocarbon and fixed gas concentrations within the vadose zone for high and low water table conditions. Pressure readings, fixed gas concentrations (including oxygen, carbon dioxide and methane), and total organic vapor concentrations from selected nested vapor monitoring wells and multipurpose monitoring points may be incorporated into the model. Vapor phase concentrations for select petroleum related hydrocarbons including benzene and hexane could also be incorporated into the model, where sufficient data is available. This could also include field and analytical results for sub-slab soil gas (measured as part of the in-home monitoring program) from select monitoring events.

USEPA Specific Comment No. 26 (Section 5.0): LNAPL can and does displace water in the "saturated zone" and exist as continuous mobile phase providing the LNAPL head is enough to overcome the pore entry pressure of the saturated media. The pore entry pressure for saturated media is less for coarse textured materials—sands—than it is for fines—clay.

> ***Trihydro Response to USEPA Specific Comment No. 26:*** Section 5.0 of the revised *LNAPL Component to the CSM* has been updated to state, "Within the saturated zone, where the pore spaces are primarily filled with water, LNAPL is generally present as less connected globules within the smaller pore spaces (2-phase conditions). That is, while some of the LNAPL might be connected and potentially capable of mobilizing to a well, much of it is often present as separate ganglia due to the majority of pore space being filled with water. Within the capillary fringe and vadose zone where water content is lower and air is also present (3-phase conditions), LNAPL tends to be more connected within the larger pore spaces. Put another way, LNAPL residual saturation can vary depending on whether 2-phase or 3-phase conditions are present (Charbeneau 2007). When LNAPL saturations are high and/or water saturations are low, LNAPL is better connected and therefore potentially mobile (i.e., the LNAPL is above the residual saturation). LNAPL preferentially moves within coarse-grained sediments such as sand and gravel (i.e., lower pore entry pressure), and is less able to migrate through fine-grained sediments such as silt and clay (assuming similar water content within the pore space)."

USEPA Specific Comment No. 27 (Section 5.0): What does high or low saturations imply in this case. LNAPL saturations can be lower than water and the LNAPL is still mobile. Please clarify is it is meant to imply a saturation above residual.

> **HWG Specific Comment No. 102:** It's necessary to correctly optimize LNAPL removal under these conditions to achieve long-term sustainable LNAPL production from a large area around a given well. Pilot test and long-term recovery data demonstrate that overpumping can snap off the LNAPL flow paths and thus create the short-term, localized conditions described.
>
> > ***Trihydro Response to USEPA Specific Comment No. 27:*** Section 5.0 of the revised LNAPL Component to the CSM has been updated to state, "As LNAPL is removed from the formation adjacent to the well, LNAPL saturations may decrease as water saturations increase, resulting in reduced recoverability. If the mass of mobile LNAPL in the vicinity of the recovery well is sufficient and connectivity within the formation is maintained (2-phase conditions such that LNAPL remains confined and groundwater does not become confined), then LNAPL production could be relatively sustainable."

USEPA Specific Comment No. 28 (Section 5.0): The Agency's final remedy expectation will include maximizing mass recovery of all LNAPL phases over the widest range of conditions within the Village. In the event highly unconfined conditions cannot be induced within the Village in a manner that achieves mass recovery in a reasonable timeframe, other hydraulic recovery methods may need to be explored.

> ***Trihydro Response to USEPA Specific Comment No. 28:*** Trihydro understands the Agency's expectations and anticipates that future discussions regarding remedial timeframes and recoverability goals will be required as part of defining a final remedy for the Hartford Site.

USEPA Specific Comment No. 29 (Section 5.1): The Figures only show recovery post 2010. The Figures are difficult to understand: are the skimmers dedicated, or is periodically done manually? This context has not been provided for clarity. The figures don't display recovery rate, they only provide recovery in gallons—no time element. This adds to the difficulty in trying to interpret the figures.

> ***Trihydro Response to USEPA Specific Comment No. 29:*** The figures provided within Appendix E have been modified within the revised *LNAPL Component to the CSM* to display LNAPL recovery rates in units of gallons per month. In addition, the following text will be added to the first paragraph under Section 5.3: "During manual skimming, field personnel would visit a location with more than 0.5 feet of LNAPL, conduct skimming, and then allow the LNAPL to recharge above this thickness before skimming again. This method would mean that drawdown in the monitoring well or monitoring point would only be maximized immediately after skimming, and would decrease over time until the next skimming event."

USEPA Specific Comment No. 30 (Section 5.1): In nearly all cases the figures show a decline in recovery rate, contrary to the DOLR. This is about the only thing the figures show.

> ***Trihydro Response to USEPA Specific Comment No. 30:*** The DOLR model does not state that LNAPL recovery rates will never decline. For clarity, the description of the DOLR model has been revised providing quotes directly from the *LNAPL Recharge and Production Investigation* (H2A 2006) to reduce potential misinterpretations regarding this conceptual model. Accordingly, the text that interprets the Appendix E hydrographs will be adjusted based on the revised description of the DOLR model.

USEPA Specific Comment No. 31 (Section 5.1): Some of these wells are being skimmed. What steps were taken to ensure LNAPL thicknesses had equilibrated in these well prior to transmissivity testing?

> ***Trihydro Response to USEPA Specific Comment No. 31:*** The 2005 LNAPL transmissivity estimates are based on analysis of LNAPL recharge to wells following high vacuum recovery as described in Appendix E of the *LNAPL Active Recovery System Conceptual Site Model* (Clayton 2005). The 2010 transmissivity estimates are based on baildown testing conducted when skimming was temporarily suspended. In both cases, some effort was made to allow LNAPL to accumulate in the well prior to conducting recovery or baildown tests. In 2005, fluid levels were allowed to re-establish overnight (at a minimum) before conducting subsequent MPE tests within a well. In 2010, LNAPL was allowed to accumulate in each well for at least one week before beginning a LNAPL baildown test. It is possible that equilibrium conditions were not achieved in the well prior to the MPE or baildown tests.

USEPA Specific Comment No. 32 (Section 5.1): What did the water table do over this period? It would be nice to plot average water table (piezometric) elevation on the figure to rule out water table changes as a contributing factor.

> ***Trihydro Response to USEPA Specific Comment No. 32:*** A description of the "average" piezometric surface may be inappropriate given the significant heterogeneity observed in the lithology and LNAPL distribution beneath the Hartford Site. It also seems unnecessary to display the average piezometric surface on revised Figure 34 (previously Figure 21 in the draft *LNAPL*

Component to the CSM) since individual hydrographs are provided for 22 monitoring locations where routine skimming was conducted between 2010 and 2012 and included in Appendix E. The figures show periods of both confined and unconfined conditions at many of the groundwater monitoring wells and multipurpose monitoring points where skimming was performed. The relationship of LNAPL recovery performed via skimming to the piezometric surface is described in the previous paragraphs within this section of the revised *LNAPL Component to the CSM*, referencing the figures included in Appendix E.

USEPA Specific Comment No. 33 (Section 5.1): These figures do not support the DOLR. They show that LNAPL recovery is higher under confined than under unconfined conditions.

Trihydro Response to USEPA Specific Comment No. 33: The DOLR model states that under intermediate unconfined conditions (i.e., when the aquifer is unconfined but the water elevation is still relatively high), LNAPL recoverability might be low because significant LNAPL is still submerged below the water table. Since the figures show skimming under confined and possibly intermediate unconfined conditions, the results are actually consistent with the DOLR model. For clarity, the description of the DOLR model has been revised providing quotes directly from the *LNAPL Recharge and Production Investigation* (H2A 2006) to reduce potential misinterpretations regarding this conceptual model. Additionally, this section of the revised *LNAPL Component to the CSM* has been updated to state: “As shown on the figures provided in Appendix E, testing under all anticipated hydraulic conditions described in the DOLR model has not been performed at the Hartford Site. Specifically, the DOLR model predicts that when groundwater elevations are within the lower portions of the smear zone, LNAPL recovery rates may be higher (as more of the smear zone is under 3-phase conditions).”

USEPA Specific Comment No. 34 (Section 5.2): How so? Please expand.

Trihydro Response to USEPA Specific Comment No. 34: This section of the revised *LNAPL Component to the CSM* has been updated to state: “The success of the LFDPE at the Premcor facility is reportedly attributed to installing recovery wells within localized high points within the overlying confining unit where LNAPL preferentially migrates. It is also possible that LFDPE has been successful at the Premcor facility, due to the presence of the D Clay, which has potentially acted as a barrier to downward LNAPL movement during historically low water table elevations. This might have allowed LNAPL to accumulate within the EPA stratum between the B/C Clay and the D Clay and yielded relatively high LNAPL saturations in this stratum. The EPA stratum and D-Clay are not present beneath the majority of the Hartford Site. Instead, the majority of the LNAPL appears to be located within the Main Sand, which does not have a shallow fine grained layer to act as a barrier to downward LNAPL movement. Therefore, at the Hartford site, the degree of historical smearing might have been greater, yielding lower recoverability under confined conditions (i.e., deeper submerged LNAPL).” The effectiveness of the LFDPE will be considered further as part of the *Comprehensive CSM*.

USEPA Specific Comment No. 35 (Section 6.2): Have you identified any specific potential alternative sources?

> ***Trihydro Response to USEPA Specific Comment No. 35:*** Alternate sources for petroleum hydrocarbons have not been investigated but may be as part of defining the final remedial approach in specific portions of the Hartford Site. This sentence has been removed from this component to the CSM until such time that additional data is collected.

If you have questions regarding our response to the comments included herein, please contact Paul Michalski at (513) 429-7452.

Sincerely,
Trihydro Corporation

Paul M
Ben McAlexander

Paul Michalski, P.G.
Team Leader

Ben McAlexander
Hydrogeologist

Attachments

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Kevin Dyer, Shell Oil Products US
Bob Mooshegian, URS Corporation

REVISED

LNAPL COMPONENT TO THE CONCEPTUAL SITE MODEL

HARTFORD PETROLEUM RELEASE SITE

HARTFORD, ILLINOIS

May 22, 2014

Project No.: 24S-006-001

PREPARED BY: Trihydro Corporation

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Trihydro
CORPORATION

ENGINEERING SOLUTIONS. ADVANCING BUSINESS.

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1.0 INTRODUCTION

Apex Oil Company, Inc. (Apex) has updated the light non-aqueous phase liquid (LNAPL) component to the Conceptual Site Model (CSM) for petroleum hydrocarbons present beneath the northern portions of the Village of Hartford, Illinois, referred to as the Hartford Petroleum Release Site (Hartford Site). The location of the Hartford Site is shown on Figure 1. The CSM is being updated in a step-wise fashion, starting with this LNAPL component to the CSM in accordance with the memorandum entitled *Comprehensive Conceptual Site Model Framework and Timeline, Hartford Area Hydrocarbon Plume Site* (Trihydro 2013c). The next two deliverables will provide updates to the CSM for dissolved and vapor phase petroleum hydrocarbons partitioning from the LNAPL. The final deliverable, the Comprehensive CSM, will compile all the information presented within the LNAPL, dissolved phase, and vapor phase components to the CSM, as well as additional information gathered subsequent to and as a result of preparing the first three deliverables. The final CSM deliverable will also include evaluation of any additional LNAPL recovery pilot tests performed at the Hartford Site.

1.1 PURPOSE

As described in the *Comprehensive Conceptual Site Model Framework and Timeline, Hartford Area Hydrocarbon Plume Site* (Trihydro 2013), “the CSM will integrate information previously collected at the Hartford Site with an emphasis on further analysis and visual presentation of the existing data. In addition, further investigation and monitoring activities will be proposed to resolve data gaps or update previous investigation findings as needed.” The majority of activities related to assessment of the distribution, characterization, mobility, and recoverability of LNAPL performed at the Hartford Site were conducted between July 2003 and May 2006, and previously reported within the *Active LNAPL Recovery System Conceptual Site Model* (Clayton 2005) and the *Active LNAPL Recovery System 90% Design Report* (Clayton 2006). Assessment activities performed over this timeframe included installation of: (1) 109 borings for collection of cone penetrometer and laser induced fluorescence data (HROST-prefix), (2) 66 groundwater monitoring wells (HMW-prefix), (3) 17 piezometers and boring (HP-prefix), (4) 271 multipurpose monitoring points (MP-prefix), and (5) 260 vapor monitoring probes (VMP- and VP-prefix). LNAPL recharge and recoverability tests were also performed in 19 wells via multiphase extraction (MPE) and low flow dual phase extraction (LFDPE) between May and November 2005 (H2A 2006). After May 2006, more than 75 soil vapor recovery wells (HSVE-prefix) and 5 MPE wells (MPE-prefix) were installed across the Hartford Site. Additionally, 66 multipurpose monitoring points (MP-prefix) and 3 groundwater monitoring wells (ASW-prefix) were installed primarily to monitor the effectiveness of the soil vapor extraction (SVE) system and pilot testing to be performed in Area A. Accordingly, the majority of data that was used to prepare this component to the CSM was drawn from the historical assessment activities performed between July 2003 and May 2006.

This component to the CSM also incorporates more recent data collected since May 2006, including lithologic information from newly installed wells, routine LNAPL thickness measurements, and manual LNAPL skimming results. Additional laser induced fluorescence (LIF) data collected in 2013 to evaluate changes in the smear zone are also included herein. Finally, this component of the CSM provides an explanation regarding the first phase of additional LNAPL recovery pilot testing performed beneath Area A of the Hartford Site in late 2011 and early 2012 that was reported in the *Light Non-Aqueous Phase Liquid Recovery Pilot Test Interim Report* (WSP 2012). Specific elements evaluated herein include:

- LNAPL Distribution: The lateral and vertical distribution of LNAPL, including presence in the various stratigraphic units, will be considered in the context of varying hydraulic conditions (such as the fluctuating groundwater table and large scale pumping at the adjacent refineries), as well as previously implemented mitigation and remedial measures.
- LNAPL Types: An evaluation of LNAPL types within the various hydrostratigraphic units will be conducted in an effort to explain partitioning of petroleum related constituents to groundwater and soil gas as part of subsequent updates to the CSM.
- LNAPL Recoverability: One significant data gap that remains in the LNAPL component to the CSM is related to recoverability. Multiple pilot test activities have been conducted in the past decade to evaluate potential recoverability of LNAPL within the various water bearing units beneath the Hartford Site, with further pilot test activities planned for Area A once groundwater elevation triggers have been reached and necessary infrastructure and other critical activities have been completed (Trihydro 2013a). LNAPL recovery and transmissivity are considered in the context of hydraulic conditions to provide a basis for understanding future LNAPL recoverability and defining the technical approaches and conditions under which recovery can be optimized. Resolution of data gaps regarding LNAPL recoverability will be further addressed within the Comprehensive CSM following completion of the additional LNAPL recovery pilot testing to be performed in Area A.

A three-dimensional (3D) model depicting the lithology and distribution of LNAPL within the subsurface was prepared as part of this component to the CSM. This model is used to depict LNAPL occurrence within the multiple hydrostratigraphic units beneath the Hartford Site. The model will continue to be refined as part of the updates to the dissolved and vapor phase components to the CSM.

1.2 DOCUMENT ORGANIZATION

This update to the LNAPL CSM is organized as follows:

- Section 2.0 presents the site setting including historical background, interim measures, geology and hydrogeology at the Hartford Site.
- Section 3.0 reviews historical data related to LNAPL chemistry and physical properties. The LNAPL chemistry data are compared to historical laser induced fluorescence (LIF) data to assess the comparability of the two data sets. The LNAPL chemistry data are also used to generate LNAPL partitioning estimates to assess the potential for LNAPL to affect groundwater.
- Section 4.0 evaluates the distribution of LNAPL types within the various hydrostratigraphic units in the context of a 3D visualization model prepared using historical lithologic and LIF data.
- Section 5.0 considers historical petrophysical data, transmissivity estimates, as well as qualitative and quantitative modeling that has been completed to better understand LNAPL recoverability at the Hartford Site. This section also provides a comparison of the LNAPL recovery efforts performed during additional pilot testing and manual LNAPL skimming since 2009, as well as the LNAPL recovery efforts at the adjacent refinery, to predictions made using the historical model.
- Section 6.0 summarizes the LNAPL component to the CSM and data gaps to be resolved prior to completing the Comprehensive CSM.

2.0 SITE SETTING

The Village of Hartford is located in Madison County, Illinois on the east bank of the Mississippi River, approximately twelve miles northeast of St. Louis, Missouri. The definition of the site boundary is described in the Unilateral Administrative Order issued by the USEPA under Section 7003 of the Resource Conservation and Recovery Act (Docket No. RCRA-05-2010-0020). This component to the CSM does not seek to redefine the legal definition of the site boundary; however, discussions pertaining to the Hartford Site will focus on the current extent of petroleum related constituents in soil, groundwater, and soil. As such, references to the Hartford Site included herein will only include the area depicted on Figure 1 and described in the following bullets:

- To the West by the eastern limits of the right-of-way for the United States Army Corps of Engineers' Flood Control Levees. The western boundary could also be defined as the eastern limit of the Illinois Route 3 right-of-way and does not extend into the highway.
- To the North by the northern edge of the Rand Avenue right of way.
- To the East by the westernmost boundary of the Shell facility (aka Tannery property) and the western boundary of the Premcor Refining Group (Premcor) Refinery.
- To the South by the transect from northwest to southeast defined as:
    - The southern edge of the right-of-way for West Watkins Street from the western edge of the North Delmar Avenue right-of-way to the eastern edge of the current Illinois Route 3 right-of-way.
    - The western edge of the North Delmar Avenue right-of-way from the southern edge of the right-of-way for West Maple Street to the southern edge of the right-of-way for West Watkins Street.
    - The southern edge of the right-of-way for East Maple Street between the western edge of the North Olive Street right-of-way and the western edge of the North Delmar Avenue right-of-way.
    - The western edge of the North Olive Street right-of-way from the southern edge of the right-of-way for East Hawthorne Street to the southern edge of the right-of-way for East Maple Street.
    - The southern edge of the right-of-way for East Hawthorne Street between the western edge of the Premcor facility to the western edge of the North Olive Street right-of-way.

It should be noted that while the Hartford Site boundaries encompass the rights-of-way for the Norfolk and Western, Union Pacific, Kansas City Southern, and Norfolk Southern Railroads, further assessment of these four railroad rights-of-way has been limited due to access issues.

The railroad rights-of-way are therefore shown to be separated from the remaining portions of the Hartford Site on Figure 1 as an area that is 25 feet east and west of the centerline of the tracks.

2.1 SOURCES OF PETROLEUM HYDROCARBONS

Three refineries were constructed around the Hartford Site between 1907 and 1941, the Amoco Oil Refinery (currently the British Petroleum facility), the Clark Oil Refinery (currently the Premcor facility), and the Shell Oil Refinery (currently the Phillips66 facility). In addition, a bulk petroleum storage facility was constructed north of the Village of Hartford (currently the Hartford Wood River Terminal Oil Company facility). Refining, storage and transport of petroleum hydrocarbons continues to be conducted around the Village of Hartford associated with portions of these refineries. In addition, numerous underground and aboveground petroleum pipelines connected the refineries to the bulk storage terminal, loading and unloading facilities located on the Mississippi River, and to other entities. Numerous releases of petroleum hydrocarbons have been documented within or immediately adjacent to Hartford.

Generally, the released hydrocarbons (referred to herein as LNAPL) migrated down through the subsurface under the influence of gravity until encountering the water table or less permeable layers (such as clays and silts). Due to capillary forces, some fraction of the LNAPL was retained in soil pore space in the unsaturated zone, whereas some fraction of the LNAPL reached the capillary fringe where it displaced water present in soil pore space. As the volume of LNAPL became sufficient to overcome hydrostatic forces, further lateral migration occurred. Vertical migration into deeper hydrostratigraphic units occurred where the less permeable layers were discontinuous or absent. The distribution of LNAPL stabilized as gravity and capillary forces approached equilibrium and natural smear zone depletion reduced the mass of hydrocarbons (notably along the vertical and horizontal margins of the smear zone).

2.2 INTERIM MEASURES

Interim measures performed at the Hartford Site since 1978 have primarily included skimming of LNAPL and operation of the SVE system. As documented in prior reports pertaining to the Hartford Site, between 1978 and 2013 approximately 2.25 million gallons of LNAPL has been recovered beneath the Hartford Site with 1.3 million gallons of LNAPL recovered via skimming (USEPA 2010, RAM 2013) and another 0.95 million gallons via operation of the SVE system (URS 2014). Over time, the recovery of hydrocarbons via skimming has diminished as LNAPL saturations in the shallow portions of the smear zone have been reduced (within the radius of influence of the well over time). Conversely, vapor recovery rates fluctuate each year with the highest rate of recovery occurring in 2012, corresponding to a decrease in the water table during the second half of the year (Figure 2).

2.2.1 LNAPL RECOVERY

Between 1978 and 1979, Clark Oil Company installed two large diameter groundwater production wells (RW-001 and RW-002 shown on Figure 1) at the Hartford Site for the purpose of skimming LNAPL from the shallow portions of the smear zone. Between 1978 and 1990, LNAPL skimming was performed within these two production wells, with the exception of a period between 1983 and 1984 when operations were temporarily ceased. Approximately 1,162,000 gallons of LNAPL was recovered from these two wells through 1990. Skimming rates ranged from approximately 1,000 to 29,000 gallons per month (USEPA 2010).

An additional production well (RW-003 depicted on Figure 1) was installed at the Hartford Site by Premcor in 1993. From January 1994 through September 2002, Premcor reportedly recovered an additional 82,700 gallons of LNAPL from the three production wells installed across the Hartford Site (USEPA 2010).

Beginning in 2004, a consortium of oil companies (referred to as the Hartford Working Group) including Premcor, Shell, BP, and Sinclair Oil Corporation began managing interim measures, including LNAPL skimming. In 2004, the Hartford Working Group installed three additional wells (RW-004, RW-004A, and RW-005 shown on Figure 1) for the purpose of LNAPL recovery. Approximately 18,000 gallons of LNAPL were recovered via skimming activities between 2004 and 2009.

In addition, the Hartford Working Group performed a number of pilot tests over this five-year period to evaluate potential remedial technologies. These pilot tests primarily involved (1) MPE, which was defined as high vacuum recovery of vapor, groundwater and LNAPL using a stinger placed slightly above the LNAPL-air interface, and (2) dual phase extraction (DPE), defined as LNAPL recovery augmented with limited groundwater extraction (maximum of 2.5 feet of drawdown was achieved during testing). An additional 6,000 gallons of LNAPL was recovered as part of performing these pilot tests by the Hartford Working Group.

In March 2009, routine operations, monitoring, and maintenance (OM&M) interim measures at the Hartford Site were transferred to Apex. Apex continued to conduct LNAPL skimming in two of the recovery wells (RW-002 and RW-004A) until December 2010 and recovered an additional 15,000 gallons of LNAPL. In addition, Apex conducted LNAPL skimming activities within the groundwater monitoring network beginning in late 2009 and recovered an additional 25,000 gallons of LNAPL through the end of 2012.

WSP Environmental & Energy (WSP) conducted a LNAPL recovery pilot test between October 2011 and January 2012 (the WSP pilot test) with the primary objective of evaluating previously selected technologies for LNAPL recovery including SVE, MPE, and DPE. As described in the *Light Non-Aqueous Phase Liquid Recovery Pilot Test Interim*

Report (WSP 2012), groundwater and LNAPL were confined within the test well MPE-A001 throughout most of the WSP pilot test. Well MPE-A001 is located in Area A and screened across the top of the Main Sand Stratum. Immediately prior to testing, the LNAPL thickness in well MPE-A001 was 3.24 feet, greater than that typically observed in this well under unconfined conditions as shown on the figure provided as Appendix A (reproduced from the *Light Non-Aqueous Phase Liquid Recovery Pilot Test Interim Report* [WSP 2012]). The elevated LNAPL thickness observed in the test well prior to pilot testing was consistent with exaggerated LNAPL thicknesses observed in many of the wells under confined conditions across the Hartford Site (Table 1). The LNAPL-water interface was present within the screened interval of the well.

2.2.1.1 WSP PILOT TEST RESULTS

Although planned, SVE could not be tested as the screen became occluded once a vacuum was induced on well MPE-A001 during the pilot test. MPE was tested on November 7 through November 10, 2011. A drop tube was placed in the well with an applied vacuum for three hours the first day and near continuous thereafter. The drop tube diameter and elevation were varied during the testing, and airflow ranged from 13 standard cubic feet per minute (scfm) to 85 scfm. The applied vacuum achieved removal of fluids from well MPE-A001 with a maximum drawdown of 2.2 feet, but did not lower the fluid levels to below the top of the screen. Although a LNAPL thickness of 3.24 feet was measured prior to testing, no measurable LNAPL recovery was achieved during the test. Instead, approximately 6,900 gallons of groundwater were extracted. Pilot testing of DPE was planned, but based on the lack of significant drawdown during pilot testing of MPE, a pumping test was performed instead to assess achievable drawdown within the test well. Following a step test, a constant rate pump test was conducted at 20 gallons per minute (gpm) for 6.5 hours. Approximately 9 feet of drawdown was observed in the test well, exposing approximately 8 feet of the well screen. However, the LNAPL thickness in the well decreased from 2.89 feet to 0.14 feet. Fluid level monitoring within the nearby wells indicated some influence within 50 feet of the test well, but LNAPL thicknesses did not increase during the pump test. Overall, the pilot test resulted in no measureable LNAPL recovery using MPE, and insufficient drawdown in the well to expose the screen. Additionally, groundwater pumping did not affect LNAPL thickness in the test or nearby monitoring wells over the 6.5 hour test duration. The results suggest that MPE is not sufficient to achieve LNAPL recovery in Area A under confined conditions. The results also suggest that groundwater extraction may influence the piezometric surface in nearby wells. This supports the use of groundwater extraction as a possible means to change fluid levels in the formation and perhaps induce mobilization of LNAPL to wells under unconfined conditions. This is discussed further in Section 5.0.

2.2.2 SOIL VAPOR EXTRACTION

The original SVE system was installed by Clark Oil & Refining Corporation (now Premcor) and operated from approximately 1992 until it was upgraded in 2005. The original SVE system consisted of 12 vapor control boreholes, two 75- horsepower (HP) blowers with a combined capacity of approximately 1,500 standard cubic feet per minute (scfm) and a single thermal treatment oxidizer capable of treating up to 27 million British thermal units (BTU) per hour (URS 2013).

The original system was replaced in three phases beginning in 2005 by the Hartford Working Group and currently consists of a network of approximately 120 vapor extraction wells connected through a series of piping and valves to a single 12-inch pipe. The 12-inch pipe conveys the recovered vapors from the Hartford Site below the Union Pacific, Kansas City Southern, and Norfolk Southern Railroads rights-of-way located east of North Olive Street to four 75-HP blowers located on the Premcor facility. The four blowers have a total capacity of approximately 3,200 scfm. The recovered soil vapor is treated using between one and four thermal oxidizers, each capable of processing 9 million BTUs per hour.

Detailed records of hydrocarbon recovery rates have been documented for the SVE system since it was replaced by the Hartford Working Group in 2005. As shown on Figure 2, approximately 950,000 gallons of volatile petroleum hydrocarbons have been recovered through the SVE system between May 2005 and December 2013 (URS 2014). Vapor recovery has not reached asymptotic conditions - the highest daily recovery occurring in late 2012, as low water table conditions were observed beneath the Hartford Site.

2.3 GEOLOGIC SETTING

The Village of Hartford is located in the Springfield Plain of the Interior Plains Section of the Central Lowland Province. Specifically, the Village is situated within a shallow valley approximately 30 miles long and 11 miles across at its widest point and underlain by more than 100 feet of unconsolidated deposits created by alluvial and glacial processes during the Pleistocene period.

The Hartford Site is located along the historical edges of the Mississippi and Missouri River flood plains. Over the last 125,000 years, the Mississippi River has changed its course frequently through a process known as avulsion. An avulsion occurs when a river breaches its natural levee and then cuts a new channel in the adjacent floodplain. These frequent avulsions of the river have resulted in deposition of sediments with widely-varying grain size (including thick sequences of channel sands, lenticular splay sands, fine-grained levee sands, and finer-grained silty clay floodplain deposits) across a broad area creating a highly heterogeneous unconsolidated stratigraphy (USEPA 2010). These deposits are collectively referred to as the Cahokia Alluvium of Holocene Age. Underlying these alluvial deposits are a relatively thick sequence of sandy glacial outwash (between 60 and 150 feet thick) deposited during the Pleistocene Epoch, as the broad shallow valley was filled as part of a large outwash plain as the continental glaciers retreated. These sands are referred to as the Mackinaw Member of the Henry Formation. Locally these sands are referred to as the Main Sand hydrostratigraphic unit as described in Section 2.3.9.

These fluvial and glacial sediments are underlain by the Glasford Till or consolidated sedimentary bedrock more than 3,800 feet thick. These bedrock formations dip gently to the northeast from the Ozark Highlands toward the Illinois Basin and predominantly consist of limestone and dolomite with lesser amounts of sandstone and shale. Mississippian age bedrock believed to be the Renault Limestone underlies the Hartford Site. The Renault Limestone consists of relatively pure limestone and an upper sandy limestone (Clayton 2006). The limestone generally occurs more than 100 feet below ground surface (ft-bgs).

The following subsections describe the local geology beneath the Hartford Site with a focus on the alluvial and glacial units where petroleum hydrocarbons associated with releases from the refineries and pipelines may be present. Isopach maps and detailed descriptions of the shallow geology have previously been presented in the *LNAPL Active Recovery System Conceptual Site Model* (Clayton 2005).

2.3.1 A CLAY

The A Clay is the shallowest stratum beneath the Hartford Site. This clay unit ranges in thickness from 5 to 24 feet and is continuously present beneath Hartford, with the exception of areas where it has been removed as part of construction activities. As described in the *LNAPL Active Recovery System Conceptual Site Model* (Clayton 2005), this stratum is generally thickest: (1) near the intersection of West Date Street and North Delmar Avenue, and (2) north of West Rand Avenue along Illinois State Route 3. These areas are separated by relatively thin zones (less than 10 feet thick) that are generally situated: (1) near the intersection of West Date Street and Old St. Louis Road, (2) between West Watkins and West Forest Streets along Old St. Louis Road, (3) between East Rand Avenue and East Forest Street along North Olive Street, and (4) along East Forest Street between North Delmar Avenue and North Olive Street.

Geotechnical samples collected from the less permeable fine grained units, including the A Clay, beneath the Hartford Site contain mixtures of silt and clay ranging between 85% clay-15% silt and 20% clay-80% silt. Minor amounts of sand, generally less than 15% can be measured within these less permeable units (Clayton 2005).

2.3.2 NORTH OLIVE STRATUM

The North Olive stratum is encountered at depths ranging from approximately 8 to 15 ft-bgs and extends across the majority of the Hartford Site, with the most notable absence in the central area of the Site along North Delmar Avenue and North Market Street, as shown on Figure 3. The North Olive stratum is bounded by the A and B Clay and is comprised of approximately 12% sand, 71% silt, and 17% clay based on previously collected geotechnical samples (Clayton 2005). The North Olive stratum ranges from less than 1-foot to 10-feet thick and is generally thickest (1) along the southern portion of North Olive Street, (2) south of East Rand Avenue along North Olive Street, (3) at the intersection of North Delmar Avenue and West Birch Street, and (4) in the vicinity of the Hartford Community Center. The North Olive stratum is thinnest near the margins of the B Clay (Clayton 2005).

2.3.3 B CLAY

The B Clay, underlies and defines the extent of the North Olive stratum, where present, and overlies the Rand stratum. The B Clay is highly discontinuous and is generally absent beneath the central and southern portions of the Hartford Site as described in the previous section. The B Clay ranges in thickness from less than 1 foot to 12 feet and is generally thickest (1) near the intersection of East Elm and North Olive Streets, (2) between East Date and East Cherry Streets, (3) near the intersection of East Birch and North Market Streets, (4) between West Cherry and West Date Streets, and (5) near the intersection of East Rand Avenue and North Olive Street. The B Clay stratum is generally 6 feet thick east and west of North Delmar Avenue, near the Hartford Community Center (Clayton 2005).

2.3.4 RAND STRATUM

The Rand stratum is discontinuous and generally encountered at depths ranging from approximately 12 to 27 ft-bgs and is defined by the extent of the C Clay. Based on previously collected geotechnical samples, the Rand stratum is composed of approximately 10% sand, 70% silt, and 20% clay and is similar in composition to the North Olive stratum, and also that of the Main Silt in some areas (Clayton 2005). This stratum appears to extend across the majority of the northern and eastern portions of the Hartford Site as shown on Figure 4. To the south of Date Street, the Rand stratum grades laterally into the Main Sand (or Main Silt where present) and is locally absent near the intersections of West Rand Avenue and North Delmar Avenue, as well as West Rand Avenue and North Old St. Louis Road, where the Rand Stratum is absent and the B and C Clays are undifferentiated. The Rand stratum ranges in thickness from less than 1 foot to 11 feet and is thickest (1) near the intersection of East Birch and North Olive Streets, (2) south of East Rand Avenue along North Olive Street, and (3) between East Date and East Elm Streets. It is thinnest at the intersection of West Date Street and North Delmar Avenue (Clayton 2005).

2.3.5 C CLAY

The C Clay defines the extent of the Rand stratum and ranges in thickness from less than 1 foot to approximately 8 feet. The C Clay is highly discontinuous and only present in the northern and eastern portion of the Site, with the edge of this stratum trending southeast from the west side of West Cherry Street to the east side of West Watkins Street. The C Clay is thickest in the area (1) near the intersection of East Cherry and North Olive Streets, (2) near the intersection of East Date and North Market Streets, and (3) between East Elm and East Forest Streets west of North Olive Street. The C Clay is thinnest near the intersection of North Market and East Forest Streets (Clayton 2005).

2.3.6 EPA STRATUM

As shown on Figure 5, the EPA stratum is only present in the northeastern portion of the Hartford Site at depths ranging from 27 to 46 ft-bgs. Based on prior geotechnical analyses, the EPA is composed of approximately 68% sand, 22% silt, and 10% clay (Clayton 2005). This stratum is defined from the Main Sand by the thin D Clay. The EPA grades laterally into the Main Sand south of a southeasterly trending line starting at the intersection of Old St. Louis Road and North Delmar Avenue to the intersection of East Date and North Olive Streets. Along this boundary, the EPA and Main Sand are hydraulically connected. The EPA stratum ranges from approximately 4 to 9 feet thick within the northeastern portion of Hartford and is thickest north of West Rand Avenue (Clayton 2005).

2.3.7 D CLAY

The D Clay underlies the EPA stratum and ranges in thickness from approximately 2 to 7 feet thick. This thin fine grained unit could be considered a discontinuous lens within the Main Sand, based on its relative thickness and limited extent. The D Clay stratum is thickest near the intersection of North Delmar Avenue and Old St. Louis Road and thins out along its western margin (Clayton 2005).

2.3.8 MAIN SILT STRATUM

The Main Silt is encountered at depths ranging from approximately 6 to 30 ft-bgs, where the B and/or C Clay are absent, along a northwest to southeast trending line across the central and southern portion of the Hartford Site as shown on Figure 6. Previous descriptions (Clayton 2005, Clayton 2006) of the extent of the Main Silt have been inconsistent due in part to the challenges in differentiating the stratum from the Rand and Main Sand. The Main Silt has been described as compositionally similar to the North Olive and Rand strata (approximately 25% sand, 64% silt, and 11% clay), and although compositionally different from the Main Sand, the gradational contact between the Main Silt and Main Sand makes discerning the units difficult (Clayton 2005). The interpretation of the lateral extent of the Main Silt is based on a review of historical isopach maps, geologic cross-sections, and lithologic logs from borings installed throughout the Village of Hartford.

In general, the top surface of the Main Silt is equivalent to the same horizon as the top of the North Olive stratum. The majority of the bottom surface of the Main Silt is equivalent to the same horizon as the top of the EPA stratum. The Main Silt ranges in thickness from approximately 2 to 19 feet and is thickest on North Delmar Avenue (1) between West Watkins and West Maple Streets, and (2) between West Elm and West Forest Streets. The Main Silt is thinnest in areas where the A Clay is thickest, such as between West Forest and West Watkins Streets along North Delmar Avenue. The nature and distribution of groundwater and LNAPL within the Main Silt is combined with descriptions regarding the Main Sand herein.

2.3.9 MAIN SAND STRATUM

The Main Sand is aerially extensive throughout the region. In Hartford, it is encountered at depths ranging from 19 and 45 ft-bgs based on the presence or absence of the overlying Clay strata. Although the Main Sand is primarily comprised of 90% sand, 7% silt, and 3% clay, discontinuous silty clay and clayey silt lenses of limited thickness and extent occur at various depths within the Main Sand (Clayton 2005). Gravels are also observed in lenses within the Main Sand stratum. The thickness of the Main Sand stratum ranges from 80 to 100 feet, with bedrock generally encountered at an elevation between 300 and 325 feet above mean sea level (ft-amsl).

2.4 HYDROGEOLOGIC SETTING

Groundwater present within the aerially extensive deposits of unconsolidated valley fill of the Mackinaw Member of the Henry Formation, extending across an area of approximately 175 square miles, is considered the most significant aquifer in the region. This aquifer, present in the Main Sand stratum beneath the Hartford Site, is commonly referred to as the American Bottoms aquifer. Natural groundwater movement within the American Bottoms aquifer is to the west, draining water from the limestone bluffs (along the east wall of the floodplain valley) into the Mississippi River (Engineering Science 1992).

There are three additional water bearing, or hydrostratigraphic units, located within the Cahokia Alluvium beneath the Hartford Site. These hydrostratigraphic units are generally present within the coarser grained silt and sand deposits including the North Olive, Rand, and EPA strata. Multiple flow directions have been observed in these shallower, less permeable hydrostratigraphic units. These shallow water-bearing zones are generally discontinuous and do not appear to have an effect on regional flow in the underlying Main Sand aquifer beneath the Hartford Site, with the exception of areas of recharge where the shallower units are contiguous within the Main Sand aquifer.

The Mississippi River is located less than a half mile from the Hartford Site and is hydraulically connected to the deeper hydrostratigraphic units (Rand, EPA, and Main Sand), where present, beneath the Hartford Site. Water level fluctuations in each unit are affected by changes in the Mississippi River stage. Since the river stage varies by more than 20 feet during a year, the groundwater conditions can fluctuate from unconfined to confined conditions throughout the year. There are some areas within the Main Sand where confined conditions may persist during low river stage, such as the northwest portion of the Hartford Site near the intersection of North Olive Street and West Rand Avenue where the D Clay is present.

2.4.1 NORTH OLIVE STRATUM

Groundwater within the North Olive stratum occurs as isolated areas of temporarily perched water on the surface of the underlying B Clay prior to migrating deeper into the subsurface. Therefore, it is not possible to generate a representative potentiometric surface map representing flow within this stratum. Figure 3 presents the groundwater elevation data where groundwater occurs within the monitoring wells and monitoring points screened in the North Olive stratum. Hydraulic conductivity estimates based on a limited number of slug tests performed by the Hartford Working Group in the North Olive stratum ranged from 2.9E-04 to 1.4E-06 centimeters per second (cm/s). These hydraulic conductivity estimates within the North Olive stratum were similar to the hydraulic conductivities measured in the over and underlying clay strata, which ranged from 1.7E-04 to 6.0E-09 cm/s (Clayton 2005).

2.4.2 RAND STRATUM

Groundwater in the Rand stratum, south of Rand Avenue, also represents localized areas of perched water. Groundwater elevations measured in October 2013 within the monitoring wells and monitoring points installed within this hydrostratigraphic unit are included on Figure 4. Hydraulic conductivity measured in the Rand stratum ranged from 7.9E-03 to 5.5E-05 cm/s (Clayton 2005). Similar to the underlying hydrostratigraphic units, groundwater within the Rand stratum is unconfined during periods of low Mississippi River stage, and becomes confined during times of high river stage. Groundwater within the Rand and underlying EPA stratum in northeast Hartford are hydraulically separate, although the C Clay located between these two units is discontinuous and leaky allowing vertical drainage between these hydrostratigraphic units.

2.4.3 EPA STRATUM

A groundwater divide is generally present within the EPA stratum, with groundwater flow on the southern side of the divide (beneath the northeastern portion of the Hartford Site) to the southwest. As groundwater flows southwesterly beyond the extent of the D Clay, it is hydraulically connected to the Main Sand and flows to the west and northwest. Groundwater elevations in the monitoring wells screened in the EPA stratum are shown on Figure 5. The average hydraulic conductivity of the EPA stratum was within the range of values for both the North Olive and the

Rand strata. In the northeastern portion of Hartford where the EPA stratum is present, the hydraulic conductivity has been measured between 3.8E-04 and 1.5E-05 cm/s (Clayton 2005).

2.4.4 MAIN SAND STRATUM

Groundwater in the Main Sand aquifer within the Village of Hartford is generally unconfined during periods of drought and low Mississippi River stage which generally occurs for no more than several months each year, typically in the late Fall and Winter months. Groundwater becomes confined by the C and D Clay (where these finer units are present beneath the Hartford Site) during times of normal and high river stage, and usually extends throughout most of the year. Groundwater elevations within the Main Sand have fluctuated significantly over the past 50 years. Historical fluid level monitoring data indicate that groundwater elevations reached a high of approximately 415 ft-amsl during the early-1990s and have been as low as approximately 380 ft-amsl in the mid-1950s, which is typically 10 to 15 feet lower than conditions that have prevailed since 2004. The low groundwater elevations observed during the mid-1950s (that have not been observed since then) may be attributed to (1) the lowest mean Mississippi River stage as a result of extreme drought conditions, and (2) a period of maximum pumping of groundwater from the facilities adjacent to the Hartford Site (USEPA 2010). It should be noted that the Army Corp of Engineers constructed Dam No. 27 (a.k.a. the Chain of Rocks Dam), between 1959 and 1963, down-stream of the Hartford Site. This low water dam raised the minimum river stage to 9 feet within the Mississippi River from the dam up-stream to the Melvin Price Dam (which replaced Dam No. 26), which also may explain why groundwater elevations in the Main Sand have not reached the historical lows observed in the 1950s.

There is a significant difference between the hydraulic conductivity measured in the Main Sand aquifer and those of the overlying hydrostratigraphic units. The hydraulic conductivity for the Main Sand in the central portion of the Hartford Site determined via slug testing performed under unconfined conditions in wells screened across the upper portion of the hydrostratigraphic unit ranged from 1.6E-02 to 3.1E-02 cm/s. Hydraulic conductivities estimates reported via pump tests in the production wells installed on the Premcor facility were as high as 1.0E-01 cm/s (Clayton 2005). The Village of Hartford and adjacent refinery groundwater production wells are generally screened within deeper portions of the Main Sand stratum because of the elevated hydraulic conductivity and saturated thickness (between 80 and 100 feet), resulting in high groundwater transmissivity within this aquifer.

Natural flow of groundwater in the Main Sand aquifer has been locally altered beneath the Hartford Site due to pumping on the BP, Phillips 66, and Premcor facilities. In 2013, the pumping rate at the BP facility averaged 1,225 gpm, while pumping at the Premcor facility averaged 288 gpm with periods of pumping in excess of 500 gpm. Additional pumping wells located west and northwest of the Village of Hartford at the Phillips66 River Dock operated at rates between 6,300 and 7,100 gpm. In addition, groundwater production rates were reported between 3,000 and 3,800 gpm at the Phillips66 facility located northeast of the Village of Hartford (SJMA 2014).

The groundwater flow direction in the Main Sand is also influenced by the stage of the Mississippi River. During periods of high river stage groundwater flow is generally towards the east to northeast due to recharge from the river and bank storage within the Main Sand. During moderate river elevations, the groundwater flow direction is northward. During low river stages, groundwater flow trends westerly to northwesterly. As shown on Figure 7, groundwater flow during the fourth quarter 2013 was generally to the west and northwest and is attributed to the low water table combined with the high rate of pumping conducted within production wells on the Phillips 66 River Dock. There is also a small area of the Hartford Site along North Olive Street between East Date and East Watkins Streets, where flow is locally to the east (as influenced by pumping at the Premcor facility). Beneath the Premcor facility, groundwater within the Main Sand converges with groundwater flowing from the western limits of the EPA Stratum.

In the absence of groundwater production by the various facilities around the Hartford Site, groundwater flow within the Main Sand under typical river stage conditions may have been to the south and southwest, parallel to surface water flow within the Mississippi River (USEPA 2010). The Village of Hartford municipal wells are installed within the Main Sand aquifer to the south of the Hartford Site (Figure 1). The two most recently installed groundwater production wells (No. 3 and No. 4) have a total depth of approximately 105 ft-bgs and were constructed with between 20 and 35 feet of screen. Discontinuous pumping from these municipal wells (average of 150 gpm) is at a much lower rate than that performed on the various facilities located to the north of the municipal wells and does not affect flow direction within the Main Sand aquifer beneath the Hartford Site.

3.0 LNAPL CHEMISTRY AND PHYSICAL PROPERTIES

Two types of data sets have historically been used to characterize LNAPL underlying the Site: (1) LNAPL chemistry data from laboratory analysis, and (2) LIF results. In 2004, 28 LNAPL samples were collected from the Main Sand stratum and characterized as primarily gasoline range hydrocarbons. The secondary product type, where present in these samples, was identified as diesel (Clayton 2005). A summary figure showing the distribution of these product types, reproduced from the *Active LNAPL Recovery System Conceptual Site Model* is provided as Appendix B. For the most part, LNAPL with gasoline reported as all or nearly all of the hydrocarbon makeup were identified in the central portions of the Hartford Site; while LNAPL with diesel as a secondary component tended to be located on the eastern and northern portions of the Site. A single LNAPL sample was also collected from the EPA (HMW-048C) and the Rand strata (MP-029C). LNAPL within these two hydrostratigraphic units was primarily characterized as diesel with lesser amounts of gasoline. The inferences from the LNAPL chemistry results were generally supported by LNAPL physical properties (i.e., molecular weight, density, and viscosity).

Twelve additional LNAPL samples were collected for laboratory analysis in 2006 and two samples were collected in 2009. These samples were collected from wells screened within the Main Sand stratum, with the exception of monitoring point MP-029C, which is screened within the Rand stratum. The laboratory analytical results for these samples are provided in Appendix B. LNAPL samples collected from the Main Sand generally consisted of low molecular weight hydrocarbons with chemical characteristics similar to a weathered gasoline. Conversely, the LNAPL sample collected from monitoring point MP-029C consisted of higher molecular weight hydrocarbons and was chemically more similar to a weathered diesel. The results for these samples are further discussed in Sections 3.2 and 3.3.

In 2004, 66 LIF borings were installed to evaluate the nature and distribution of hydrocarbons within the stratigraphic units beneath the Hartford Site using the Rapid Optical Screening Tool (ROST™). An additional 43 LIF borings were installed in 2005. The observed waveforms were categorized into three general LNAPL types including light-, mid-, and heavy-range hydrocarbons. Heavy-range hydrocarbons were primarily identified on North Olive Street between the intersections of East Date and East Watkins Streets within the Main Sand stratum. In this case, “heavy-range” generally corresponds to LNAPL with a higher proportion of diesel-range compounds than the light-range hydrocarbons which are comprised almost entirely of gasoline-range compounds (see Appendix B). Mid-range hydrocarbons were observed in the northern portion of the Hartford Site within the Main Sand and EPA strata, with several locations also showing similar LNAPL types in the overlying Rand and North Olive strata. Light-range hydrocarbons were identified within the central and southern portions of the Hartford Site within the Main Sand, with select locations showing similar light range hydrocarbons in the overlying EPA, Rand, and North Olive strata. Commingling of the three different LNAPL types was observed in some locations (Clayton 2004).

3.1 COMPARISON OF FLUORESCENCE WAVEFORMS AND LNAPL CHEMISTRY

In general, waveforms obtained by LIF are a qualitative indicator of LNAPL types, and not a quantitative measurement such as can be obtained by laboratory analysis of carbon distributions and individual constituents in LNAPL. Therefore, this section provides a comparison of the LNAPL chemistry results for the samples collected in 2006 to the historical LIF waveforms. This comparison was performed to increase the confidence of the LIF results as a direct indicator of LNAPL chemistry. The location of the seven monitoring points and wells where LNAPL samples were collected (total of ten samples), as well as the closest corresponding LIF borings, are shown on Figure 8.

In general, carbon distributions for LNAPL samples collected from the Main Sand stratum, included in Appendix D, peaked at C8 and have a shallower decrease in the direction of shorter chained constituents compared to longer chained constituents (in other words, there is an abundance of light-end constituents centered at the C8 carbon range). Several of the LNAPL samples collected from the Main Sand show a secondary peak in the carbon distribution centered at C5 (e.g., MP-029D, MP-047C, MP-079C). Both of these carbon distributions are characteristic of light-range hydrocarbons such as gasoline. The LNAPL chemistry results for samples collected from the Main Sand are consistent with the LIF data measured in the same stratum within the nearby borings, which show waveforms that are peaked at the first (or shortest) waveband. Two exceptions include LIF response within borings HROST-026 and HROST-130, which are collocated with LNAPL samples collected from monitoring points MP-047C and MP-029D, respectively. The waveform for HROST-026 suggests a mid-range hydrocarbon with the peak at the second waveband, which is not consistent with the carbon distribution for the LNAPL sample collected from monitoring point MP-047C. The poor match between the LNAPL chemistry and the nearby LIF response may be an indication of a transition or mixing of LNAPL types along the eastern edge of the Site. In addition, the waveform observed within boring HROST-130 appears to be a mid-range hydrocarbon type (peak at the second waveband) which is inconsistent with the carbon distribution for the LNAPL sample collected from monitoring point MP-029D. The poor match between the LNAPL chemistry data and LIF response may be an indication of commingling of LNAPL types or heterogeneities in their distribution along the northern portions of the Hartford Site, where multiple releases are known to be present across the hydrostratigraphic units.

The carbon distribution for the LNAPL sample collected from the Rand stratum at monitoring point MP-029C peaked at C11, and does not reach a “tail” beyond the C15 carbon range. The carbon peak is suggestive of a mid-range hydrocarbon, though it is possible that other peaks are present above C15.

The LIF waveform observed within the Rand stratum from nearby boring HROST-130 shows the highest response within the second waveband, consistent with the interpretation of a mid-range hydrocarbon.

These comparisons generally confirm that the LIF waveforms are a reasonable indicator of LNAPL types at the Hartford Site. The LNAPL chemistry data set is strongest for light-range LNAPL with a gasoline-like carbon distribution and could be bolstered by collecting LNAPL samples from areas with mid- and heavy-range LNAPL types.

3.2 LNAPL PARTITIONING ESTIMATES

The LNAPL chemistry results reported for the samples collected in 2006 can also be used to estimate potential partitioning of individual constituents from the LNAPL to groundwater. Effective solubility estimates for benzene based on the LNAPL chemistry results are presented on Table 2, and compared to dissolved phase benzene concentrations measured in groundwater samples collected from nearby monitoring points and wells (Figure 9). The effective solubility estimates for benzene in the Main Sand stratum exceeded 10 milligrams per liter (mg/L) for each of the LNAPL samples, which are similar to the dissolved phase concentrations measured in groundwater samples collected from nearby wells, with a difference generally less than a factor of two. These results indicate general agreement between LNAPL effective solubility and dissolved phase concentrations and suggest that dissolution processes have reached equilibrium within the Main Sand stratum; therefore, measurements of individual hydrocarbon constituents in groundwater and LNAPL can be used somewhat interchangeably. This also means that depletion of constituents within the dissolved phase can be interpreted as depletion of individual constituents within the LNAPL, which will be discussed as part of the forthcoming dissolved phase component to the CSM.

3.3 LNAPL PHYSICAL PROPERTIES

The physical properties of the LNAPL can provide a supporting line of evidence regarding product type. This is especially the case for viscosity, which can vary over large ranges for different product types (e.g., less than 1 centipoise [cp] for gasoline and greater than 100 cp for motor oil). Physical properties of the LNAPL can also significantly affect the efficacy of various recovery approaches (e.g., high viscosity LNAPL is not amenable to recovery using traditional approaches). For example, moving from a 1 cp LNAPL to a 5 cp LNAPL can significantly decrease LNAPL recovery rates.

Figures 10 and 11 present measured kinematic viscosities for LNAPL samples collected from the Rand and Main Sand stratum, respectively. Viscosities for LNAPL samples collected from the Rand stratum range between 0.55 (MP-083B) and 3.39 centipoise (MP-029C). The higher viscosity at monitoring point MP-029C is indicative of a heavier-range hydrocarbon, which is consistent with the LNAPL chemistry and waveform from the nearby LIF boring.

Most measured viscosities for LNAPL samples collected from the Main Sand are less than 1 centipoise, with the lowest values generally observed within the central portions of the Hartford Site, consistent with other lines of evidence indicating predominantly light-range hydrocarbons within this stratum. The highest viscosity LNAPL in the Main Sand was measured in samples collected from wells HMW-045C and HMW-046C, located in the northwest corner of the Harford Site. These higher viscosity measurements may indicate a different LNAPL source, which is consistent with the LNAPL chemistry results. Slightly higher viscosities (but still below 1 centipoise) were measured in eastern and northeastern portions of the Hartford Site, possibly consistent with commingled LNAPL in these areas.

3.4 PROPOSED DATA COLLECTION AND UPDATES TO THE COMPREHENSIVE CSM

A robust data set for correlating carbon distributions with LIF response for the light-range hydrocarbons has previously been collected at the Hartford Site. However, the mid- and heavy-range LNAPL types have a smaller LNAPL chemistry data set for correlating carbon distributions with LIF responses. It is recommended that additional LNAPL samples be collected from groundwater monitoring wells and monitoring points HMW-044C, HMW-046C, and MP-029D screened in the Main Sand, as well as monitoring point MP-029C screened in the Rand stratum to bolster this data comparison.

Additional light-range LNAPL samples are also recommended from monitoring points MP-038C, MP-039C, MP-046C, MP-047C, MP-060C, and MP-079C screened within the EPA and Main Sand strata and monitoring points MP-053B and MP-054B screened in the Rand stratum. The light-, mid-, and heavy-range samples will be used to assess individual constituent and mass depletion of the smear zone beneath the Hartford Site.

The LNAPL samples will be collected from these wells using skimmer pumps, peristaltic pumps, or hydrophobic bailers. These samples will be collected and submitted for laboratory analysis of volatile and semivolatile organic constituents via USEPA Methods 8260 and 8270, respectively. Samples will also be analyzed for API gravity via ASTM Method D287, viscosity via ASTM Method D445, and simulated distillation by gas chromatography/flame ionization detector for carbon fraction ranges. The carbon distributions for the mid- and heavy-range LNAPL will be compared to the LIF results within the nearby borings. In addition, the mole fraction of benzene, as well as other select petroleum related constituents, will be estimated within the light-, mid-, and heavy-range LNAPL samples and compared to historical results to assess depletion of the LNAPL. These analyses will be provided within the Comprehensive CSM, if LNAPL samples are able to be collected and analyzed prior to preparing that document.

4.0 LNAPL DISTRIBUTION

LNAPL distribution is affected by several factors including but not limited to the lithology, groundwater fluctuations, release history, and LNAPL recovery efforts. As detailed in Section 2.2, approximately 2.25 million gallons of LNAPL have been recovered from the Hartford Site, with approximately half of that mass removed from the Main Sand via LNAPL skimming and the other half from the overlying strata via vapor extraction. Recent investigation and routine monitoring activities indicate that while the extent and mass of petroleum hydrocarbons has been reduced over the past three decades, LNAPL remains beneath many portions of the Hartford Site.

4.1 3D VISUALIZATION MODEL

Historical investigations have documented that LNAPL is primarily distributed within the more permeable strata including the North Olive, Rand, EPA, and Main Sand hydrostratigraphic units. Because historical LIF data provide information about the horizontal and vertical extent of LNAPL, as well as hydrocarbon type across the Hartford Site, these data were incorporated into a 3D visualization model. This model also incorporates lithologic information from 379 soil borings. In addition, cone penetrometer testing conducted contemporaneous to ROST™ within the same boring was used to verify the lithologic descriptions. Ground surface elevations for each boring and monitoring location were also incorporated into the model where available. It should be noted that some information from off-site borings and monitoring locations were incorporated into the 3D model to improve interpretations along the lateral limits of the Hartford Site. Figure 12 presents the data that was incorporated into the 3D model.

Leapfrog Hydro 4.0™ was used to integrate the LIF, lithology, and ground surface data for display in three dimensions. Lithology is generated as a 3D mesh, with zones between data points using all adjacent borings for interpolation. Contaminant distribution, in this case LNAPL, is developed by krigging a dataset and displaying the 3D shape of interpolated values. The krigging parameters can be adjusted by the modeler and this was done to develop LNAPL bodies consistent with the general understanding of LNAPL morphology. For instance, LNAPL tends to spread along the contact between the more permeable, hydrostratigraphic units and the less permeable strata.

A total of 379 locations providing subsurface lithology were incorporated into the 3D model. When interpolated between locations, a 3D depiction of the various clays layers is generated, as shown in the oblique views on Figure 13. In addition, LIF data from approximately 109 borings installed in 2004 and 2005 were incorporated into the model, in a manner consistent with historical conventions and interpretations (Clayton 2004). Interpretations from two of the historical LIF borings were adjusted slightly based on observations within nearby locations. Specifically, LNAPL present within the lower portions of the smear zone in the Main Sand stratum (approximately 40 to 45 ft-bgs) within borings HROST-002 and HROST-003 was previously identified as a mid-range hydrocarbon. However, these waveforms were "borderline" with a heavy-range LNAPL type. More recent borings HROST-087 and HROST-090 indicated heavy-range LNAPL with this portion of the Main Sand; therefore, LNAPL within the lower portion of the Main Sand within borings HROST-002 and HROST-003 were changed from a mid-range to heavy-range LNAPL.

An oblique view of the LIF boring locations and depiction of the various LNAPL types beneath the Hartford Site are shown on Figure 14. If the waveforms indicated more than one LNAPL type within a boring, these different LNAPL types were depicted within the model. Figure 14 includes the vertical and horizontal limits of the smear zone where LNAPL shares pore space (whether residual or mobile) with groundwater and soil vapor (if within the vadose zone). While the model indicates the presence or absence of LNAPL (i.e., normalized fluorescence measurements above background), it does not provide any indication of LNAPL saturations or potential recoverability. In addition, Figure 14 shows edges of the model that are beyond the boundaries of the Hartford Site where less data is available (Figure 12). The model algorithm interpolates areas between data points and often extrapolates them to the domain boundaries. Thus, observations for areas beyond the Site boundary should be considered in the context of the density of data integrated into the model in the area of interest.

4.2 LNAPL PRESENCE IN NORTH OLIVE STRATUM

Figure 15 displays the B Clay, as well as LNAPL present within the overlying North Olive stratum. It should be noted that the North Olive stratum is defined by the presence of the underlying B Clay, such that the North Olive is absent if the underlying B Clay is absent. The North Olive stratum extends across the majority of the Hartford Site, with the most notable absence in the central area of the Site along North Delmar Avenue and North Market Street. Within the North Olive stratum, all three LNAPL types described in Section 3.1 are identified.

Light-range LNAPL is present in the northeast corner of the Site along East Rand Avenue. This LNAPL type is also present in localized areas along: (1) North Old St. Louis Road between West Birch and West Cherry Streets, (2) near the intersection between East Forest Street and North Olive Street, and (3) on the eastern portion of the Hartford Site, between East Cherry and East Date Streets. A body of light-range LNAPL is also present in the central portion of the Site, along the southern edge of the B Clay stratum. Light-range LNAPL is also present immediately below these locations within the Rand and Main Sand strata which may indicate vertical migration downward as LNAPL reached the edges of the B and C Clay.

Mid-range LNAPL is present in the northeast corner of the Hartford Site, flanking the light-range LNAPL in this area. Two localized bodies of the mid-range LNAPL are observed in the northwest portion of the Site (one south of West

Rand Avenue and the other at the corner of West Arbor Street and North Old St. Louis Road) and two are present on the eastern side of the Site (both along East Elm Street).

Heavy-range LNAPL is present at the eastern edge of the Site along North Olive Street. These heavy-range hydrocarbons are not identified in other portions of the Site within the North Olive stratum.

The above describes the distribution of LNAPL within the shallowest hydrostratigraphic unit beneath the Hartford Site. LNAPL and groundwater generally occur in isolated areas that are temporarily perched on the surface of the underlying B Clay before draining into underlying stratum. LNAPL is generally not measured in wells screened in the North Olive stratum. There are only two groundwater monitoring wells (HMW-013 and HMW-044A) and two monitoring points (MP-055A and MP-108B) screened within the North Olive stratum where LNAPL has been measured (thickness greater than 0.01 feet), with the most recent occurrence reported in monitoring point MP-108B in April 2011. LNAPL has only been measured 22 times in these four locations and only under unconfined conditions. It is possible that LNAPL is currently present at residual saturations based on the lack of LNAPL thickness measured in wells screened in this stratum since April 2011.

4.3 LNAPL PRESENCE IN RAND STRATUM

Figure 16 displays the C Clay, as well as LNAPL present within the overlying Rand stratum. The C Clay is highly discontinuous and only present in the northern and eastern portion of the Site, with the edge of this clay stratum trending southeast from the west side of West Cherry Street to the east side of West Watkins Street. Similar to the North Olive stratum, the Rand stratum is absent south of Watkins Street, although it generally covers a smaller footprint than the North Olive stratum. All three LNAPL types have been observed within the Rand stratum.

Light-range LNAPL is present in a localized area along North Old St. Louis Road, south of West Birch Street and along West Cherry Street and appears continuous with light-range LNAPL within the North Olive stratum but with a larger lateral extent. This, combined with the localized absence of B Clay in the area (Figure 15), suggests a release within or above the North Olive stratum that migrated downward to the top of the C Clay. Light-range LNAPL is also present to the south near the edge of the C Clay. This light-range LNAPL is also present immediately above in the North Olive and below in the Main Sand and appears to have migrated downward as it reached the edges of the B and C Clay.

Mid-range LNAPL is present primarily at the northeast corner of the Hartford Site in the Rand stratum. This mid-range LNAPL overlaps with that present in the overlying North Olive stratum, suggesting a similar source. However, mid-range LNAPL in the Rand extends across a wider footprint compared to that in the North Olive, and again could be an indication of lateral LNAPL spreading that occurred at the top of the C Clay. A localized body of mid-range LNAPL is present in the northwest portion of the Site, near the corner of West Arbor Street and North Old St. Louis Road. A localized mid-range LNAPL has also been identified to the south along East Elm Street and might be an indication of commingling of the heavy-range and light-range LNAPL bodies in this area.

Heavy-range LNAPL is present at the eastern edge of the Site along North Olive Street. This LNAPL type is not identified in other portions of the Site within the Rand stratum.

The above summarizes LNAPL present at intermediate depths beneath the Hartford Site. In general, water and LNAPL are discontinuous and perched within the monitoring wells and points screened in this stratum. As shown on the comparison of LNAPL thickness and groundwater elevations over time for select wells screened within the Rand Stratum (Figure 17), the frequency and occurrence of LNAPL at thicknesses greater than 0.1 feet in groundwater monitoring wells and multipurpose monitoring points has been decreasing over the past five years.

4.4 LNAPL PRESENCE IN MAIN SILT, EPA, AND MAIN SAND STRATA

Figure 18 displays the D Clay, as well as LNAPL present within the overlying EPA stratum, and underlying Main Sand where the D Clay is absent. The D Clay could be considered a thin lens within the Main Sand stratum and is only present in the northeastern most portion of the Hartford Site. This means that the EPA stratum is limited in aerial extent in the Village of Hartford and that the Main Sand is present beneath most of the Site. All three LNAPL types are observed within these strata across a wider footprint than the shallower hydrostratigraphic units. The majority of the LNAPL mass is currently present within the EPA and Main Sand strata (Clayton 2005).

Light-range LNAPL is present throughout much of the central portions of the Site within the Main Sand. These light-range hydrocarbons are similar to that present in the Rand and North Olive strata; however, they extend across a larger aerial extent within the Main Sand. This morphology suggests that LNAPL released from within or above the North Olive stratum migrated downward with distribution controlled by the multiple factors previously discussed in Section 2.1. LNAPL occurs across the greatest vertical interval within the Main Sand. This thickness is variable, measuring less than one foot along the southern and western limits of the smear zone and as much as 29 feet within the central portions of the Hartford Site. It appears that the predominant LNAPL mass is present in the Main Sand, which is consistent with fluid level measurements and the volume of LNAPL recovered from the various strata via skimming.

The large vertical extent over which the smear zone is observed within the Main Sand can be attributed to the volume of hydrocarbons present at the time of the release(s), the period over which hydrocarbons were released, as well as the magnitude of water table fluctuations within this deeper hydrostratigraphic unit. Localized and discontinuous bodies of light-range LNAPL also appear to be present northwest of the Site.

Mid-range LNAPL is present at the northeast corner of the Hartford Site and appears continuous with mid-range hydrocarbons present in the overlying Rand and North Olive strata, suggesting a similar source. However, LNAPL present in the EPA and Main Sand has a larger footprint than either of the above hydrostratigraphic units and could be an indication of LNAPL spreading that occurred along less permeable zones (e.g., D Clay or Main Silt), as well as along the groundwater table. A localized body of mid-range LNAPL is also present at the eastern edge of the Site at the intersection of East Elm Street and North Olive Street and might be an indication of commingling of heavy-range and light-range LNAPL bodies.

Heavy-range LNAPL is present at the eastern edge of the Site along North Olive Street. This LNAPL is not present in other portions of the Site within the EPA and Main Sand strata. A discontinuous body of heavy-range LNAPL is also present to the northwest of the Site.

The above describes LNAPL present within the deeper saturated strata beneath the Hartford Site. Groundwater and LNAPL present in these strata can occur under confined or unconfined conditions depending on the fluid level elevation and occurrence of overlying less permeable strata including the D Clay to the northeast, the C Clay within the central and eastern portions of the smear zone, and sometimes the Main Silt present in the western and southern portions of the Hartford Site. As shown on Figure 19, LNAPL is generally not observed at a high frequency nor at significant thickness within monitoring locations screened within the Main Silt (e.g., MP-038B and MP-048B) compared to locations screened in the Main Sand.

There are locations where the Main Silt appears to have a confining effect on LNAPL thickness measurements in the Main Sand; however, this is only reflected in the routine gauging results from a few locations such as monitoring point MP-038C. In other locations, the Main Silt does not appear to have any effect on apparent LNAPL thicknesses measurements, such as monitoring point MP-048C (where LNAPL thicknesses do not substantially change relative to the groundwater and LNAPL elevations) or monitoring point MP-049C (where the overlying fine grained unit appears to result in confined LNAPL and groundwater conditions but not the Main Silt).

LNAPL is only measured above 0.01-foot thickness in two monitoring locations (HMW-048 and MP-085C) screened within the EPA. As shown of Figure 20, LNAPL occurrence within monitoring point MP-085C is relatively thin and infrequent. LNAPL thickness measurements in monitoring well HMW-048C have generally been decreasing over the past two years with the exception of periods when water and LNAPL are unconfined, and groundwater elevations are measured below approximately 395 ft-amsl.

LNAPL has been measured within many of the groundwater monitoring wells and monitoring points screened in the Main Sand; therefore LNAPL skimming has historically been focused within wells screened within these strata. As shown on Figures 21A and 21B depicting fluid level elevations in selected monitoring locations screened in the Main Sand stratum, LNAPL thicknesses have generally decreased since 2004 under both confined and unconfined conditions. These decreases in LNAPL thickness may suggest an overall reduction in the mass or saturations of LNAPL near these wells. These reductions may be attributable to mass recovery via manual LNAPL skimming, redistribution of LNAPL with fluctuating groundwater elevations, and natural smear zone depletion. Losses attributed to skimming performed within the groundwater monitoring wells and monitoring points since 2009 may be localized to portions of the stratum immediately adjacent to the well screen. A discussion regarding the influence of LNAPL skimming on the radius of capture near the monitoring locations is provided in Sections 5.2 and 5.3.

Figures 22 through 24 show the maximum thickness of LNAPL measured within groundwater monitoring wells and multipurpose monitoring points screened within the Main Sand Stratum over three time periods including 2003 through 2005, 2007 through 2009, and 2011 through 2013. These figures present the maximum LNAPL thickness measured within the monitoring locations over each two year span. LNAPL thicknesses were only considered when the fluid levels were present within the screen interval of the monitoring location. In general, the lateral extent of monitoring locations where LNAPL has been measured at thicknesses less than one foot under unconfined conditions has been consistent beneath the western and northern portions of the Hartford Site, providing evidence that the smear zone is stable. The thickness of LNAPL measured in the monitoring locations screened in the Main Sand along the southern limits of the Hartford Site are generally decreasing suggesting that the saturations may be decreasing in this portion of the smear zone. While LNAPL thicknesses generally appear stable or decreasing along the edges, redistribution of LNAPL is occurring within the interior portions of the smear zone. This redistribution results in increasing thicknesses observed in some areas with decreases in LNAPL thicknesses observed in other portions of the smear zone over time. This redistribution could be attributed to LNAPL recovery efforts including skimming which have resulted in LNAPL gradients towards recovery wells, hydraulic controls from nearby facilities, and fluctuating fluid level elevations over time.

4.5 COMPARISON OF HISTORICAL AND RECENT LIF RESULTS

A total of 24 LIF borings were installed in September 2013 across the Hartford Site using an Ultraviolet Optical Screening Tool (UVOST™). As shown on Figure 25, fourteen borings were installed at previous ROST™ monitoring locations within the six proposed remediation areas (Areas A, B1, B2, B3, B4, and C) described in the *LNAPL Active Recovery System 90% Design Report* (Clayton 2006). These fourteen LIF borings were installed to assess changes in the LNAPL distribution within the hydrostratigraphic units targeted for remediation. To assess changes in the lateral and vertical distribution of LNAPL along the western and southern limits of the smear zone, ten additional borings were installed at previous LIF borings installed in 2004 and 2005 (including borings HROST-007, -013, -019, -028, -049, -066, -068, -072, -090, and -099). Each boring was installed to a minimum of five feet below the vertical smear zone limits in the Main Sand. It should be noted that a proposed LIF boring at location HROST-123 could not be completed in September 2013; multiple attempts to install an LIF boring at this location resulted in refusal at approximately 3 to 5 ft-bgs.

Both the ROST™ and UVOST™ make use of fluorescence and data acquisition systems developed wholly or in part by Dakota Technologies. These two methods differ primarily in the laser and associated wavelength used to excite polycyclic aromatic hydrocarbons (PAHs) within the LNAPL (290 and 308 nanometer wavelengths, respectively). The PAH mixtures within the LNAPL emit photons of a distinctive wavelength irrespective of the excitation wavelength, although the intensity of the response may vary. By sampling the total fluorescence at different wavelength channels (which are nearly identical for both tools), a multi-wavelength waveform is generated. The waveform allows simultaneous description of the spectral and temporal qualities of the fluorescence with depth and can be used to identify different product types. The waveform data are referenced and displayed as a percent of the response compared to the calibration reference emitter (RE). The RE is similar to a calibration gas used in a flame ionization or photoionization detector, and is placed on the sapphire probe window before collecting fluorescence data at each boring. The same RE is used for the ROST™ and UVOST™ (that is to say, the RE produces the same multi-wavelength waveform). Fluorescence measurements generated in the borings are normalized to the RE measurements which allows for spatial and temporal comparisons of the fluorescence results despite changes in the optics, laser energy drift, window, mirror, etc.

Both the ROST™ and UVOST™ readily detect most light- to mid-range product types including diesel and gasoline. The fluorescence response for these product types are generally linear, with higher concentrations of PAHs within a given product type resulting in a greater percent response relative to the RE (excluding any matrix interferences described below). With respect to gasoline, ROST™ will potentially have an advantage over UVOST™ since its laser system produces a shorter wavelength. But much of this advantage may be normalized through comparison of the LIF results from ROST™ and UVOST™ to the same RE. This is generally observed in the waveforms for the ROST™

borings installed in 2004 and 2005 when compared to the UVOST™ borings installed at the Hartford Site in 2013. The fluorescence results from the 24 collocated borings are presented as mirror images on the figures included in Appendix E. The scale for the total waveform from the ROST™ was adjusted in the horizontal direction (i.e., stretched or compressed) so the percent fluorescence response (%RE) was equivalent to that of the corresponding scale for the UVOST™ waveform.

This comparison of the ROST™ and UVOST™ waveforms is semi-qualitative and may be affected by changes in the distribution or weathering of the LNAPL within the hydrostratigraphic units due to groundwater fluctuations, remedial system operation, and natural smear zone depletion. These results are semi-qualitative as there are several sources of variation with respect to fluorescence response beyond the aforementioned differences in the ROST™ and UVOST™. For instance, only the relative fraction of LNAPL that is optically accessible at the sapphire window of the probe can contribute to the fluorescence response. Therefore, significant heterogeneities in the lithologic setting and LNAPL distribution within the soil matrix can affect the fraction of LNAPL present within a few centimeters of the window. In addition, the method used to install the borings (e.g., cone penetrometer, direct push) can result in differing physical response of the soils and LNAPL such that the diameter of probe, push speed, and other factors combine to influence how much LNAPL gets preferentially drawn towards or pushed away from the sapphire window.

These figures provided in Appendix E show the current vertical distribution of LNAPL within the hydrostratigraphic units at these 24 locations compared to the historical results for borings installed in 2004 and 2005. In addition, a comparison of the vertical extent of LNAPL, as well as the depth and degree of maximum fluorescence response is included in Table 3. Temporal changes in the vertical extent of the LNAPL and maximum fluorescence response within a location may indicate preferential depletion of the smear zone due to a combination of interim measures, redistribution due to fluctuating groundwater elevations, and natural smear zone depletion processes. Apparent temporal changes (subject to the differences in the ROST™ and UVOST™, inherent variation associated with LIF, and subsurface heterogeneity described above) were most prevalent within the North Olive stratum and within the deeper hydrostratigraphic units along the western and southern boundaries of the smear zone.

4.5.1 SMEAR ZONE DEPLETION IN THE NORTH OLIVE STRATUM

At those locations where LNAPL was identified in 2004 and 2005 via a fluorescence response (Figures D-1, D-2, D-4, D-12, D-13, D-14, D-19, and D-21), there was either no response or a significantly reduced response observed within the North Olive stratum in 2013. This includes locations situated along the margins, as well as the interior portions of the smear zone. Petroleum hydrocarbons within this shallowest hydrostratigraphic unit are being targeted for recovery using the SVE system. Natural smear zone depletion may also be occurring within the North Olive stratum via

(1) volatilization and subsequent biodegradation within the vadose and (2) nutrient delivery within rainwater infiltrate and subsequent oxidation by petrophyllic bacteria in the saturated zone. Additional evaluation of the effects of the SVE system and natural smear zone depletion processes will be considered as part of future components to the CSM.

4.5.2 SMEAR ZONE DEPLETION IN THE DEEPER HYDROSTRATIGRAPHIC UNITS

A comparison of the historical and more recent LIF results for boring installed along the western (Figures D-5, D-6, D-8, D-18, and D-20) and southern (Figures D-13 and D-17) edges of the smear zone provides evidence of depletion of the smear zone within the deeper hydrostratigraphic units (Rand and Main Sand strata). Similar depletion of the smear zone within the deeper hydrostratigraphic units was not observed in the LIF comparisons for collocated borings installed along the northern and eastern portions of the Hartford Site (Figure D-1, D-2, D-12, and D-14). Additional evidence of smear zone depletion along the southern and western limits of the smear zone will be considered in the forthcoming components to the CSM.

It should be noted that significant decreases in the maximum fluorescence intensity between the historical and recent LIF borings was observed at four locations within the interior portions of the smear zone (Figures D-9, D-10, D-22, and D-23). However, these decreases in the maximum fluorescence intensity were not coupled with significant decreases in the vertical thickness of the smear zone observed via the LIF response.

4.6 LNAPL DISTRIBUTION ACROSS THE HYDROSTRATIGRAPHIC UNITS

Figure 26 provides the full lithologic and LNAPL sequence observed beneath the Hartford Site through various oblique cross sections. The lines of section are oriented northwest to southeast and parallel to the edge of the C Clay (bottom of Rand stratum) and spaced approximately 200 feet apart to show a progression of the LNAPL distribution and lithologic sequence.

Light-range LNAPL is the predominant hydrocarbon type observed within each segment shown on Figure 26, except for Oblique Cut 1 showing the northeastern portion of the Hartford Site (Segments A and E). These light-range hydrocarbons have the broadest footprint and occur across the greatest vertical interval, extending from several feet below the displayed water table in the EPA and Main Sand strata (January 2004) upward nearly to the bottom of the A Clay. The submerged portions of the smear zone in the EPA and Main Sand may be attributed to historical low water table conditions present prior to the construction of Dam No. 27 by the Army Corp of Engineers between 1959 and 1963. The light-range LNAPL, as well as the other distillates, are acting as a continuous source for petroleum related constituents in groundwater as described in Section 3.2.

Two additional LNAPL bodies that are notable include the mid-range hydrocarbons in the northeastern portion of the Site and heavy-range LNAPL along the eastern boundary. In both cases, the largest lateral extent is observed in the EPA and Main Sand strata, with a decreased footprint of these LNAPL types observed in the overlying Rand and North Olive strata. An isolated heavy-range LNAPL body is also observed northwest of the Hartford Site, and again is identified in multiple strata above the piezometric surface. It is worth noting that there are also multiple localized LNAPL bodies, especially in the northern portions of the Hartford Site. While these may not stand out on a large-scale rendering of the Site, these smaller LNAPL bodies may be important in providing a source of volatile petroleum hydrocarbons partitioning to soil vapor beneath individual structures.

The largest identified LNAPL bodies beneath the Hartford Site are present in multiple strata suggesting that LNAPL has migrated through gaps and fractures within the discontinuous finer grained layers (e.g. B Clay, C Clay, D Clay) or along the margins where these layers pinch out. Still, the LNAPL morphologies suggest lateral spreading of the LNAPL bodies along the contacts of the finer grained layers, as well as the groundwater table within the deeper hydrostratigraphic units, especially when groundwater was unconfined within the Main Sand. In either case, vertical migration of LNAPL would have been restricted due to elevated water content within the pore space of the unconsolidated sediments, leading to components of flow in horizontal directions.

The lines of section provided on Figure 26 highlight the variability in the vertical sequence of the finer grained less permeable deposits depending on location. On Oblique Cut 1, at least three fine grained layers are evident across the full line of section, and a fourth layer, the D Clay, is present beneath the northeastern most segment (Section E). Also along this line of section, the B and C Clay merge in areas, meaning that the Rand stratum is thin or absent. Oblique Cut 1 shows the largest variety of LNAPL types across the various strata. While lithology is likely not the only reason for this variety (the release history itself can also be of importance, for instance), the presence of the multiple fine grained layers likely enhanced lateral migration of LNAPL within the various strata. On Oblique Cuts 2 through 4, fewer fine grained layers are present and a single light-range LNAPL body is observed, with little evidence of other LNAPL types. The less frequent occurrence of the fine grained layers in these areas could have meant that the water table was the primary mechanism limiting vertical migration of LNAPL and may have facilitated lateral spreading, smearing, and mixing of different LNAPL releases, resulting in an inferred homogeneous LNAPL type in these areas.

4.7 PROPOSED DATA COLLECTION AND UPDATES TO THE COMPREHENSIVE CSM

The data sets reviewed in this section are historical and mapped LNAPL distributions are consistent with interpretations presented in previous reports (Clayton 2004, 2005, 2006). The most pertinent update for the current CSM is the 3D model, which was noted as an important gap in the CSM (USEPA 2010). While the model makes the overall data visualization simpler by displaying all LNAPL bodies at once rather than on multiple maps and cross sections, its greatest use may be in future remedial system optimization. Lines of section can be produced and rotated for any portion of the Hartford Site, allowing for a close inspection of an area of interest. For instance, this may be useful for siting future recovery wells (e.g., soil vapor or LNAPL), evaluating potential sources for vapors present beneath specific structures, or determining dissolved phase hydrocarbon longevity within groundwater at specific monitoring locations.

In addition, select dissolved and vapor phase analytical results will be incorporated into the 3D model to better understand partitioning of petroleum related constituents from LNAPL to groundwater and soil vapor.   These updates will be made as part of the dissolved and vapor phase components to the CSM. For example, dissolved phase benzene results collected over several timeframes within the various hydrostratigraphic units may be incorporated into the model. Timeframes that could be considered include (1) 2003 through 2005, (2) 2007 through 2009, and (3) 2011 through 2013. Data would be evaluated for representativeness (e.g., samples collected when the groundwater table was within the vertical extent of the well screen, LNAPL not present in the monitoring location). Fluid level results (groundwater and LNAPL elevations) may also be incorporated into the model including periods when the water table is elevated and confining conditions are present and periods when groundwater is seasonally low and unconfined conditions are present in the Main Sand stratum. The 3D model may also be updated to include select volatile petroleum related hydrocarbon and fixed gas concentrations within the vadose zone for high and low water table conditions. Pressure readings, fixed gas concentrations (including oxygen, carbon dioxide and methane), and total organic vapor concentrations from selected nested vapor monitoring wells and multipurpose monitoring points may be incorporated into the model. Vapor phase concentrations for select petroleum related hydrocarbons including benzene and hexane could also be incorporated into the model, where sufficient data is available. This could also include field and analytical data for sub-slab soil gas (measured as part of the in-home monitoring program) for select monitoring events.

5.0 LNAPL RECOVERABILITY

The Dual Optimal LNAPL Response (DOLR) conceptual model was developed (H2A 2006) to explain the occurrence and potential recoverability of LNAPL under various hydraulic conditions. The DOLR model applies to the LNAPL present in the Main Sand, where the water table periodically transitions from unconfined to confined conditions. The DOLR model might also be applicable to shallower permeable strata such as the Rand and Main Silt, where LNAPL transitions between unconfined and confined conditions. However, as described in Section 4.0, LNAPL is detected infrequently in monitoring locations screened within these strata, suggesting that the fraction of total LNAPL that is potentially mobile and recoverable is relatively low. Therefore, the DOLR model is most useful in understanding historical LNAPL recovery within the Main Sand stratum, where the majority of LNAPL appears to be distributed as described in Section 4.0. This conceptual model can also be used to evaluate potential methods and select the optimal approach for attaining additional LNAPL recovery in the future.

Prior to describing the DOLR model, it is important to review general heuristics for LNAPL behavior and movement within unconsolidated sediments. LNAPL, when present, shares available pore space between sediment grains with water and air. In order for LNAPL to be mobile and recoverable it needs to be continuous or connected within the pore spaces. Within the saturated zone, where the pore spaces are primarily filled with water, LNAPL is generally present as less connected globules within the smaller pore spaces (2-phase conditions). That is, while some of the LNAPL might be connected and potentially capable of mobilizing to a well, much of it is often present as separate ganglia due to the majority of pore space being filled with water. Within the capillary fringe and vadose zone where water content is lower and air is also present (3-phase conditions), LNAPL tends to be more connected within the larger pore spaces. Put another way, LNAPL residual saturation can vary depending on whether 2-phase or 3-phase conditions are present (Charbeneau 2007). When LNAPL saturations are high and/or water saturations are low, LNAPL is better connected and therefore potentially mobile (i.e., the LNAPL is above the residual saturation). LNAPL preferentially moves within coarse-grained sediments such as sand and gravel (i.e., lower pore entry pressure), and is less able to migrate through fine-grained sediments such as silt and clay (assuming similar water content within the pore space).

With the above heuristics in mind, the first part of the DOLR model can be considered. Under confining conditions (created when groundwater within the Main Sand stratum intercepts and is forced against overlying finer-grained stratum), hydrostatic forces drive LNAPL into wells that behave essentially as pressure relief points. This is schematically depicted in the first panel on Figure 27. As the water table rises, some LNAPL in the smear zone also rises within connected pore spaces between the coarse-grained sediments and eventually contacts the bottom of the overlying fine-grained stratum. At that point, even though the piezometric surface continues to rise, the LNAPL remains trapped at the bottom of the confining stratum as it is unable to displace water from the smaller pore spaces present between the fine-grained sediment. Although the LNAPL is unable to move any further vertically, it is able to move laterally along the contact of the coarser Main Sand and overlying fine grained stratum. This potential for lateral movement is limited under these confined conditions because any portion of the pore space not occupied by LNAPL tends to be filled with water (2-phase conditions). Still, if a well is screened across the contact of the confining unit and the Main Sand, some fraction of LNAPL can move laterally into the well. The top elevation of the LNAPL in this well will be higher than the base of the confining stratum since it is under hydrostatic pressure resulting in an exaggerated LNAPL thickness. Such a condition could mean relatively high initial LNAPL recoverability from the well if mobile LNAPL can collect at the base of the confining layer and water in the well does not exert a significant backpressure. However, under this condition the “mass of available mobile LNAPL is minimal since much of the LNAPL mass is trapped underneath this high water table” (p. 59 of Appendix E within the *Active LNAPL Recovery System 90% Design Report* [Clayton 2006]). As LNAPL is removed from the formation adjacent to the well, LNAPL saturations may decrease as water saturations increase, resulting in reduced recoverability. Only if the LNAPL in the vicinity of the recovery well remains above residual saturations (i.e., has sufficient connectivity in this 2-phase condition) would recovery remain sustainable.

The second part of the DOLR model states that under unconfined conditions, LNAPL can vertically drain from the coarse sediments within the Main Sand as the water table falls below the confining strata. Under intermediate unconfined conditions (i.e., when the aquifer is unconfined but the water table is still relatively high), LNAPL thicknesses in wells can be relatively low because the confining pressure is no longer present and “much of the LNAPL is still submerged and entrapped under the water table” (p. 60 of Appendix E within the *Active LNAPL Recovery System 90% Design Report* [Clayton 2006]). LNAPL will subsequently accumulate above and below the water table, as depicted in the second panel on Figure 27. If the water table falls further, “much of the submerged residual LNAPL drains from the Main Sand, (and) larger volumes of mobile LNAPL are available to accumulate in wells” (p. 60 of Appendix E within the *Active LNAPL Recovery System 90% Design Report* [Clayton 2006]). The further the water table falls, the more LNAPL that drains and accumulates near the water table. This LNAPL is also able to move laterally within the Main Sand. If the screen interval within a well intersects the mobile LNAPL interval and the water table is sufficiently low for a sustained period of time, LNAPL can enter it and have an elevation that is consistent with the vertical interval of recoverable LNAPL in the formation (i.e., no exaggerated thickness). As shown on the third panel on Figure 27, “greater thicknesses [in wells] occur and relatively larger production capacities are observed” (p. 60 of Appendix E within the *Active LNAPL Recovery System 90% Design Report* [Clayton 2006]).

In summary, the DOLR model predicts that: (1) LNAPL thickness in wells will be high under confined conditions, with initially high LNAPL recovery rates, but a potentially lower mass of available mobile LNAPL within the zone of capture of the recovery well, (2) under intermediate unconfined conditions, LNAPL thicknesses may be smaller and recovery rates lower due to a significant portion of the LNAPL mass remaining submerged below the unconfined water table, and (3) high recovery rates may be attainable under the lowest water table conditions due to a larger mass of mobile LNAPL present under 3-phase conditions (i.e., unsubmerged) and therefore potentially recoverable.

At the Hartford Site, LNAPL recoverability has been previously assessed by several methods, such as: (1) soil coring, petrophysical analysis, and subsequent modeling; (2) LNAPL transmissivity estimates; and (3) LNAPL recovery pilot testing. These data, and information about LNAPL recovery at the adjacent Premcor facility, are reviewed in the remainder of this section. Of particular focus is the relationship of the hydrologic conditions (confined, intermediate unconfined, highly unconfined) and LNAPL recoverability estimates, and how these data support the DOLR model.

5.1 SOIL PETROPHYSICAL ANALYSIS

Soil coring and petrophysical analysis were conducted in 2005. The purpose of this sampling and analysis was “an evaluation of LNAPL recoverability within differing geological and hydrogeological settings” (Clayton 2006). The petrophysical data were used as inputs to two calculations related to LNAPL recoverability: estimates of the LNAPL specific thickness (Do) and LNAPL recovery modeling. The petrophysical analysis and calculations are reviewed herein in the context of LNAPL recoverability.

Six soil cores were collected from the smear zone in 2005 at the locations displayed on Figure 28. One location, boring HCSB-1, was installed along the eastern boundary of the Hartford Site along North Olive Street, and the other five were obtained within the interior portions of the smear zone to the north and west of boring HCSB-1. Core samples were collected within the Main Sand stratum from each boring. Core samples were also collected from the shallower strata (i.e., North Olive and Rand) from a subset of the borings. The soil cores were submitted to PTS Laboratories for petrophysical analysis. At the laboratory, individual plugs (i.e., subsamples) were extracted from each core and analyzed for moisture content, density, porosity, pore fluid saturations, grain size distributions, air-water drainage curves, and free product mobility by centrifuge. The results of these analyses are reported in Appendix C of the *Active LNAPL Recovery System 90% Design Report* (Clayton 2006).

A total of 73 plugs were analyzed for pore fluid saturations. LNAPL was detected in all but two of the plugs (HCSB-1 at 21.9 feet and HCSB-2 at 29.3 feet), with detected saturations ranging from 0.3% pore volume (HCSB-2 at 31.5 feet and HCSB-4 at 29.5 feet) to 40.2% pore volume (HCSB-1 at 31.6 feet). The total fluid saturations are displayed graphically for plugs obtained below the water table in the Main Sand on Figure 29. Water saturations were considerably higher than LNAPL saturations, with the exception of sample HCSB-1 at 27.3 feet. This suggests that *in situ* LNAPL saturations were generally low below the water table at the time of sampling. However, there is a limitation to this inference. As shown on Figure 29, between 14% and 40% of the plug pore volumes were reported as being absent of both LNAPL and water (shown as Sa on the figure). While it is possible that this indicates significant quantities of gases are trapped below the water table, it seems more likely that fluids were preferentially lost from the cores during collection in the field. If these fluids were primarily water, then this would not affect the inference that LNAPL saturations at many of the coring locations were relatively low. However, if the majority of fluids that drained from the cores during collection were primarily LNAPL, this would open the possibility that LNAPL was not adequately measured in the cores. LNAPL drainage from the cores during collection has been observed at other sites and is not considered a reason to reject the pore fluid saturation analytical results. However, any inferences based on measured saturations (especially LNAPL) should be considered with other lines of evidence. For instance, the measured LNAPL saturations might be considered low-end estimates of the true *in situ* values.

5.1.1 LNAPL SPECIFIC THICKNESS ESTIMATES

The LNAPL saturation results were subsequently used to estimate the LNAPL specific thickness (Do) across the full vertical interval of the smear zone at the five coring locations as described in Appendix D of the *LNAPL Active Recovery System Conceptual Site Model* (Clayton 2005). The Do calculations used site-specific data, including calibration of the van Genuchten “N” and “α” to measured LNAPL saturations (provided in Section 3.1.4 of Appendix D of the *LNAPL Active Recovery System Conceptual Site Model* [Clayton 2005]). The calibrated Do calculations for the five soil cores were then used to generate Do correction factors that could be applied to measured LNAPL thicknesses in wells where soil coring data were not available. Using this correction, Do values were estimated for the Rand, EPA, and Main Sand strata for the October 2005 gauging event (Figures 3-4 through 3-6 of *LNAPL Active Recovery System Conceptual Site Model* [Clayton 2005]). The Do values were higher across a wider footprint in the Main Sand than the overlying strata, which follows from the Do calculation being directly based on LNAPL thicknesses gauged in wells.

The Do estimates are useful for evaluating the volume of LNAPL in a well, which tends to be greater than that within the adjacent formation (per unit lateral area) due to the formation volume also being occupied by soil, water, and to a lesser degree gases. Still, there are several limitations to the Do calculation that are worth noting:

- The Do estimates provided on Figures 3-4 through 3-6 of the *LNAPL Active Recovery System Conceptual Site Model* (Clayton 2005) are applicable only to the vertical interval of the formation adjacent to the LNAPL in the displayed well. The reported Do values in these figures do not account for LNAPL above or below this vertical interval. If LNAPL thicknesses in a well change due to piezometric surface fluctuations, the calculated Do value changes (it scales with the measured LNAPL thickness in the well) even though the actual amount of LNAPL in the full vertical interval of the smear zone does not change.

- Since the underlying curve fits for the Do calculations were calibrated to estimates of LNAPL saturations made using the petrophysical analysis, any limitations in the field or laboratory methods would extend to the Do estimates. As noted above, the LNAPL saturation data might best be considered low-end estimates of the true in situ values.
- Do estimates are not a direct measure of the mobile fraction of the LNAPL in the formation.

5.1.2 LNAPL SATURATIONS

PTS Laboratories assessed the mobile versus residual LNAPL saturations for 12 plugs (9 from soil cores collected from boring HCSB-1 and 3 from boring HCSB-5) by centrifuging the plugs and measuring the volume of removed LNAPL. The reported residual LNAPL saturations can be considered low-end estimates because the force applied in the lab (i.e., 1,000 times gravity) are greater than what would be achieved in the field for a hydraulic recovery system. The results are displayed graphically on Figure 30.

Plugs collected from the North Olive and Rand strata were reported with lower mobile fractions versus those collected from the Main Sand. While the mobile versus residual LNAPL saturation data is considerably smaller than the routine well gauging data set (specifically, frequency of LNAPL occurrence in wells, an imperfect indicator) for the Hartford Site, both data sets suggest a relatively small portion of the pore space in the North Olive and Rand strata contain mobile LNAPL.

5.1.3 LNAPL RECOVERY MODELING

The petrophysical laboratory analyses were used to support LNAPL recovery modeling in the *Active LNAPL Recovery System 90% Design Report* (Clayton 2006). Four different technologies were modeled: skimming, vacuum-enhanced skimming, dual pump recovery, and dual phase extraction. The simulations, performed for 1, 6, and 10 year timeframes, suggested that LNAPL skimming would attain recovery rates that are relatively low versus the other technologies. For the selected input parameters, vacuum-enhanced skimming and dual pump recovery attained similar rates, although the following should be noted:

- The modeling assumed a maximum groundwater extraction rate of 20 gpm for dual pump recovery (listed on Table 2 in Appendix D of the *Active LNAPL Recovery System 90% Design Report* [Clayton 2006]) at all locations except boring HCSB-5, where a maximum of 4 gpm was selected. If a higher groundwater extraction rate had been selected, then the simulated dual pump recovery rates would have correspondingly been higher (assuming an increased modeled radius of capture). In that case, the modeled LNAPL recovery rates using vacuum-enhanced skimming could have been considerably lower than that predicted using dual pump recovery.

- The modeling is highly sensitive to the inputted LNAPL thickness in the well (Table 5 in Appendix D of the *Active LNAPL Recovery System 90% Design Report* [Clayton 2006]). This is partially because the model assumes that recoverable LNAPL only exists within the vertical interval of that measured within the well. Increasing the LNAPL thickness within the model increases the vertical interval of recoverable LNAPL. If, in reality, recoverable LNAPL is submerged below the vertical interval of LNAPL, then the model will not account for recovery that could be achieved with a lower water table that further exposes the smear zone.

This second bullet is worth further consideration in the context of the modeled results from boring HCSB-1 located near groundwater monitoring well HMW-044C in Area A. The measured versus modeled saturation profiles, from Appendix F of the *Active LNAPL Recovery System 90% Design Report* (Clayton 2006), are presented herein in Appendix F. LNAPL was detected in plugs obtained from approximately 10 to 41.6 ft-bgs. The maximum measured LNAPL saturation of 40.2% pore volume was measured near the water table at 31.6 ft-bgs. The maximum LNAPL saturation below the water table was 8.3% at 39.7 ft-bgs. Based on the centrifuge data (Figure 30), LNAPL saturations at both of these depths are above the residual saturation and indicate potentially mobile LNAPL. However, the modeled interval of LNAPL presence shown on the right-hand graph presented in Appendix F is only for the interval located near the water table, from 30.5 to 33.4 ft-bgs. This modeled interval is based on the measured LNAPL thickness in well HMW-044C during gauging in September 2005. The model assumes that LNAPL is not present below this interval, and therefore does not simulate recovery of the potentially mobile LNAPL as deep as 39.7 ft-bgs. If groundwater extraction were conducted near boring HCSB-1 at a high enough rate to substantially lower the water table, potentially mobilized LNAPL within lower portions of the smear zone would not be simulated in this model.

The limitations to the LNAPL recovery modeling provided in the *Active LNAPL Recovery System 90% Design Report* (Clayton 2006), as well as inherent uncertainties in estimating LNAPL saturations via petrophysical analysis, suggest that additional pilot testing to assess LNAPL recoverability is warranted. MPE and LNAPL skimming have been tested at the Hartford Site over the past decade. Pilot testing of LNAPL recovery under higher groundwater extraction rates has been a data gap for LNAPL recoverability. The *Final Light Non-Aqueous Phase Liquid Recovery Pilot Test Work Plan Addendum* (Trihydro 2013a) proposes to lower the piezometric surface to expose currently submerged portions of the smear zone to determine whether the deeper LNAPL is potentially recoverable at rates that exceed vacuum enhanced skimming. This could provide an indicator of mobile LNAPL across a large footprint (i.e., the radius of capture of the recovery well) for lower water table conditions.

5.2 LNAPL TRANSMISSIVITY MEASUREMENTS

LNAPL transmissivity has been proposed as a metric to assess the potential for hydraulic recovery of LNAPL under the specific conditions tested (WSP 2012). LNAPL transmissivity can be estimated by analyzing data collected via multiple methods, such as LNAPL baildown tests, manual skimming, and continuous recovery (ASTM 2011). LNAPL transmissivities have been measured at the Hartford Site using various methods since 2004. These data are reviewed in this subsection in the context of LNAPL recoverability.

The dynamic nature of the piezometric surface within the Main Sand is one of the most important conditions affecting LNAPL transmissivity. As stated by WSP (2012), ". . . as the water table elevation at a site fluctuates, some of the mobile LNAPL at the water table may travel with the water table or it may be submerged (rising water table) or released (falling water table). As a result, the mobile and residual LNAPL saturations can decrease or increase." The piezometric surface in the Main Sand rises and falls in response to the Mississippi River elevation and precipitation events, frequently transitioning between confined, semiconfined, and unconfined conditions. This phenomenon, and its relationship to measured LNAPL transmissivities, is considered herein.

As shown on Table 4, a total of 96 quantitative LNAPL transmissivity estimates have been completed for 26 different groundwater monitoring wells and multipurpose monitoring points between 2004 and 2012. The LNAPL transmissivity estimates provided in Table 4 are generally based on LNAPL baildown testing, with the exception of recharge data following MPE testing in 2005. No LNAPL transmissivity values are available between 2006 and 2008. Reported values span multiple orders of magnitude, from a low of 0.0010 square feet per day (ft^2/day) in monitoring point MP-52C in August 2005 to a high of 94 ft^2/day in monitoring point MP-50C in May 2005. The transmissivity estimates were conducted at a minimum piezometric surface elevation of approximately 396 ft-amsl and a maximum of 410.5 ft-amsl.

These LNAPL transmissivity estimates can be compared to the minimum endpoint (0.3 ft^2/day) proposed by HWG for hydraulic recovery of LNAPL (WSP 2012). In 2004 and 2005, 69% (46 of 67) of the estimated LNAPL transmissivities were above this threshold, while in 2009 and 2010, 60% (15 of 25) of the values were above this threshold. In 2011 and 2012, none (0 of 4) of the values were above this threshold. Overall, these results might be an indication of decreasing LNAPL recoverability at the Hartford Site. That is, the quantity of LNAPL above residual saturations in the Main Sand has decreased as a result of LNAPL recovery by skimming, natural source zone depletion, and continued smearing of LNAPL due to piezometric fluctuations. However, this inference is limited by variations in the location, test method, and hydraulic conditions during testing. The repeatability of the results and influence of groundwater elevation changes on LNAPL transmissivity are examined more closely in the following bullets.

- LNAPL transmissivity estimates made using the 2005 MPE pilot test results (referred to as high-vacuum recovery pilot tests) are available for ten wells. As shown in Figure 31, LNAPL transmissivity values at a given well tend to have low repeatability. Of the seven wells with multiple LNAPL transmissivity values, five of the wells show variation over at least one order of magnitude. The other two wells vary over a factor of approximately 2 to 3. Some of the variation might be related to high vacuum recovery possibly affecting the assumption of equilibrium conditions at the start of each test. Another possible reason for the large amount of variation may be piezometric surface fluctuations. As shown on Figure 31, the piezometric surface did vary at each well over the course of testing (maximum variation of approximately 3.3 feet within well HMW-19), with hydraulic conditions reportedly alternating between confined and unconfined at multiple locations.

- LNAPL transmissivity estimates were made using baildown tests within four groundwater monitoring wells and monitoring points (HMW-020, HMW-044C, MP-035D, and MP-039C) in 2010 for comparison to the 2005 estimates. LNAPL transmissivity estimates in 2010 were generally lower, with more than an order of magnitude decrease in wells HMW-020 and HMW-044C, and an approximate 50% decrease in monitoring point MP-035D. LNAPL skimming had been conducted at each of these locations for several months preceding the baildown tests suggesting that LNAPL skimming could have been one factor reducing transmissivity. However, this inference is of course limited by generally poor repeatability of LNAPL transmissivity values in any given location using differing test methods.

- LNAPL transmissivity was estimated using LNAPL baildown tests conducted within monitoring points MP-134, MP-135, and MP-137 in October 2011 and in January 2012, prior to and following MPE pilot testing in Area A. These estimates are plotted on Figure 32. The 2011 and 2012 LNAPL transmissivity estimates showed less variation than previously, with ranges of less than one order of magnitude for all three monitoring locations. The LNAPL transmissivities were lower in 2011 compared to 2012, with the elevation of the piezometric surface possibly contributing to the difference in the estimates. The conditions were reportedly confined in 2011 and unconfined in 2012, with the piezometric surface varying by a maximum of approximately 8 feet within monitoring point MP-137 (WSP 2012).

These results suggest that if LNAPL recoverability is to be assessed under ambient conditions, then LNAPL transmissivities should be estimated at multiple locations and points in time corresponding to the range of ambient fluctuations of the piezometric surface. Additionally, if the elevation of the piezometric surface has an influence on LNAPL transmissivities, then it follows that a lower water table induced by pumping could result in an increase in LNAPL transmissivity not observed under ambient conditions. This was suggested within Appendix D of the *Light Non-Aqueous Phase Liquid Recovery Pilot Test Interim Report* (WSP 2012) in which it is stated that: "…given a suitable physical setting, residual LNAPL that is submerged may become mobile during a given decrease in the water table thereby resulting in an increase in LNAPL transmissivity." It is understood that WSP was likely referring to an ambient change in water table conditions and even suggested that it may be impractical to use hydraulic recovery to address submerged LNAPL. Still, it stands to reason that LNAPL transmissivities may increase under stressed conditions within the radius of influence of the pumping well.

5.3 HISTORICAL LNAPL RECOVERY WITHIN THE MAIN SAND STRATUM

For the most part, historical LNAPL recovery at the Hartford Site has been conducted under confined (the first panel on Figure 27) or intermediate unconfined (the second panel on Figure 27) conditions. The figures provided in Appendix G depict fluid level elevations and LNAPL recovery rates since 2005 within the 22 recovery wells, groundwater monitoring wells, and multipurpose monitoring points shown on Figure 33. These locations were selected because they were included as part of pilot testing of MPE (referred to as high-vacuum recovery) in 2005 (H2A 2006) and have subsequently undergone routine manual LNAPL skimming between 2010 and 2012. During manual skimming, field personnel would visit a location with more than 0.5 foot of LNAPL, conduct skimming, and then allow the LNAPL to recharge above this thickness before skimming again. This method would mean that drawdown in the monitoring well or monitoring point would only be maximized immediately after skimming, and would decrease over time until the next skimming event.

The LNAPL recovery rates depicted on the figures in Appendix G are the monthly volume recovered via manual skimming (i.e., units are gallons per month). These figures also display the elevation of the confining stratum based on the lithology recorded during installation of these wells and monitoring points. Confined conditions are inferred where the groundwater elevation (piezometric surface) is above the bottom of the fine grained stratum. Finally, the hydrographs display the vertical interval of the LNAPL smear zone based on nearby LIF borings. Note that the lithology and LIF data presented on the figures included within Appendix G are a subset of the data used to develop the 3D model described in Section 4.0.

These hydrographs indicate that the majority of manual LNAPL skimming has been conducted under confined conditions compared to intermediate unconfined conditions since 2005, as confined conditions occurred more frequently and lead to exaggerated LNAPL thicknesses targeted for skimming by the field personnel. The LNAPL recovery rates for skimming under confined conditions show significant variability at a given location that may be related to competing LNAPL recoverability characteristics as described by the DOLR model. The confining pressures may result in the groundwater monitoring well or monitoring point acting as a pressure relief point; however, elevated water saturations may mean only a minimal mass of mobile LNAPL is available within the radius of capture of the monitoring location.

When skimming is conducted under unconfined conditions, LNAPL recovery tends to remove smaller volumes of LNAPL. Inspection of the hydrographs provided in Appendix G, shows that between 2005 and 2012 when skimming was performed, unconfined conditions have been limited to the upper portions of the smear zone in the Main Sand stratum. This may be an indication of intermediate unconfined conditions described in the DOLR model where the majority of the smear zone remains submerged.

Overall, LNAPL recovery rates decreased between 2010 and 2012 as shown on Figure 34, which displays cumulative LNAPL recovery from the Main Sand stratum, as well as average recovery rates from individual wells and monitoring points. This decrease in LNAPL recovery rates can be inferred to represent a decrease in the LNAPL transmissivity near those wells and monitoring points where skimming has been conducted (providing a supporting line of evidence for the LNAPL transmissivity estimates described in Section 5.2). However, it is possible that other factors such as natural smear zone depletion, fluctuation of the piezometric surface resulting in additional smearing of LNAPL, and LNAPL recovery conducted at the adjacent facilities may have contributed to decreasing LNAPL recoverability within these monitoring locations. Since manual skimming targeted any monitoring point or groundwater monitoring well where LNAPL was measured above 0.5 feet, there are few locations where skimming was not performed. Therefore, it is difficult to assess the effect of manual skimming versus the other contributing factors that might have affected LNAPL recoverability in recent years.

Efforts to estimate the radius of capture for manual LNAPL skimming conducted in the groundwater monitoring wells or multipurpose monitoring points have not been performed via volumetric analyses, LNAPL tracer testing, or some other method. Charbeneau and Beckett (2007) suggest a radius of capture for LNAPL skimming between 10 and 30 feet. It is expected that the radius of capture for manual skimming would be on the low end of the suggested radius of capture as a result of the methodology used to recover LNAPL. As previously described, drawdown would be maximized immediately after skimming, and would decrease over time until the next skimming event. Since drawdown was lower during recharge, this probably meant a lower radius of capture than would have been achieved with a dedicated skimmer (i.e., consistently maximized drawdown). An evaluation of the radius of influence of manual skimming and its effects on future remedial efforts may be considered in the *Comprehensive CSM*. This evaluation will determine if future LNAPL recovery in the zone of typical piezometric surface fluctuations is expected to be low only adjacent to previously skimmed wells (as observed during pilot testing performed by WSP in 2011 and 2012), or if low recovery might also be expected across the rest of the smear zone footprint due to other contributing factors reducing LNAPL recoverability.

As shown on the figures provided in Appendix G, testing under all anticipated hydraulic conditions described in the DOLR model has not been performed at the Hartford Site. Specifically, the DOLR model predicts that when groundwater elevations are within the lower portions of the smear zone, LNAPL recovery rates may be higher (as more of the smear zone is under 3-phase conditions). As described in Section 2.4.4, water table elevations have not approached these lower portions of the smear zone since construction of Dam No. 27 (a.k.a. the Chain of Rocks Dam), between 1959 and 1963, down-stream of the Hartford Site. Therefore, a viable means to observe LNAPL recovery under low water table conditions may be to induce these conditions via extraction of groundwater at higher rates within focused portions of the Hartford Site. In this scenario, LNAPL recoverability could be observed in the vicinity of the groundwater extraction well. Such a pilot test has been approved by the USEPA as part of the *Final Light Non-Aqueous Phase Liquid Recovery Pilot Test Work Plan Addendum* (Trihydro 2013a). Area A along North Olive Street was selected as the pilot test area. Elevated LNAPL transmissivities have been estimated using data collected from monitoring wells within this portion of the Hartford Site (Clayton 2006) and previous pilot testing has been conducted in Area A in 2005 and 2011 through 2012, which allows comparative analysis of the various approaches. However, any comparison in the remedial approaches will not be perfect, as nearly a decade has passed since the original pilot tests were performed by HWG, which allows for additional factors to affect LNAPL recoverability. These include natural source zone depletion, continued smearing of LNAPL due to piezometric surface fluctuations, manual LNAPL skimming performed throughout the Area, and LNAPL recovery performed at the adjacent Premcor facility. Still, the proposed pilot test will allow for an assessment of the amount of LNAPL that could be mobilized under stressed conditions within the radius of capture of the production well. The results of this additional pilot test will help to resolve many of the remaining data gaps regarding LNAPL recoverability and will be integrated into the *Comprehensive CSM*.

5.4 HISTORICAL LNAPL RECOVERY AT THE PREMCOR FACILITY

LNAPL recovery conducted along the western property boundary of the adjacent Premcor facility can provide some insight into the applicability of the DOLR model to the Hartford Site. LNAPL recovery at the Premcor facility has been focused within the EPA and Main Sand strata. From 1994 to 2002, LNAPL was primarily removed using scavenger pumps deployed in select wells. Following this timeframe, LNAPL recovery at the Premcor facility has been conducted using a combination of techniques including automated LNAPL skimming, periodic manual skimming, LFDPE, and SVE. It should be noted that a significant volume of LNAPL has also been recovered from the groundwater production wells installed at the Premcor facility for gradient control purposes using a skimmer pump and intermittently applied vacuum.

Pumping has been conducted for the purpose of gradient control using various wells installed along the western boundary of the Premcor facility, with well RPW-01 being used as the primary well since 2005. Pumping has been performed to enhance inward hydraulic gradients in an attempt to prevent migration of petroleum-related constituents from the refinery to beneath the Hartford Site. In 2006, following approximately four months of groundwater extraction at 100 to 120 gpm from well RPW-01, LNAPL was observed in the pumping well (WSP 2011). A skimmer pump was installed in well RPW-01 in March 2006 to recover LNAPL, and beginning in January 2007, a vacuum was applied during low water table conditions. Approximately 118,000 gallons of LNAPL have been recovered from well RPW-01 since 2006, with the maximum LNAPL recovery observed in 2008 (groundwater elevations during that year varied from 398 to 411 ft-amsl within the Main Sand stratum, transitioning from unconfined to confined). An additional 80,000 gallons have been recovered via skimming in other wells installed along this portion of the Premcor facility. In recent years, the specific capacity of groundwater production well RPW-01 has decreased due to a combination of biofouling and silting of the gravel pack, and LNAPL recovery rates have diminished. Consistent with the DOLR model, pumping at the Premcor facility mobilized additional LNAPL towards the recovery wells (greater than what may otherwise be observed). Pumping which stimulates unconfined conditions within the Main Sand stratum locally beneath the western property boundary may have enhanced LNAPL recovery.

LFDPE has been conducted within 14 extraction wells screened in the EPA Stratum and shallow portions of the Main Sand along the western portions of the Premcor facility since December 2010. This method involves limited groundwater extraction at flow rates of approximately 5 to 10 gpm, combined with LNAPL removal with either submersible pumps or a vacuum stinger placed above the LNAPL-groundwater interface. Dual phase recovery is optimized when LNAPL is under confined conditions (depicted schematically in Figure 35). The recovery system uses a vacuum above the LNAPL/air interface to induce fluid movement to the well while a groundwater pump maintains the LNAPL/water interface in the well adjacent to the interval of mobile LNAPL within the formation. Approximately 122,000 gallons of LNAPL have been removed via LFDPE from beneath this portion of the Premcor facility. In addition, approximately, 100,000 gallons of LNAPL have been recovered via the mobile LFDPE system. In the case of the Premcor LFDPE system, the confining clay stratum is the B/C Clay, which is present beneath the western boundary of the refinery. The success of the LFDPE at the Premcor facility is reportedly attributed to installing recovery wells within localized high points within the overlying confining unit where LNAPL preferentially migrates. It is also possible that LFDPE has been successful at the Premcor facility, due to the presence of the D Clay, which has potentially acted as a barrier to downward LNAPL movement during historically low water table elevations. This might have allowed LNAPL to accumulate within the EPA stratum between the B/C Clay and the D Clay and yielded relatively high LNAPL saturations in this stratum. The EPA stratum and D-Clay are not present beneath the majority of the Hartford Site. Instead, the majority of the LNAPL appears to be located within the Main Sand, which does not have a shallow fine grained layer to act as a barrier to downward LNAPL movement. Therefore, at the Hartford site, the degree of historical smearing might have been greater, yielding lower recoverability under confined conditions (i.e., deeper submerged LNAPL). The effectiveness of the LFDPE will be considered further as part of the *Comprehensive CSM*.

WSP pilot tested LFDPE beneath Area A of the Hartford Site in January 2012, as described in Section 2.2.1. During the WSP pilot test, groundwater and LNAPL were confined. Groundwater extraction was tested up to a maximum rate of 25 gpm, in an attempt to define rates necessary to optimize LNAPL recovery using a vacuum stinger. Pilot testing of LFDPE failed to induce significant LNAPL recovery beneath this portion of the Hartford Site. Additional vacuum enhanced recovery performed in combination with focused pumping may be performed in Area A of the Hartford Site. The results of this approach will be integrated into the *Comprehensive CSM.*

5.5 PROPOSED DATA COLLECTION AND UPDATES TO THE COMPREHENSIVE CSM

In recent years, LNAPL recovery at the Hartford Site has been conducted via skimming activities primarily under confined conditions, with some recovery under intermediate unconfined conditions. Recovery rates have been observed within these groundwater monitoring wells and multipurpose monitoring points where manual skimming has been performed. The available data suggest that under these conditions LNAPL transmissivities are approaching the low practical recovery endpoints (0.3 to 0.8 ft^2/day) suggested by HWG for recovery within the upper portions of the smear zone. An evaluation of the radius of influence of manual skimming, as well as other factors contributing to reduced recoverability, and the combined effect on future remedial efforts may be considered in the *Comprehensive CSM*. This evaluation will determine if future LNAPL recovery in the zone of typical piezometric surface fluctuations is expected to be low only adjacent to previously skimmed wells (as observed during pilot testing performed by WSP in 2011 and 2012), or if low recovery might also be expected across the rest of the smear zone footprint.

However, predictions of the DOLR model, as well as enhanced LNAPL mobility achieved via hydraulic controls implemented along the western boundary of the Premcor facility, suggest that additional LNAPL recovery may be possible beneath portions of the Hartford Site using a focused pumping approach. Focused pumping can induce a transition to unconfined conditions near the production well if performed during already low ambient water table conditions. This technique will be pilot tested in Area A at the Site, as described in the *Final Light Non-Aqueous Phase Liquid Recovery Pilot Test Work Plan Addendum* (Trihydro 2013a). The pilot testing will assess whether inducing unconfined conditions in the vicinity of a groundwater production well installed in Area A can increase LNAPL recovery rates within the Main Sand stratum. Additional enhanced vacuum recovery may also be performed as part of this additional pilot testing in Area A. The results from this pilot test will also be incorporated into the *Comprehensive CSM*.

6.0 SUMMARY OF THE LNAPL COMPONENT TO THE CSM

The Comprehensive CSM will integrate data previously collected at the Hartford Site with new analyses and visual presentation of the existing data to provide a comprehensive depiction of current conditions that will serve as the baseline for understanding the distribution of the LNAPL and subsequent partitioning to the dissolved and vapor phases, as well as the pathways for potential exposure to receptors. The Comprehensive CSM will guide: (1) evaluation of the current remedial activities (e.g., SVE, LNAPL skimming), (2) the remedy selection process, and (3) expectations for evaluating remedy performance in the future.

The Comprehensive CSM for the Hartford Site is being prepared in a step-wise fashion, starting with this LNAPL component to the CSM. The next two deliverables will provide updates to the CSM for dissolved and vapor phase petroleum hydrocarbons partitioning from the LNAPL. The final deliverable, the Comprehensive CSM, will compile all the information presented within the LNAPL, dissolved phase, and vapor phase components to the CSM, as well as additional information gathered as part of resolving data gaps.

6.1 SETTING

The Hartford Site is located along the historical edges of the Mississippi and Missouri River flood plains within a shallow valley approximately 30 miles long and 11 miles across at its widest point, and underlain by more than 100 feet of unconsolidated deposits created by alluvial and glacial processes during the Pleistocene period. Over the last 125,000 years, the Mississippi River has changed its course frequently resulting in deposition of sediments with widely-varying grain size across a broad area creating a highly heterogeneous unconsolidated stratigraphy (USEPA 2010). As a result, the lithology beneath the Hartford Site consists of alternating alluvial deposits of clay and silt overlying a regionally extensive sand deposit referred to as the Main Sand stratum. The Main Sand stratum consists of alluvial sands and coarse grained glacial outwash that ranges from 80 to 100 feet in thickness. The permeable zones of alluvial deposits overlying the Main Sand are locally known (in descending order) as the North Olive, the Rand, and the EPA hydrostratigraphic units. These permeable zones are bounded by discontinuous clay deposits identified as (in descending order) the A, B, C, and D Clay strata.

The A Clay stratum is continuously present beneath the Hartford Site, with the exception of areas where it has been removed as part of construction activities. The B and C Clay strata are highly discontinuous and of limited aerial extent. The B and C Clay strata define the extent of the North Olive and Rand hydrostratigraphic units, respectively. The North Olive and Rand strata laterally grade into and are hydraulically connected with the Main Sand (and Main Silt where present under the western and southwestern portions of the Hartford Site), where the B and C Clay strata are absent. Groundwater within the North Olive and Rand strata generally occurs as isolated areas of perched water on the surface of the underlying clay.

The D Clay stratum underlies and defines the limits of the EPA stratum. The D Clay stratum could be considered a discontinuous lens within the Main Sand stratum based on its relative thickness (thickness between approximately 2 to 7 feet) and limited extent (only present in the northeastern portion of the Hartford Site). The EPA stratum grades laterally into the Main Sand to the south of a southwesterly trending line extending from the intersection of Old St. Louis Road and North Delmar Avenue to just north of the intersection of East Date Street and North Olive Street. Along this boundary, the EPA and Main Sand strata are hydraulically connected with flow in the EPA stratum towards the southwest.

Groundwater present in the Main Sand stratum is part of an extensive aquifer system commonly referred to as the American Bottoms aquifer. Groundwater flow in the Main Sand stratum has been altered beneath the Hartford Site due to pumping on the BP (approximately 1,225 gpm), Phillips66 (more than 6,000 gpm along the river dock and 3,000 gpm on the refinery), and Premcor (approximately 300 gpm) facilities. The groundwater flow direction in the Main Sand is also influenced by the stage of the Mississippi River. During periods of high river stage groundwater flow is generally towards the east to northeast due to recharge from the river and bank storage within the Main Sand. During moderate river elevations, the groundwater flow direction is northward. During low river stages, groundwater flow trends westerly to northwesterly.

The Mississippi River is located less than a half mile from the Hartford Site and is hydraulically connected to the two deeper hydrostratigraphic units (EPA and Main Sand), and on occasion during very high river stages, the groundwater surface in the Main Silt and Main Sand can reach the Rand stratum. Water level fluctuations in the EPA stratum and Main Sand correspond to changes in the Mississippi River stage. Since the river stage varies by more than 20 feet during a year, the groundwater conditions can fluctuate from unconfined to confined conditions throughout the year.

6.2 LNAPL DISTRIBUTION

Petroleum hydrocarbon releases occurred from the former refineries and related facilities located to the north and east of the Village of Hartford, as well as from pipelines connecting these refineries and facilities with terminal operations on or near the Mississippi River (Figure 1). Released hydrocarbons (LNAPL) migrated down through the subsurface under the influence of gravity until encountering the groundwater or less permeable layers. Due to capillary forces, some fraction of the LNAPL was retained in soil pore space in the unsaturated zone, whereas some fraction of the LNAPL reached the capillary fringe where it displaced water present in soil pore space. As the volume of LNAPL became sufficient to overcome hydrostatic forces, further lateral migration occurred. Vertical migration into deeper hydrostratigraphic units occurred where the clay layers are discontinuous or absent. The distribution of LNAPL stabilized as gravity and capillary forces approached equilibrium.

Vertical smearing of the LNAPL occurred over time as a result of fluctuation of the groundwater elevations within the hydrostratigraphic units beneath the Hartford Site, leaving some LNAPL within the soil pore spaces below and above the water table. The smear zone describes the horizontal and vertical extent of LNAPL (including residual and mobile) beneath the Hartford Site. The nature and extent of the LNAPL smear zone has been previously defined, at least in part, across the various hydrostratigraphic units using LIF, soil core analyses, and routine fluid level monitoring (Clayton 2004, 2005, 2006a). The bottom of the "smear zone" is roughly coincident with the historical low groundwater elevation in the Main Sand stratum (10 to 20 feet lower than typical groundwater elevations observed over the past decade). The thickness of the smear zone is variable measuring only a few inches at the periphery, to tens of feet in locations near historical releases and along the boundaries of the clay strata. The vertical and lateral distribution of the smear zone also varies due to heterogeneities in the lithology.

As part of the preparation of this component to the CSM, a 3D visualization model was developed, which had been noted as an important data gap in previous analyses (USEPA 2010). The 3D model integrates the lithology, LNAPL distribution, and hydrocarbon types across the Hartford Site. Figure 12 presents the data that was incorporated into the 3D model. The 3D model indicates that LNAPL is present within each of the hydrostratigraphic units, with the greatest lateral and vertical extent observed in the Main Sand stratum. LNAPL is continuous through the shallower hydrographic units and into the Main Sand stratum, indicating historical releases at shallower depths with subsequent lateral migration along the tops of the clay layers and vertical migration where these clay layers are discontinuous or absent. All three LNAPL types are observed within the Main Sand stratum, with light-range LNAPLs having the largest distribution beneath the Site. Mid- and heavy-range LNAPLs are primarily observed in the northeast and eastern edge of the Hartford Site, respectively. Several disconnected and smaller localized releases of light-range and mid-range LNAPLs are also observed in the shallow hydrostratigraphic units. These may be indicative of smaller, isolated sources in the shallow subsurface.

6.3 LNAPL CHEMISTRY

Historical LNAPL samples collected from the Main Sand stratum have been characterized as primarily gasoline range hydrocarbons with a secondary product type, where present, identified as diesel (Clayton 2005). For the most part, LNAPL with gasoline reported as all or nearly all of the hydrocarbon makeup were identified in the central portions of the Hartford Site; while LNAPL with diesel as a secondary component tended to be located on the eastern and northern portions of the Site. LNAPL samples collected from the EPA and the Rand strata have been primarily characterized as diesel with lesser amounts of gasoline. LNAPL samples collected beneath the Hartford Site generally have viscosities below one centipoise, consistent with gasoline and diesel mixtures. A comparison of the LIF waveforms to the LNAPL analytical results indicates that the LIF results are a reasonable indicator of LNAPL types at the Hartford Site. The LNAPL chemistry data set is strongest for light-range LNAPL with a gasoline-like carbon distribution, and could be bolstered by collecting additional LNAPL samples from areas with mid- and heavy-range LNAPL types.

6.4 LNAPL RECOVERABILITY

Approximately 2.25 million gallons of LNAPL has been recovered beneath the Hartford Site via interim measures between 1978 and 2014. LNAPL recoverability is a function of water table elevation which has changed through time. The DOLR model (H2A 2006) developed for the Hartford Site explains the occurrence and potential recoverability of LNAPL under various hydraulic conditions. In summary, the DOLR model predicts that LNAPL thickness in wells will be high under confined conditions, with initial high LNAPL recovery rates that may decrease over time because the mass of mobile LNAPL is minimal and much of the LNAPL is submerged (although optimization of recovery under confining conditions is possible under certain lithologic conditions). Under intermediate unconfined conditions, LNAPL thicknesses may be smaller, and recovery rates may be relatively low because the wells are no longer acting as “pressure relief” points and much of the LNAPL continues to be submerged. Under highly unconfined conditions, relatively high recovery rates may be attained because the largest vertical interval of LNAPL is unsubmerged.

LNAPL recovery performed under confined and intermediate unconfined conditions over the last decade at the Hartford Site have generally supported predictions of the DOLR model, with a decrease in the rate of LNAPL recovery and LNAPL transmissivity observed within the wells where skimming has been conducted. However, the DOLR model has not been tested under all anticipated hydraulic conditions beneath the Hartford Site. Specifically, the DOLR model predicts that when groundwater elevations are within the lower portions of the smear zone, LNAPL recovery rates would be most sustainable over time. Water table elevations have not approached these lower portions of the smear zone since installation of Dam No. 27 down-stream of the Village of Hartford between 1959 and 1963.

Therefore, in order to observe and confirm LNAPL recovery under low water table conditions, an additional pilot test has been developed to evaluate groundwater extraction at higher rates within a focused portion (Area A) of the Hartford Site, when groundwater within the Main Sand is approaching seasonally low and unconfined conditions. The pilot test will be conducted pursuant to the approved *Final Light Non-Aqueous Phase Liquid Recovery Pilot Test Work Plan Addendum* (Trihydro 2013a). Through the pilot test, LNAPL recoverability can be observed in the vicinity of the groundwater extraction well. The pilot testing will assess whether inducing unconfined conditions in the vicinity of a groundwater production well can increase LNAPL recovery rates within the Main Sand stratum. The results from this pilot test represent the largest remaining data gap within this component to the CSM and will be incorporated into the *Comprehensive CSM*.

6.5 PROPOSED DATA COLLECTION AND UPDATES TO THE COMPREHENSIVE CSM

The most significant data gap remaining in the LNAPL CSM is related to LNAPL recoverability. This data gap will be addressed via implementation of an additional LNAPL recovery pilot test as described within the *Comprehensive Conceptual Site Model Framework and Timeline, Hartford Area Hydrocarbon Plume Site* (Trihydro 2013c). In addition, it is recommended that additional light-, mid-, and heavy-range LNAPL samples be collected from groundwater monitoring wells and monitoring points screened in the Rand, EPA, and Main Sand strata. These LNAPL samples will be used to further correlate the hydrocarbon types to the LIF results, as well as to assess individual constituent and mass depletion of the smear zone beneath the Hartford Site. Finally, as part of preparing the dissolved and vapor phase components to the CSM, the 3D visualization model will be updated with dissolved and vapor phase analytical results to better understand partitioning of petroleum-related constituents from the LNAPL to groundwater and soil vapor, as well as to assess mass losses due to natural attenuation processes. Thus, a more complete understanding of the distribution of the LNAPL, chemical partitioning to the dissolved and vapor phases, pathways for potential exposure to receptors, and LNAPL recoverability will be secured when this additional data is obtained, analyzed, and integrated into the *Comprehensive CSM*.

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TABLES

TABLE 1. AVERAGE LNAPL THICKNESS UNDER CONFINED AND UNCONFINED CONDITIONS
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

	Average LNAPL Thickness (feet)	
Location	Confined Conditions	Unconfined Conditions
HMW-018	1.15	0.94
HMW-019	2.45	0.96
HMW-020	1.66	0.96
HMW-044C	7.74	2.13
HMW-048C	2.85	--
MP-029D	6.92	1.51
MP-035D	6.08	1.35
MP-039C	3.59	--
MP-045C	0.88	1.60
MP-047C	7.54	1.92
MP-049C	8.81	1.84
MP-050C	4.10	1.29
MP-051D	2.69	1.68
MP-052C	5.81	1.22
MP-053C	1.92	0.97
MP-054C	0.56	1.36
MP-055C	3.00	2.52
MP-056C	1.59	0.92
MP-057C	0.83	1.11
MP-079C	4.05	0.75
RW-004A	1.54	1.16
RW-005	2.30	0.71

Notes

-- unconfined conditions not observed during monitoring history

TABLE 2. COMPARISON OF BENZENE EFFECTIVE SOLUBILITY ESTIMATES AND DISSOLVED PHASE CONCENTRATIONS
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

LNAPL				Groundwater			
Monitoring Location	Stratum	Date	Benzene Effective Solubility (mg/L)	Monitoring Location	Distance Between (feet)	Date	Benzene Concentration (mg/L)
MP-029C	Rand	January 2006	1.3	HMW-007	85	October 2005	2.52
MP-029D	Main Sand	January 2006	18.3	MP-029D	0	June 2006	13.8
MP-038C	Main Sand	January 2006	35.4	MP-038C	0	January 2005	37.7
				MP-031C	140	October 2005	13.7
				MP-043C	160	October 2005	21.2
				MP-033D	255	July 2005	25.6
MP-039C	Main Sand	January 2006	30.1	MP-033D	150	July 2005	25.6
				MP-043C	185	October 2005	21.2
				MP-031C	230	October 2005	13.7
				MP-038C	250	January 2005	37.7
				HMW-019	350	June 2006	25.8
MP-046C	Main Sand	January 2006	21.8 / 23.8	MP-044D	200	October 2005	23.0
				HB-037	200	October 2005	31.2
				MP-041C	285	July 2005	18.6
				MP-055C	400	June 2006	20.1
MP-047C	Main Sand	January 2006	35.6 / 37.8	MP-055C	325	June 2006	20.1
				HB-037	325	October 2005	31.2
				MP-044D	336	October 2005	23.0
				MP-041C	430	July 2005	18.6
MP-060C	Main Sand	January 2006	32.0	MP-058C	200	October 2005	35.7
MP-079C	Main Sand	January 2006	26.0	MP-078D	265	October 2005	20.3
				HB-031	55	October 2005	25.4
				MP-080C	175	June 2006	21.1

Notes:

mg/L - milligrams per liter

TABLE 3. COMPARISON OF LASER INDUCED FLUORESCENCE RESULTS
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

	2004 and 2005 Laser Induced Fluorescence Results			2013 Laser Induced Fluorescence Results		
Laser Induced Fluorescence Boring ID	Vertical Extent of Fluorescence Response (ft-bgs)	Maximum Fluorescence Response (%)	Depth of Maximum Fluorescence Response (ft-bgs)	Vertical Extent of Fluorescence Response (ft-bgs)	Maximum Fluorescence Response (%)	Depth of Maximum Fluorescence Response (ft-bgs)
HROST/HUVOST-002	31-42	135.9	35.6	31-43	134.6	32.4
HROST/HUVOST-004	6-53	120.8	33.6	8-49.5	222.1	34.2
HROST/HUVOST-005	20-46	242.1	39.7	13.5-48.5	144.8	42.0
HROST/HUVOST-007	30-40	11.6	39.3	32-41	13.3	36.4
HROST/HUVOST-013	16-39	58.8	32.9	33-35	21.8	35.0
HROST/HUVOST-019	28-36	43.2	32.2	31-34	4.1	0.8
HROST/HUVOST-025	26.5-40.5	39.9	32.8	28-41	75.4	29.0
HROST/HUVOST-028	25-37	50.7	32.5	24-36	6.8	28.7
HROST/HUVOST-029	15-43	197.5	29.7	19-43	46.4	29.8
HROST/HUVOST-030	17-43	123.6	40.7	21.5-42.5	38.3	40.4
HROST/HUVOST-039	19.5-44.5	121.6	47.7	19-43.5	68.5	42.1
HROST/HUVOST-040	7-46	202.6	31.9	18.5-43	242	21.0
HROST/HUVOST-049	6-40	147.4	7.3	29-40	6.1	38.9
HROST/HUVOST-052	13-39	52.4	35.4	23.5-39	27.7	34.0
HROST/HUVOST-066	35-36.5	9.1	35.6	35.5-37.5	6.1	36.7
HROST/HUVOST-068	29-39	15.8	33.3	29-39.5	15.3	39.0
HROST/HUVOST-072	25.5-32	9.3	26.1	--	2.6	2.2
HROST/HUVOST-078	17-52	50.9	40.7	19-45	44.9	31.3
HROST/HUVOST-090	12-47	348.9	38.8	21-42	188.5	40.0
HROST/HUVOST-099	30-59	31.6	31.7	32-33	3.3	32.4
HROST/HUVOST-113	9-73	714.9	29.7	18-42.5	323.6	27.3
HROST/HUVOST-128	32-47	445.6	38.6	34-41	38.9	35.7
HROST/HUVOST-129	33-47	775.8	34.3	34.5-41.5	27.6	35.4
HROST/HUVOST-130	16-50	300.9	40.8	17.5-45.5	193.5	20.1

TABLE 4. LNAPL TRANSMISSIVITY SUMMARY
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Location	Test Type	Date	LNAPL Transmissivity (ft^2/day)	Piezometric Surface (ft-amsl)
ASW-001	BD	5/12/2010	0.15	406.1
HMW-018	BD	3/2/2004	3.6	396.2
HMW-018	BD	3/4/2004	0.46	396.3
HMW-018	BD	8/24/2005	3.9	397.4
HMW-019	BD	3/2/2004	1.1	396.6
HMW-019	BD	3/4/2004	1.2	396.8
HMW-019	HVR	5/23/2005	32	400.3
HMW-019	HVR	6/7/2005	0.42	399.7
HMW-019	HVR	6/21/2005	13	401.0
HMW-019	HVR	7/8/2005	39	400.2
HMW-019	HVR	7/22/2005	0.32	399.1
HMW-019	HVR	8/9/2005	2.0	398.1
HMW-019	HVR	8/10/2005	2.4	398.0
HMW-019	HVR	8/11/2005	2.4	398.0
HMW-019	HVR	8/12/2005	16	397.9
HMW-019	HVR	8/16/2005	2.6	397.8
HMW-019	HVR	8/17/2005	5.9	397.8
HMW-019	HVR	8/18/2005	2.9	397.8
HMW-019	HVR	8/19/2005	2.1	397.7
HMW-019	HVR	8/22/2005	22	397.7
HMW-019	HVR	8/23/2005	2.9	397.7
HMW-020	BD	3/3/2004	9.7	397.5
HMW-020	HVR	5/16/2005	0.029	399.9
HMW-020	HVR	6/14/2005	0.019	400.6
HMW-020	HVR	7/15/2005	0.0018	400.1
HMW-020	BD	5/4/2010	0.12	407.1
HMW-044C	BD	9/23/2004	85	398.5
HMW-044C	HVR	5/13/2005	2.2	399.0
HMW-044C	HVR	6/27/2005	13	399.6
HMW-044C	HVR	7/14/2005	2.2	399.0
HMW-044C	HVR	7/25/2005	4.3	398.4
HMW-044C	HVR	7/26/2005	4.7	398.3
HMW-044C	HVR	7/27/2005	1.5	398.2
HMW-044C	HVR	7/28/2005	3.7	398.2
HMW-044C	HVR	7/29/2005	1.5	398.1
HMW-044C	HVR	8/1/2005	0.34	398.1
HMW-044C	HVR	8/2/2005	1.5	398.0
HMW-044C	HVR	8/3/2005	0.84	398.0
HMW-044C	HVR	8/4/2005	0.58	397.9
HMW-044C	HVR	8/5/2005	0.41	397.8
HMW-044C	HVR	8/8/2005	0.13	397.7
HMW-044C	BD	8/12/2009	6.9	403.9
HMW-044C	BD	8/16/2010	0.23	409.2

TABLE 4. LNAPL TRANSMISSIVITY SUMMARY
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Location	Test Type	Date	LNAPL Transmissivity (ft^2/day)	Piezometric Surface (ft-amsl)
MP-133	BD	8/12/2009	2.8	403.9
MP-134	BD	8/12/2009	1.1	403.9
MP-134	BD	10/11/2011	0.030	403.7
MP-134	BD	1/24/2012	0.15	400.5
MP-135	BD	8/14/2009	0.60	403.9
MP-135	BD	10/11/2011	0.0020	403.7
MP-135	BD	1/24/2012	0.011	400.5
MP-136	BD	8/14/2009	4.0	403.9
MP-137	BD	8/14/2009	1.3	403.9
MP-137	BD	10/11/2011	0.020	403.7
MP-137	BD	1/24/2012	0.080	400.5
MP-035D	BD	8/30/2005	12	397.7
MP-035D	BD	5/5/2010	5.5	406.3
MP-039C	BD	9/23/2004	0.11	398.7
MP-039C	BD	8/31/2005	0.16	397.5
MP-039C	BD	4/20/2010	0.52	406.8
MP-039C	BD	5/4/2010	0.40	407.2
MP-045C	BD	9/24/2004	0.056	399.2
MP-045C	BD	8/30/2005	3.3	398.1
MP-047C	BD	9/24/2004	0.015	399.3
MP-047C	HVR	5/10/2005	0.093	400.1
MP-047C	HVR	5/25/2005	0.25	400.1
MP-047C	HVR	6/9/2005	0.83	400.0
MP-047C	HVR	7/12/2005	0.32	400.8
MP-049C	BD	8/31/2005	0.0067	397.9
MP-050C	HVR	5/26/2005	94	399.9
MP-050C	HVR	7/13/2005	1.7	399.7
MP-050C	HVR	8/24/2005	0.0051	397.6
MP-050C	HVR	8/25/2005	0.032	397.6
MP-050C	HVR	8/26/2005	0.0089	397.7
MP-050C	HVR	8/29/2005	0.013	397.6
MP-052C	BD	8/23/2005	0.0010	398.0
MP-053C	BD	9/23/2004	0.0026	399.3
MP-053C	HVR	7/19/2005	0.33	399.6
MP-055C	BD	9/23/2004	0.089	399.6
MP-055C	HVR	6/17/2005	4.0	400.9
MP-055C	HVR	7/6/2005	1.6	400.5
MP-055C	HVR	7/20/2005	1.9	399.8

TABLE 4. LNAPL TRANSMISSIVITY SUMMARY
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Location	Test Type	Date	LNAPL Transmissivity (ft^2/day)	Piezometric Surface (ft-amsl)
MP-056C	HVR	7/18/2005	0.033	399.9
MPE-A001	BD	8/11/2009	6.1	403.9
MPE-A001	BD	7/15/2010	0.12	410.5
MPE-A001	BD	8/19/2010	0.13	409.3
MPE-A002	BD	8/12/2009	0.50	403.9
MPE-A002	BD	7/16/2010	Very Low	410.5
MPE-A003	BD	8/11/2009	6.2	403.9
MPE-A004	BD	8/17/2009	10	403.9
MPE-A004	BD	7/16/2010	Very Low	410.5
MPE-A005	BD	8/13/2009	14	403.9
MPE-A005	BD	7/15/2010	0.15	410.5
MPE-A005	BD	8/19/2010	0.39	409.3
RW-004A	HVR	8/30/2005	0.45	397.8
RW-004A	HVR	8/31/2005	0.15	397.7
RW-005	HVR	9/1/2005	0.18	398.0

Notes

BD - recharge following LNAPL baildown
HVR - recharge following high vacuum recovery
ft^2/day - feet squared per day
ft-amsl - feet above mean sea level

- Piezometric surface is an approximate elevation based on field forms from the test, if available. If field forms were not available, the nearest fluid level recorded in the database was used to determine hydraulic conditions.
- LNAPL transmissivities in 2004 and 2005 are referenced from Table 3-5 of the *Proposal for an Active LNAPL Recovery System* submitted by Clayton Group Services, Inc. on February 2, 2006.
- LNAPL transmissivities in 2009 and 2010 are referenced from project database.
- LNAPL transmissivities in 2011 and 2012 are referenced from Table 9 of the *Light Non-Aqueous Phase Liquid Recovery Pilot Test Interim Report* submitted by WSP on July 5, 2012.

FIGURES

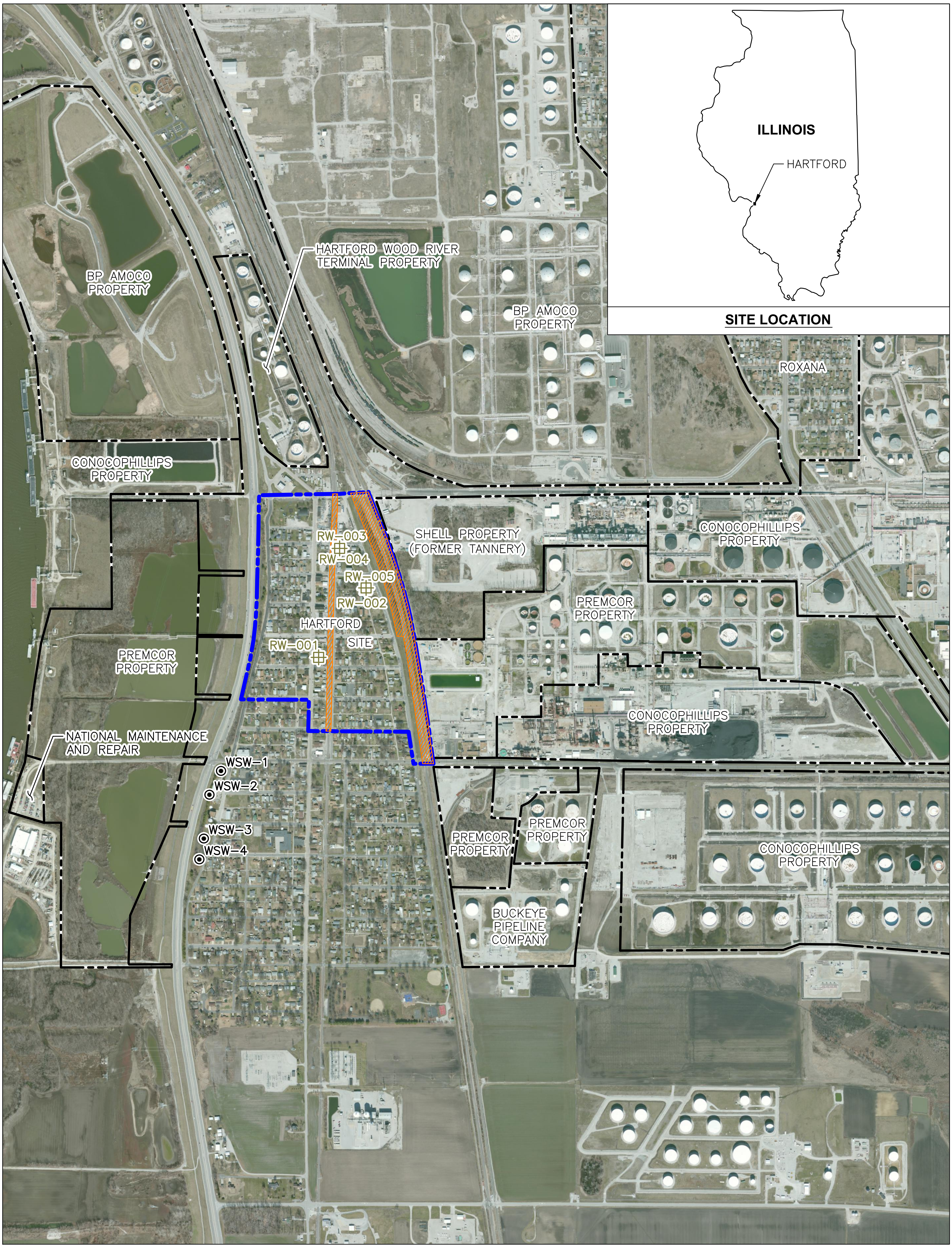

Image Cite: MapMart, Satellite Provider − DigitalGlobe, Image Capture Date − March 9, 2012

EXPLANATION

⊙ WSW−1 PUBLIC WATER SUPPLY WELL AND DESIGNATION

⊞ RW−001 LNAPL RECOVERY WELL

— · — PROPERTY BOUNDARY (APPROXIMATE)

— · — SITE BOUNDARY (APPROXIMATE)

▨ RAILROAD RIGHT-OF-WAY (APPROXIMATE)

N

0 1,000'

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FIGURE 1

SITE LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: KBW	Checked By: PM	Scale: 1" = 1,000'	Date: 5/22/14	File: 24S_SITELOCMAP201312

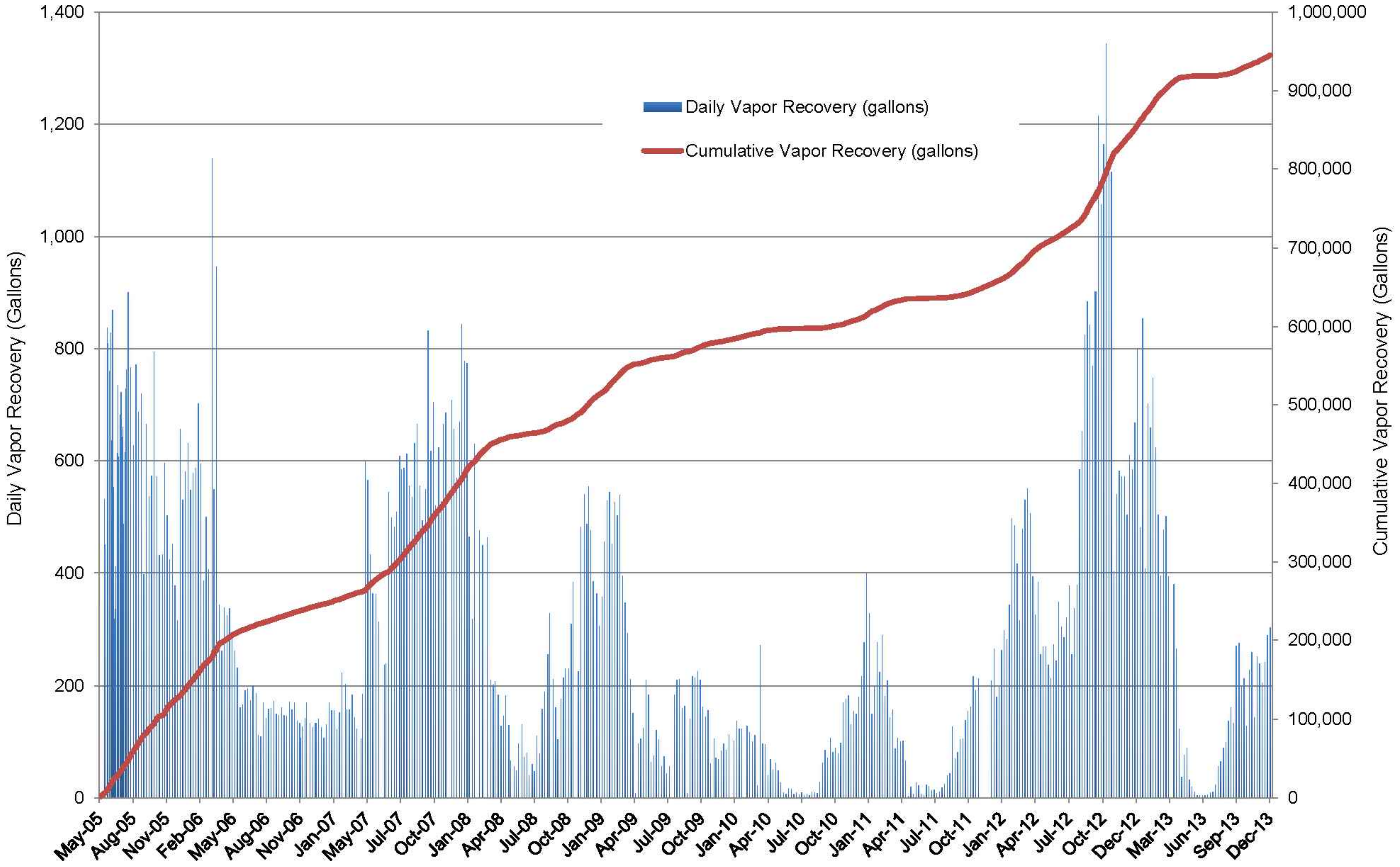

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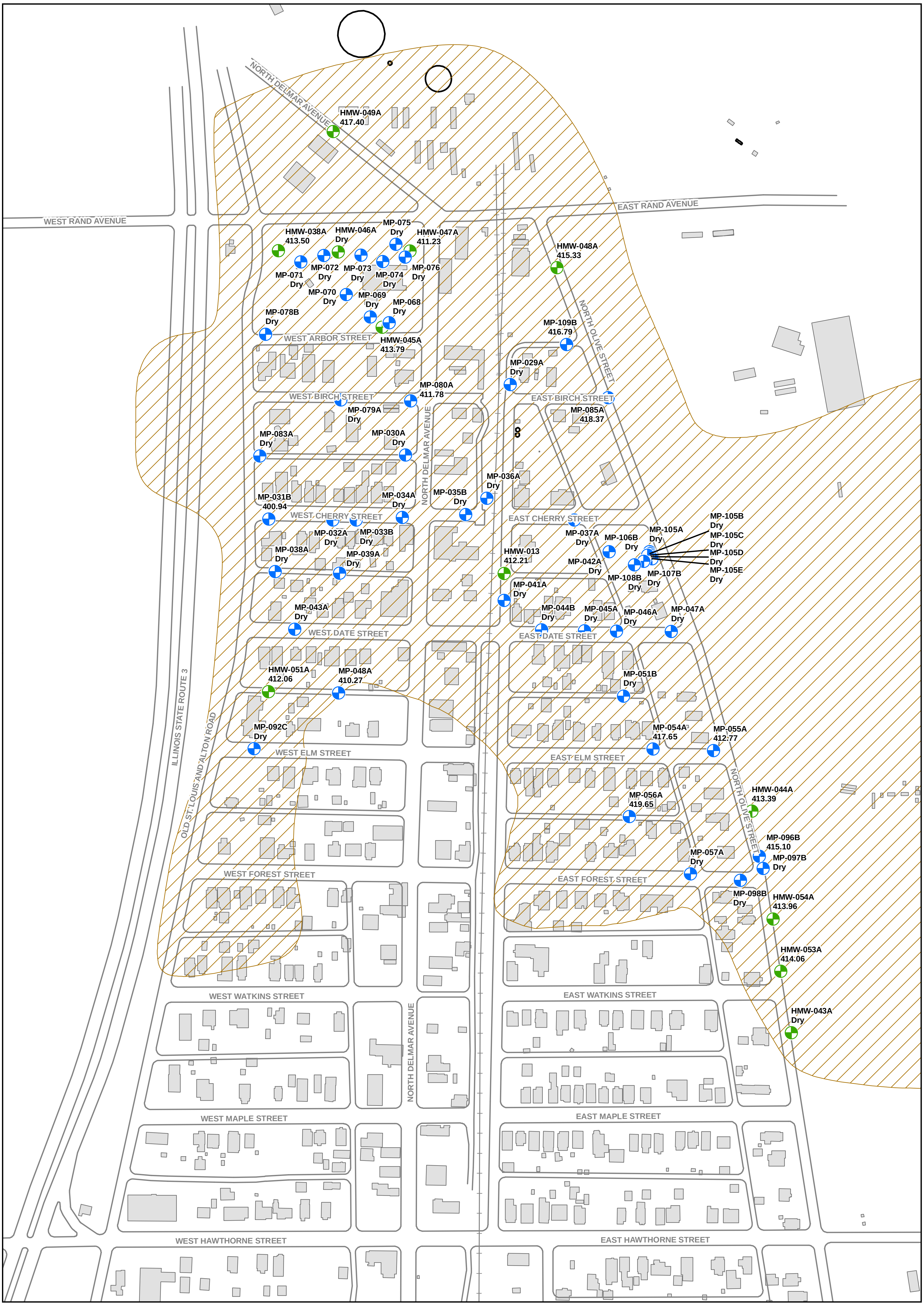
FIGURE 2

VOLATILE PETROLEUM HYDROCARBONS RECOVERED VIA SOIL VAPOR EXTRACTION SYSTEM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: KBW	Checked By: BM	Scale: NONE	Date: 5/22/14	File: 24S_HSTRCLVPHREC201402



EXPLANATION

- ◐ GROUNDWATER MONITORING WELL
- ◐ MULTIPURPOSE MONITORING POINT
- ▨ NORTH OLIVE HYDROSTRATIGRAPHIC UNIT
- ▭ TANK
- ■ BUILDING

N

0 250 '

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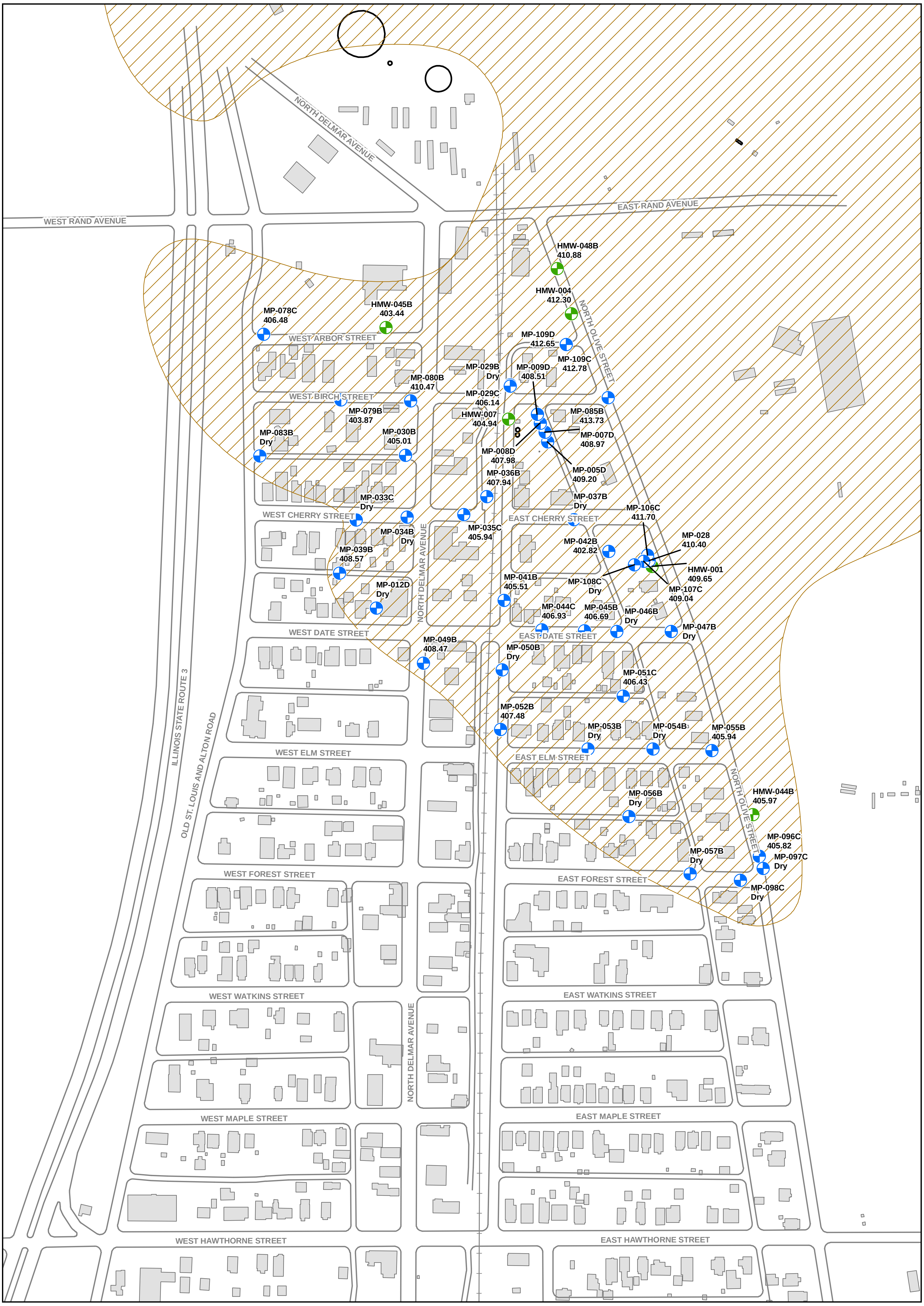
FIGURE 3

FOURTH QUARTER 2013 GROUNDWATER ELEVATIONS NORTH OLIVE HYDROSTRATIGRAPHIC UNIT

HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 250'	Date: 5/12/14	File: Fig3_AOC_4Q13_NOlive.mxd



EXPLANATION

🟢	GROUNDWATER MONITORING WELL
🔵	MULTIPURPOSE MONITORING POINT
▨	RAND HYDROSTRATIGRAPHIC UNIT
☐	TANK
■	BUILDING

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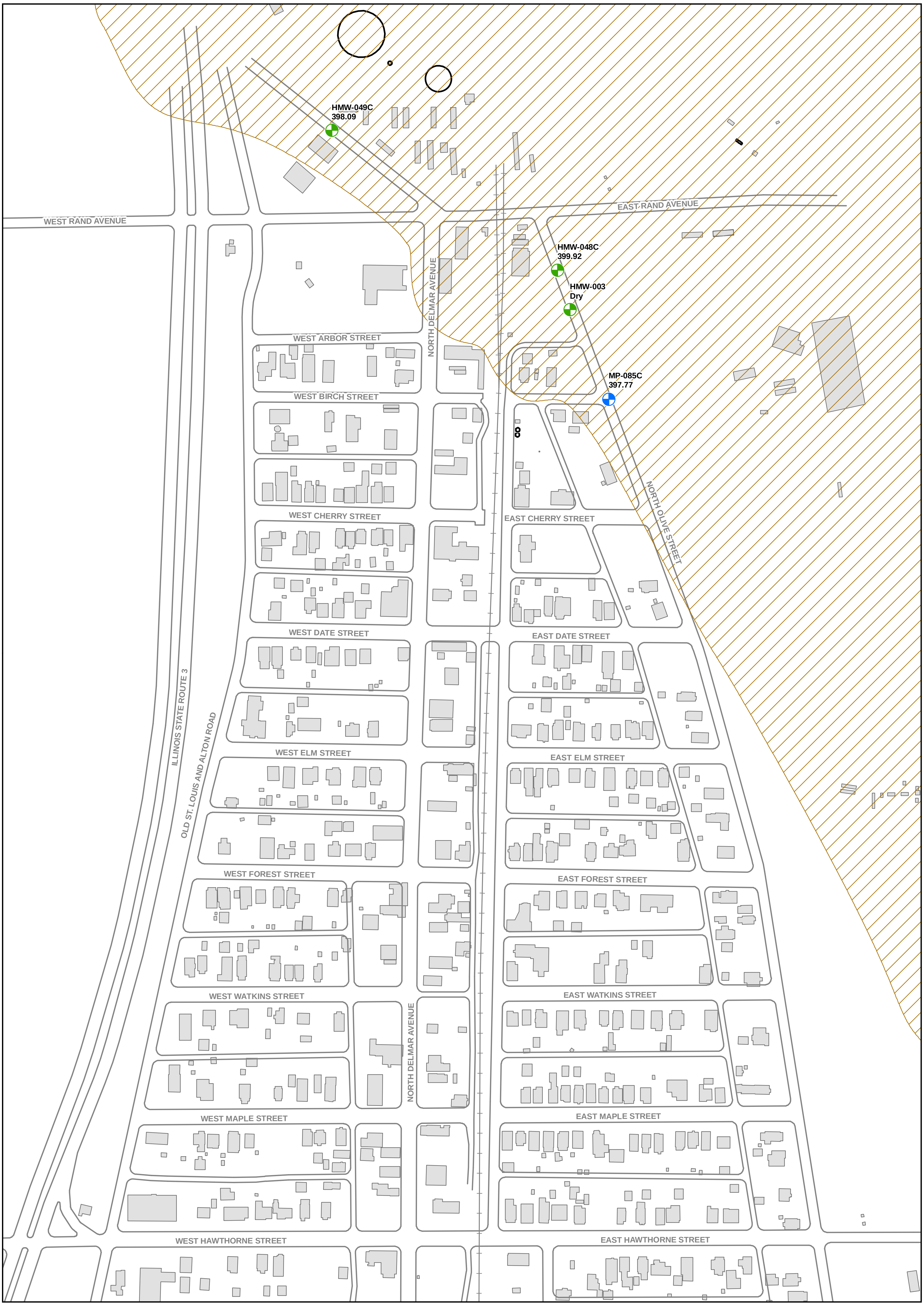
FIGURE 4

FOURTH QUARTER 2013 GROUNDWATER ELEVATIONS RAND HYDROSTRATIGRAPHIC UNIT

HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 250'	Date: 5/12/14	File: Fig4_AOC_4Q13_Rand.mxd



EXPLANATION

● GROUNDWATER MONITORING WELL

● MULTIPURPOSE MONITORING POINT

▨ EPA HYDROSTRATIGRAPHIC UNIT

☐ TANK

■ BUILDING

N

0 250 '

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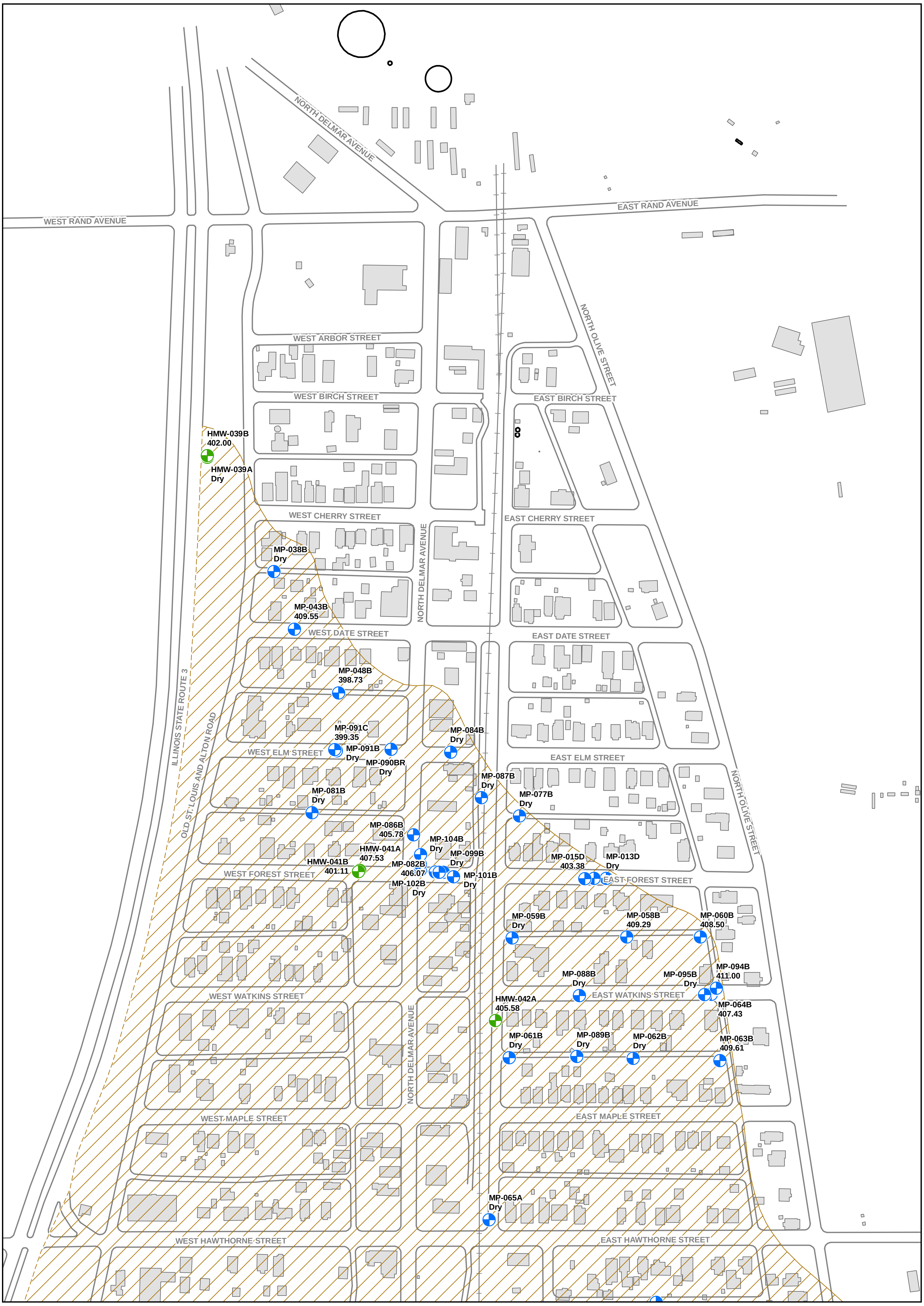
FIGURE 5

FOURTH QUARTER 2013 GROUNDWATER ELEVATIONS
EPA HYDROSTRATIGRAPHIC UNIT

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 250'	Date: 5/12/14	File: Fig5_AOC_4Q13_EPA.mxd



EXPLANATION

◕	GROUNDWATER MONITORING WELL
◕	MULTIPURPOSE MONITORING POINT
▨	MAIN SILT HYDROSTRATIGRAPHIC UNIT
☐	TANK
■	BUILDING

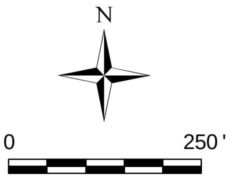


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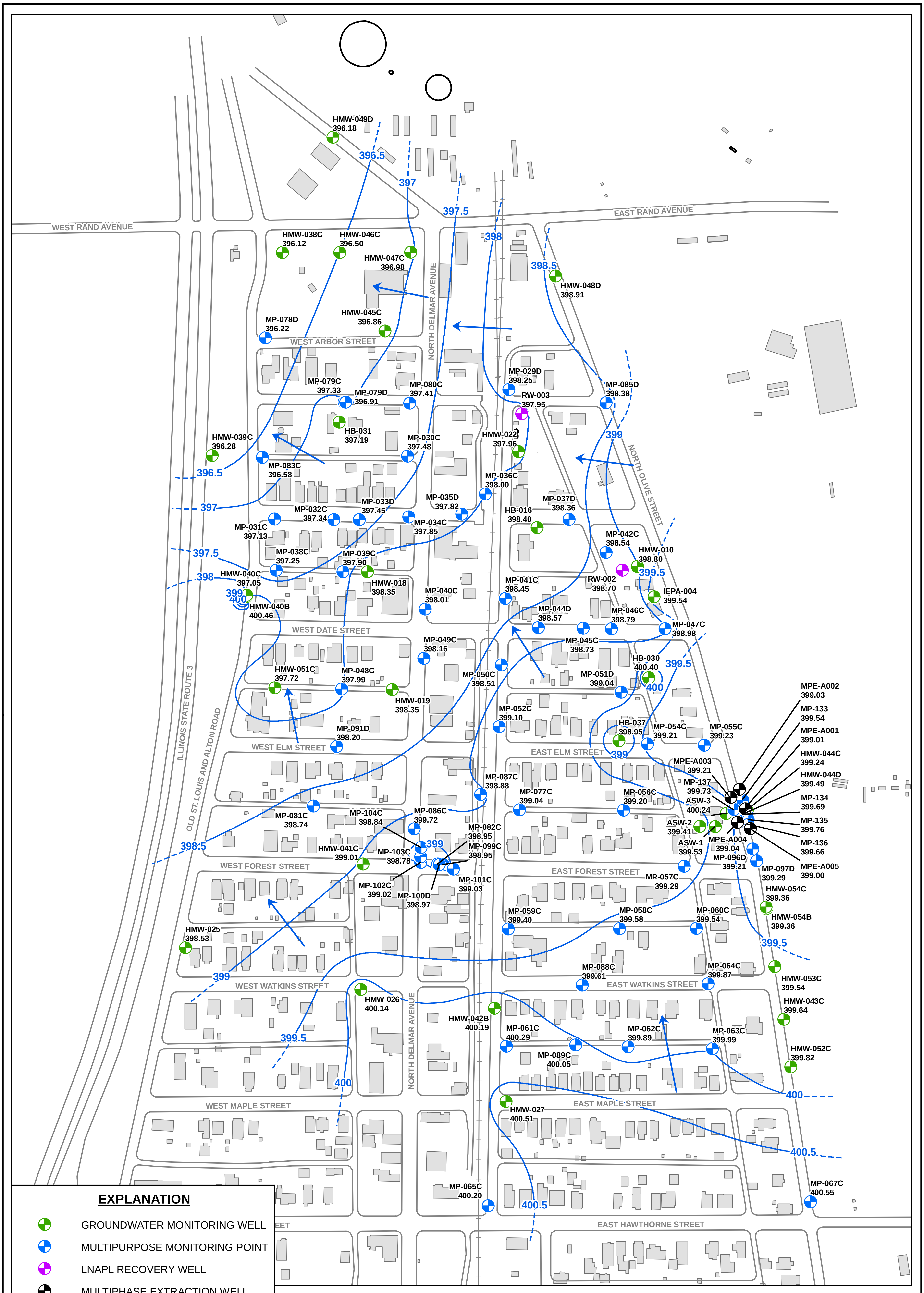
FIGURE 6

FOURTH QUARTER 2013 GROUNDWATER ELEVATIONS
MAIN SILT HYDROSTRATIGRAPHIC UNIT

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 250'	Date: 5/22/14	File: Fig6_AOC_4Q13_Silt.mxd



EXPLANATION

- ● GROUNDWATER MONITORING WELL
- ● MULTIPURPOSE MONITORING POINT
- ● LNAPL RECOVERY WELL
- ● MULTIPHASE EXTRACTION WELL
- → APPARENT GROUNDWATER FLOW DIRECTION
- — GROUNDWATER ELEVATION CONTOUR, DASHED WHERE INFERRED (0.5 FOOT INTERVAL)
- ☐ TANK
- ▨ BUILDING

N

0 250 '

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FIGURE 7

FOURTH QUARTER 2013 GROUNDWATER ELEVATIONS MAIN SAND HYDROSTRATIGRAPHIC UNIT

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 250'	Date: 5/12/14	File: Fig7_AOC_4Q13_Sand.mxd

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

EXPLANATION

● LIF BORING

● LNAPL SAMPLE LOCATION

N

0 150 '

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FIGURE 8

COLLOCATED LNAPL SAMPLE AND LIF BORING LOCATIONS

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JDF	Checked By: BCM	Scale: 1 " = 150 '	Date: 5/13/14	File: AOCHrtfrd_CdistROST.mxd

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

EXPLANATION

● GROUNDWATER SAMPLE LOCATION

● LNAPL SAMPLE LOCATION

Notes:
1. Units are milligrams per liter.
2. LNAPL and groundwater samples collected between 2005 and 2006.
3. Locations with multiple samples are displayed with a " / " between the separate results.

N

0 150 '

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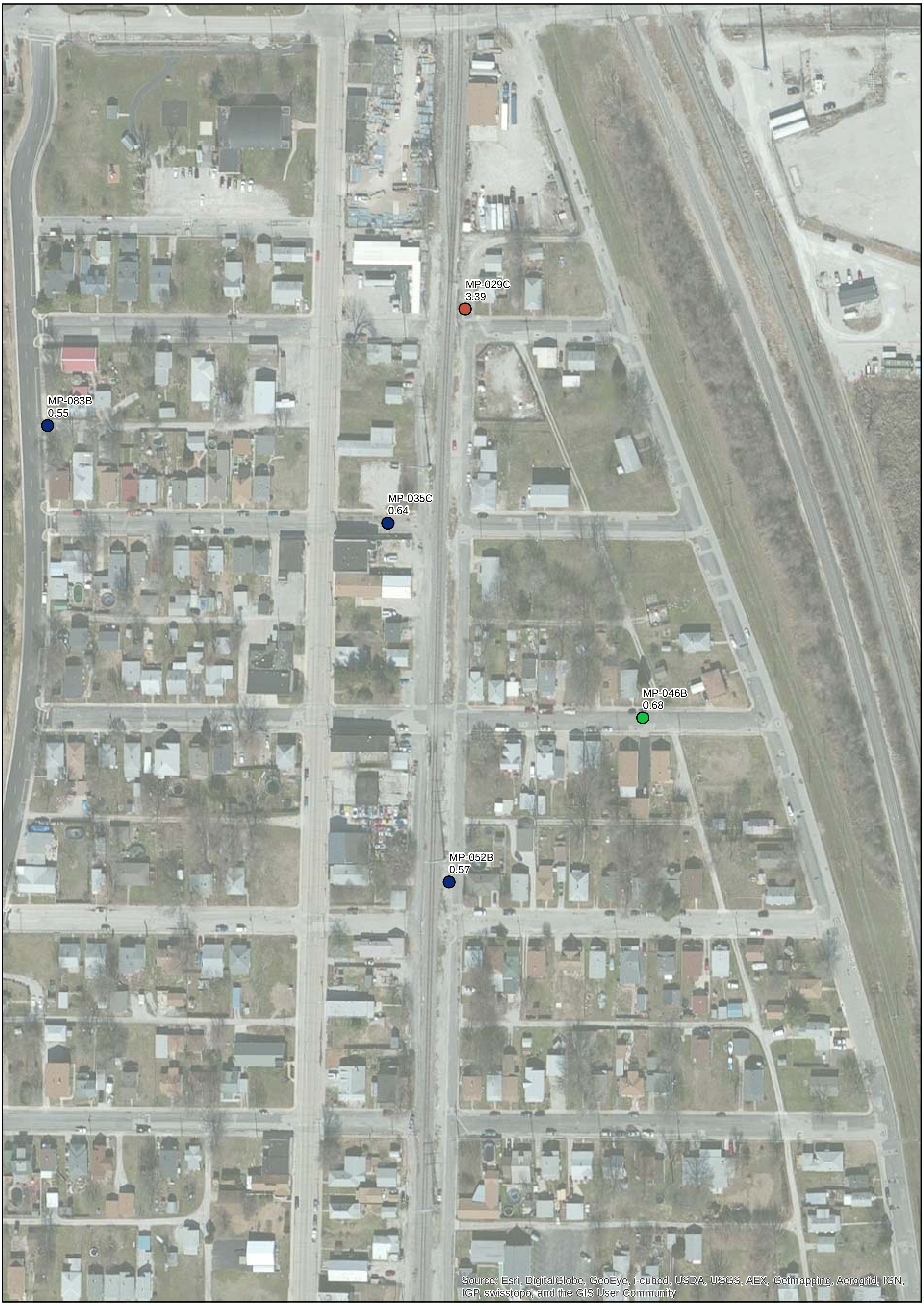
FIGURE 9

COLLOCATED BENZENE EFFECTIVE SOLUBILITY AND DISSOLVED PHASE CONCENTRATIONS

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JDF	Checked By: BLM	Scale: 1 " = 156 '	Date: 5/12/14	File: AOCHrtfrd_Partitioning.mxd



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

EXPLANATION

VISCOSITY BY WELL (CENTIPOISE)

- ● 0.31 - 0.64
- ● 0.65 - 0.90
- ● 0.91 - 1.59 (NOT SHOWN ON THIS MAP)
- ● 1.60 - 3.39

N

0 120 '

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FIGURE 10

LNAPL VISCOSITY IN THE RAND STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JDF | Checked By: JP | Scale: 1 " = 150 ' | Date: 5/12/14 | File: AOCHrtfrd_Viscos_Rand.mxd

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

EXPLANATION

VISCOSITY BY WELL (CENTIPOISE)

- ● 0.31 - 0.64
- ● 0.65 - 0.90
- ● 0.91 - 1.59
- ● 1.60 - 3.39 (NOT SHOWN ON THIS MAP)

N

0 120 '

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FIGURE 11

LNAPL VISCOSITY IN THE MAIN SAND STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JDF	Checked By: JP	Scale: 1 " = 150 '	Date: 5/12/14	File: AOCHrtfrd_Viscos_MainSand.mxd

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community, Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

EXPLANATION

🟢	GROUND SURFACE ELEVATION ONLY
●	LASER-INDUCED FLUORESCENCE, LITHOLOGY, AND GROUND SURFACE ELEVATION
🟠	LASER-INDUCED FLUORESCENCE AND GROUND SURFACE ELEVATION
🔵	LITHOLOGY AND GROUND SURFACE ELEVATION

NOTE:
ADDITIONAL POINTS OUTSIDE THE DISPLAYED EXTENT WERE ALSO USED IN GENERATING THE 3D MODEL

N

0 375 '

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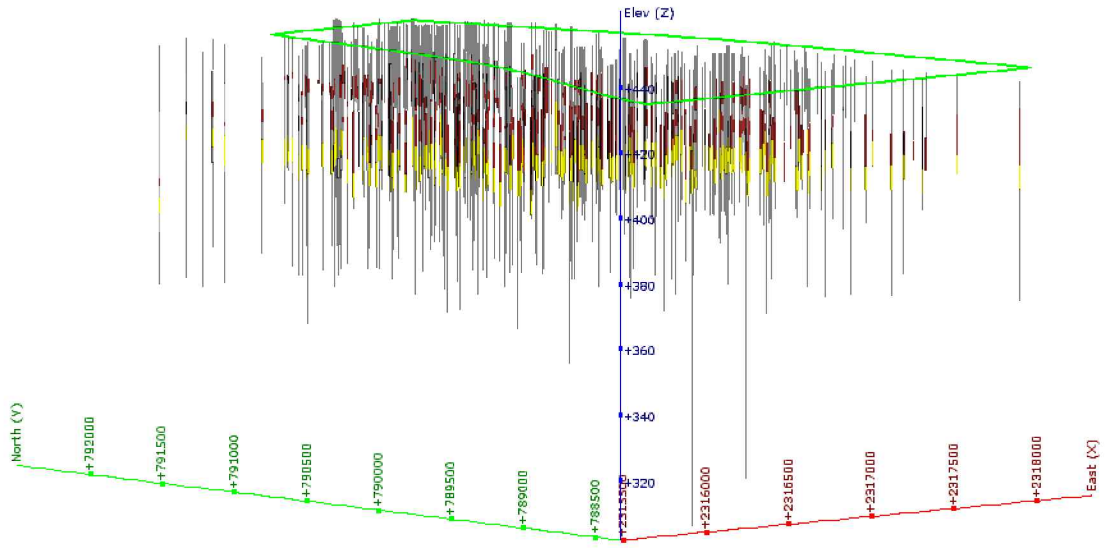
FIGURE 12

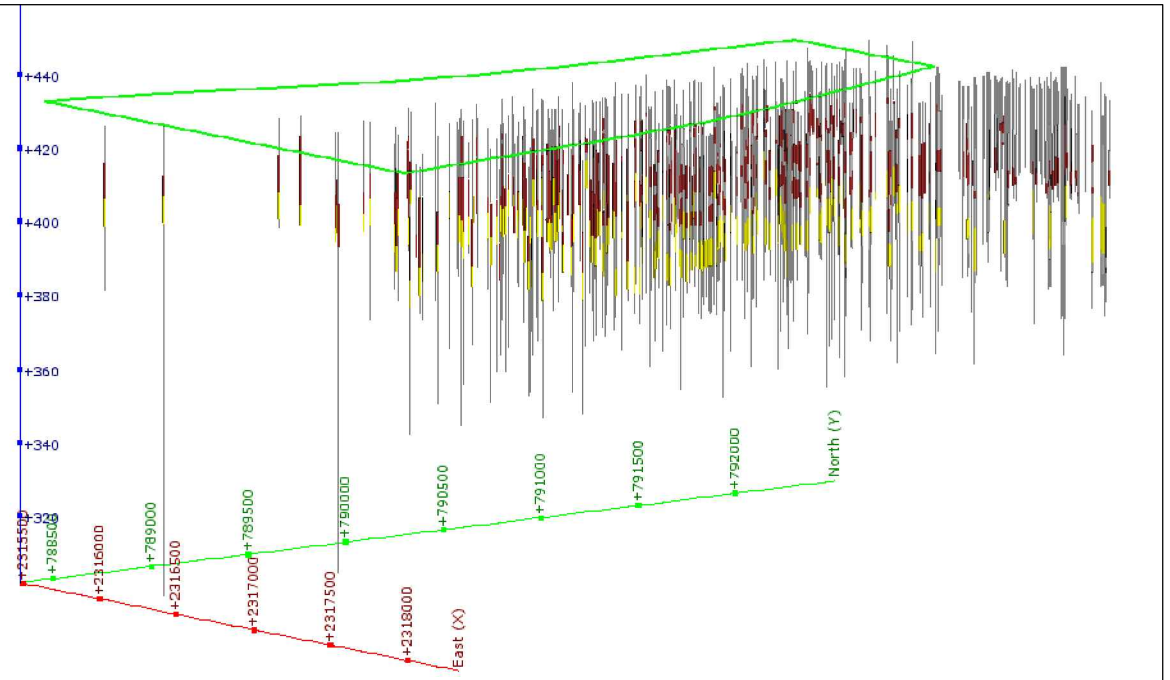
DATA POINTS USED TO GENERATE 3D MODEL

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: BLM	Checked By: JGP	Scale: 1 " = 375 '	Date: 5/12/14	File: AOCHrtfrd_Collar.mxd



Ⓐ **SOIL AND CPT BORINGS**
VIEW TO NORTHEAST

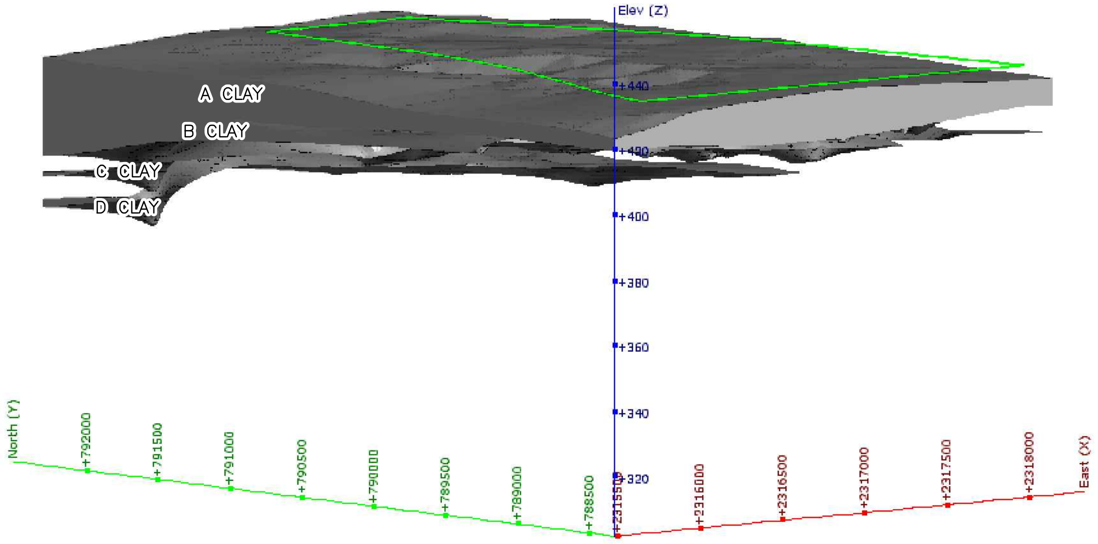


Ⓒ **SOIL AND CPT BORINGS**
VIEW TO NORTHWEST

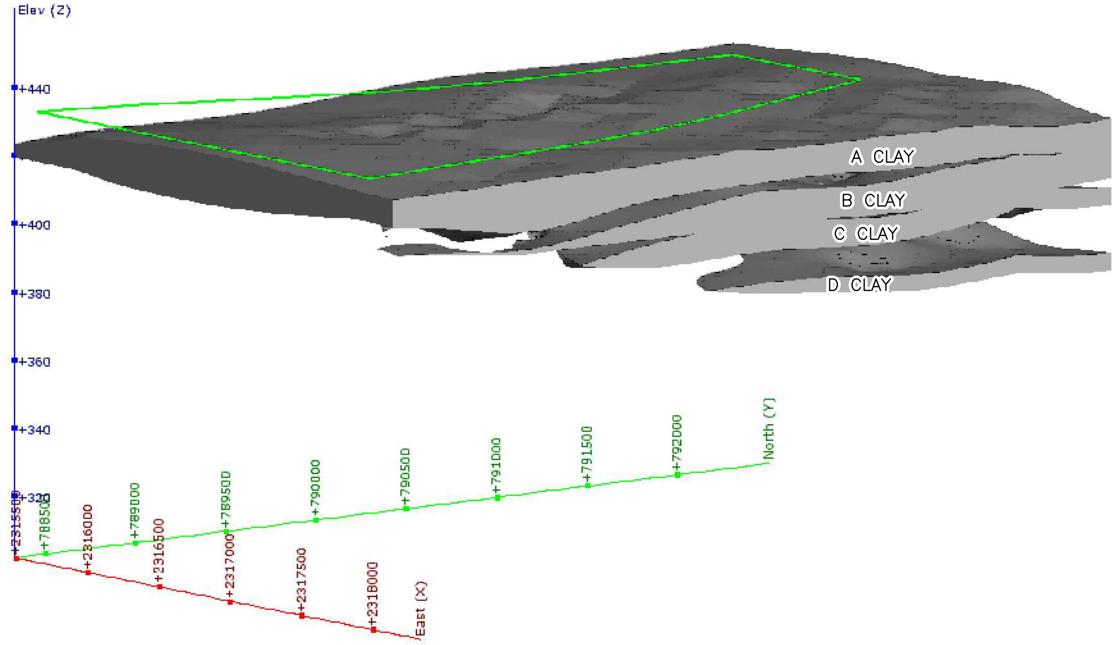
OVERVIEW MAP

A/B
12

C/D
12



Ⓑ **INTERPOLATED LITHOLOGY POLYGONS**
VIEW TO NORTHEAST



Ⓓ **INTERPOLATED LITHOLOGY POLYGONS**
VIEW TO NORTHWEST

EXPLANATION

CPT	CONE PENETROMETER TESTING

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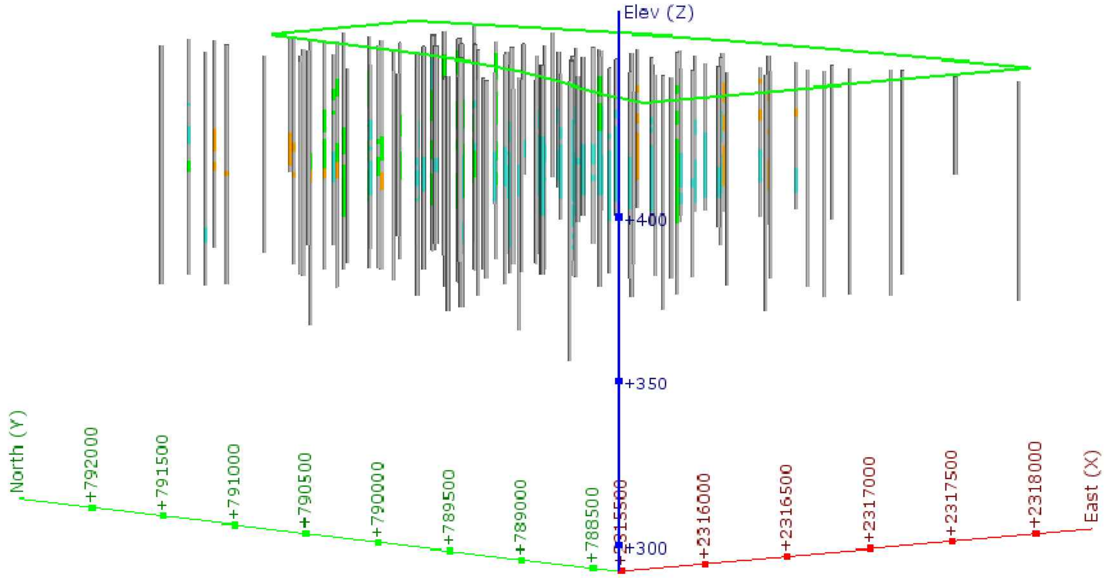
FIGURE 13

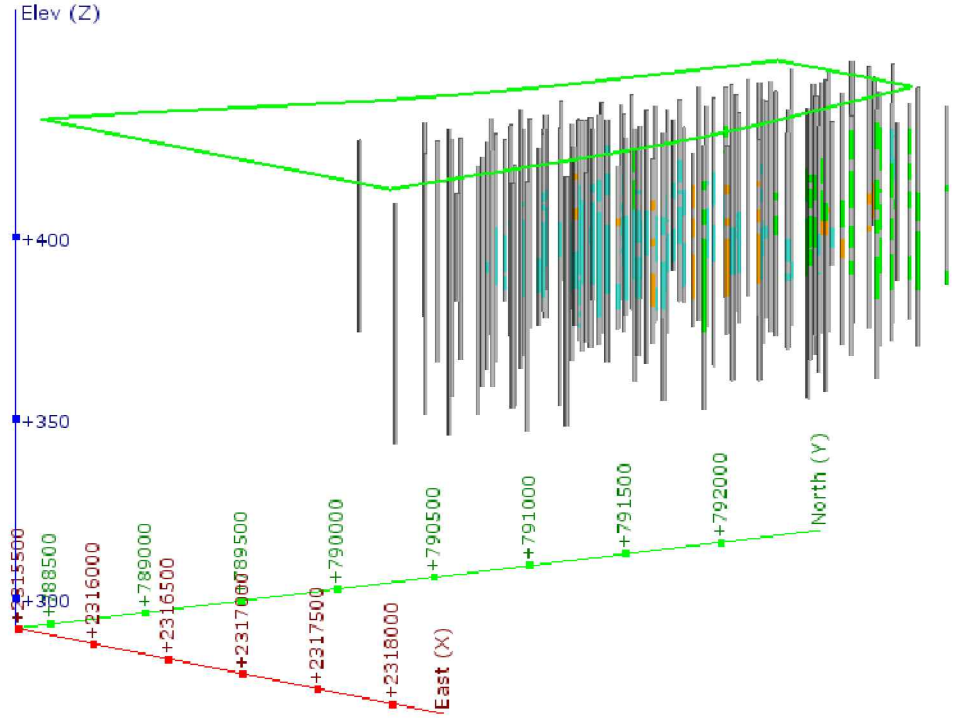
BORING LOCATIONS AND
3D LITHOLOGY DATA DISPLAY

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: BM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_LCSM_3D_

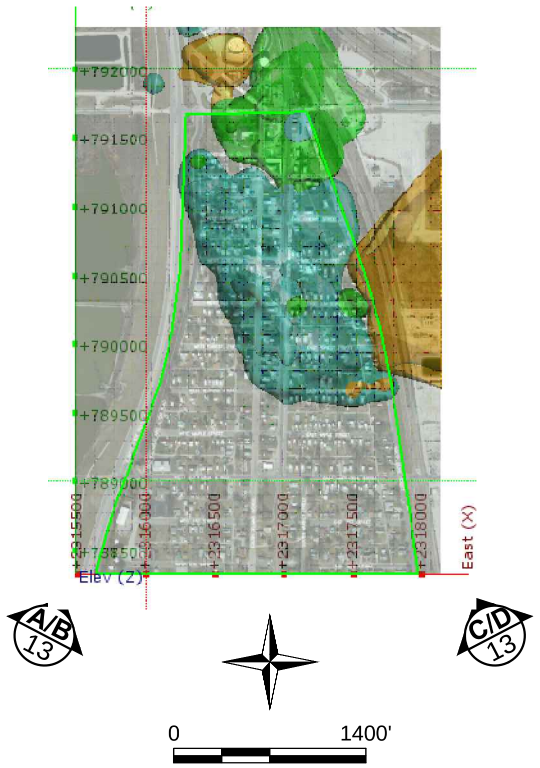


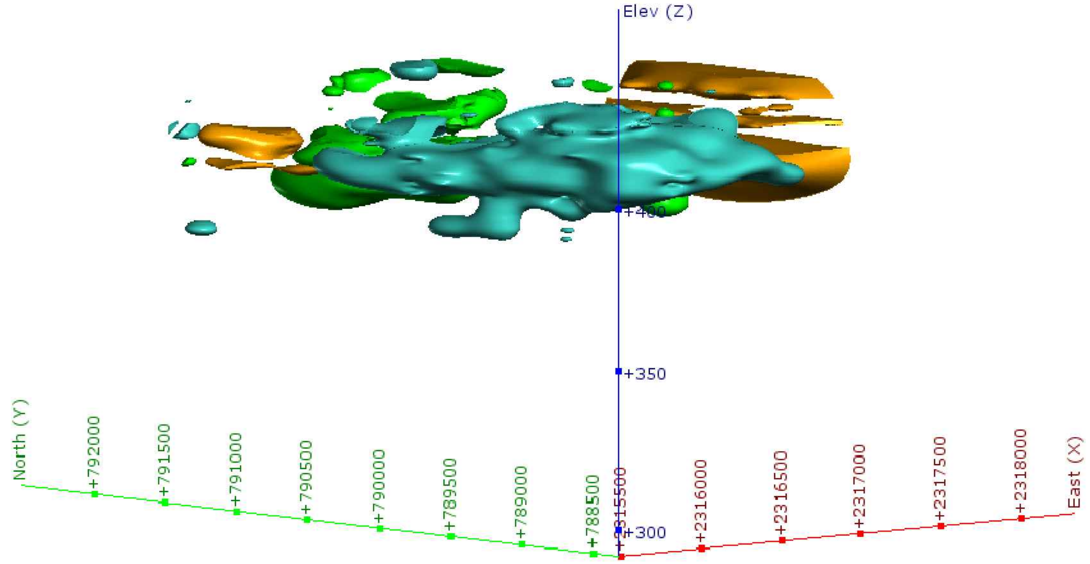
A **LIF BORINGS**
VIEW TO NORTHEAST



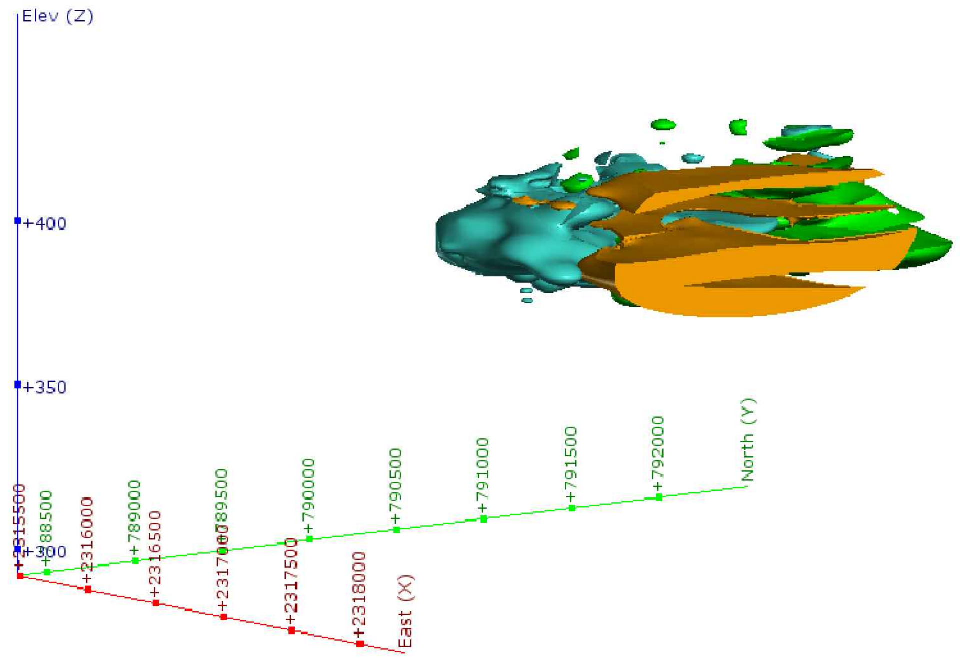
C **LIF BORINGS**
VIEW TO NORTHWEST

OVERVIEW MAP





B **INTERPOLATED LNAPL POLYGONS**
VIEW TO NORTHEAST



D **INTERPOLATED LNAPL POLYGONS**
VIEW TO NORTHWEST

EXPLANATION

LIF	LASER INDUCED FLUORESCENCE
🟦	LIGHT–RANGE LNAPL
🟩	MID–RANGE LNAPL
🟧	HEAVY–RANGE LNAPL

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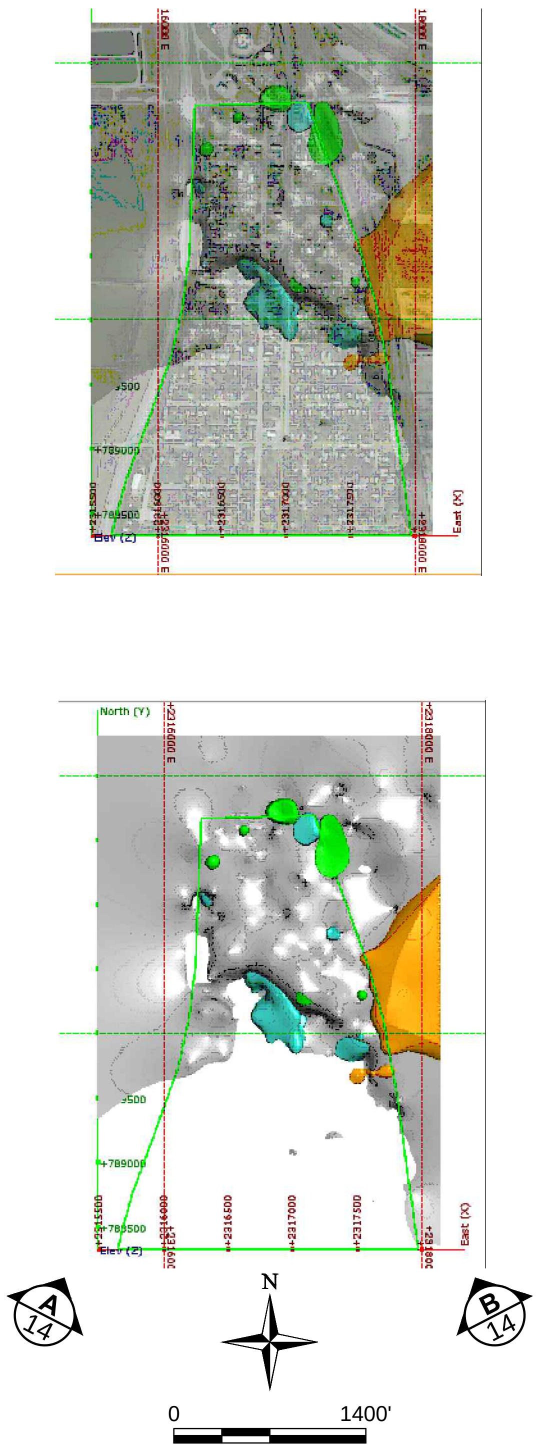
FIGURE 14

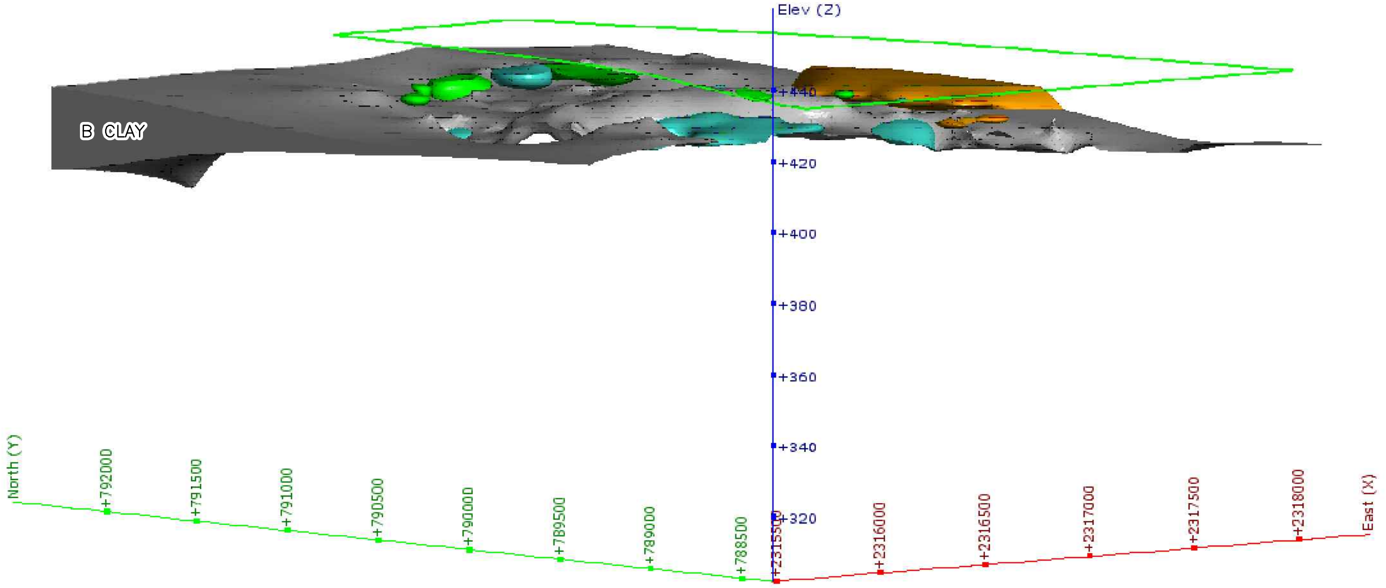
LIF LOCATIONS AND
3D LNAPL DATA DISPLAY

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

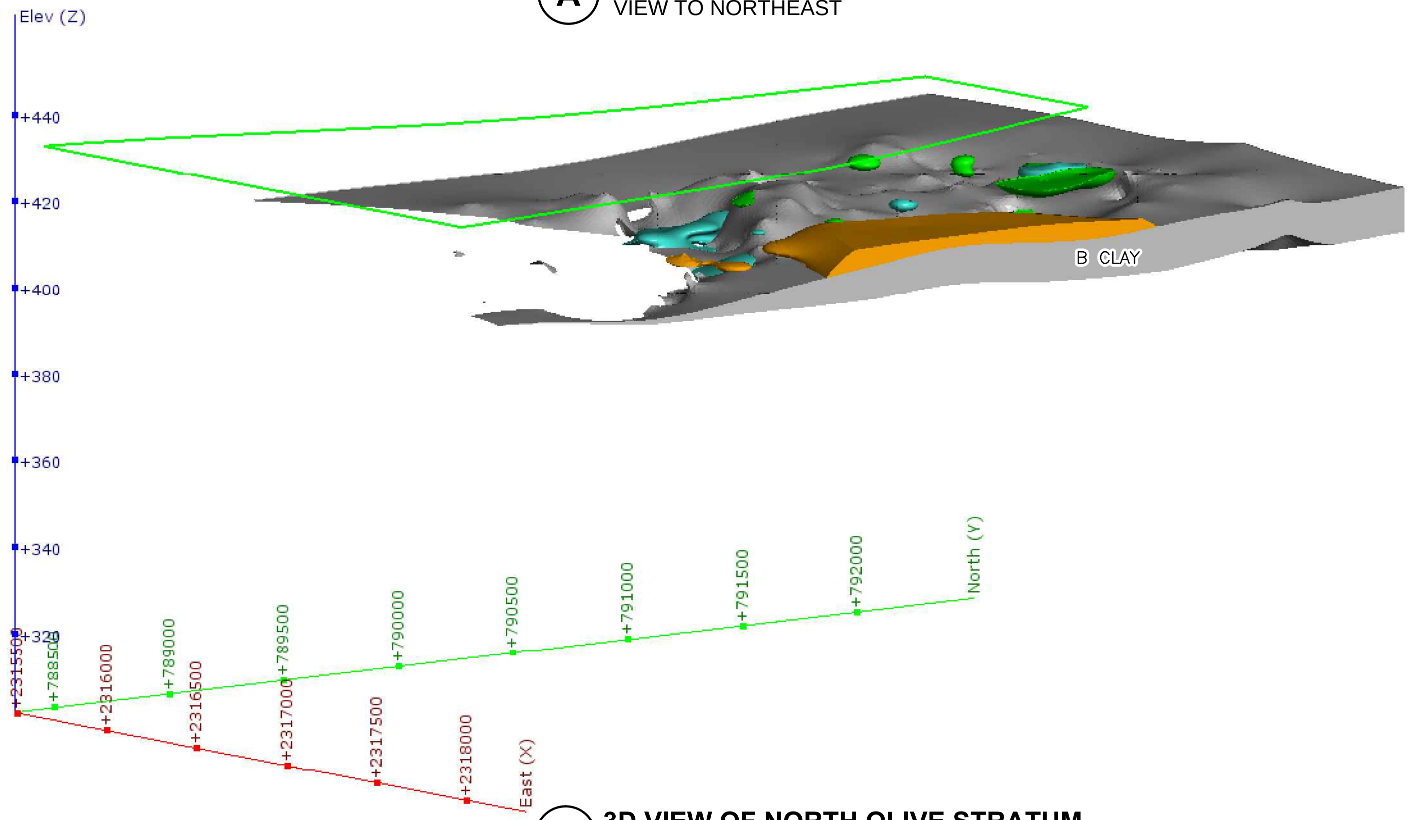
Drawn By: JGP	Checked By: BM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_LCSM_3D_

OVERVIEW MAPS





A 3D VIEW OF NORTH OLIVE STRATUM
VIEW TO NORTHEAST



B 3D VIEW OF NORTH OLIVE STRATUM
VIEW TO NORTHWEST

EXPLANATION

🟦	LIGHT–RANGE LNAPL
🟩	MID–RANGE LNAPL
🟧	HEAVY–RANGE LNAPL

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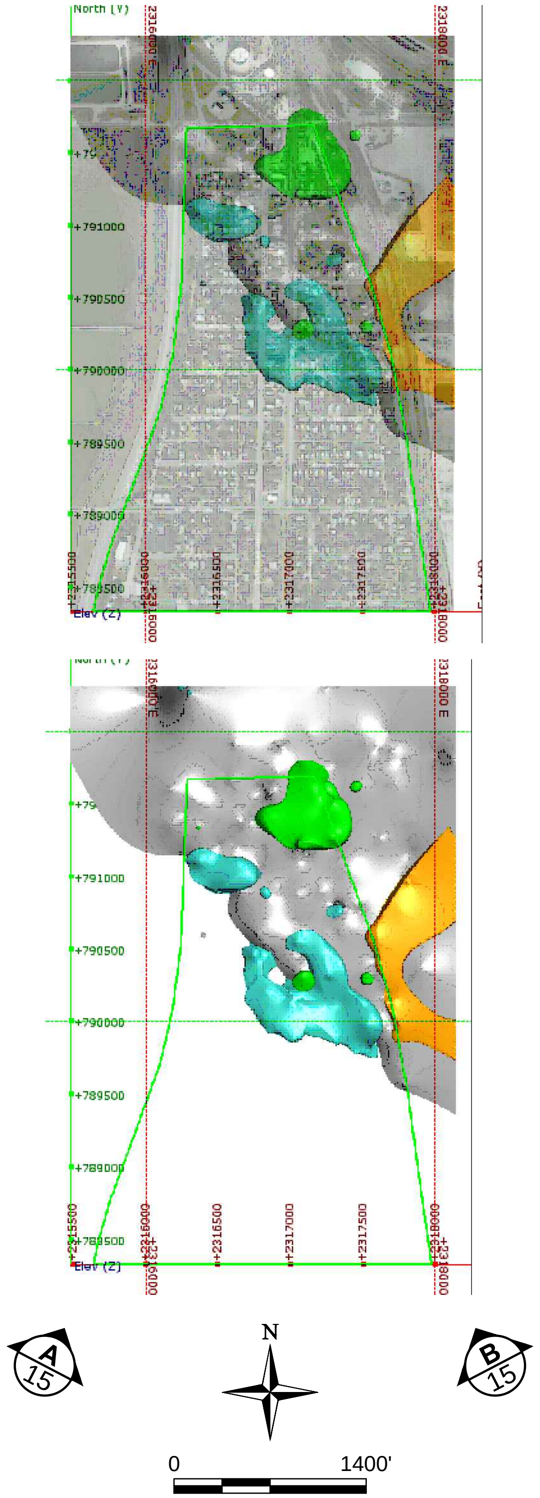
FIGURE 15

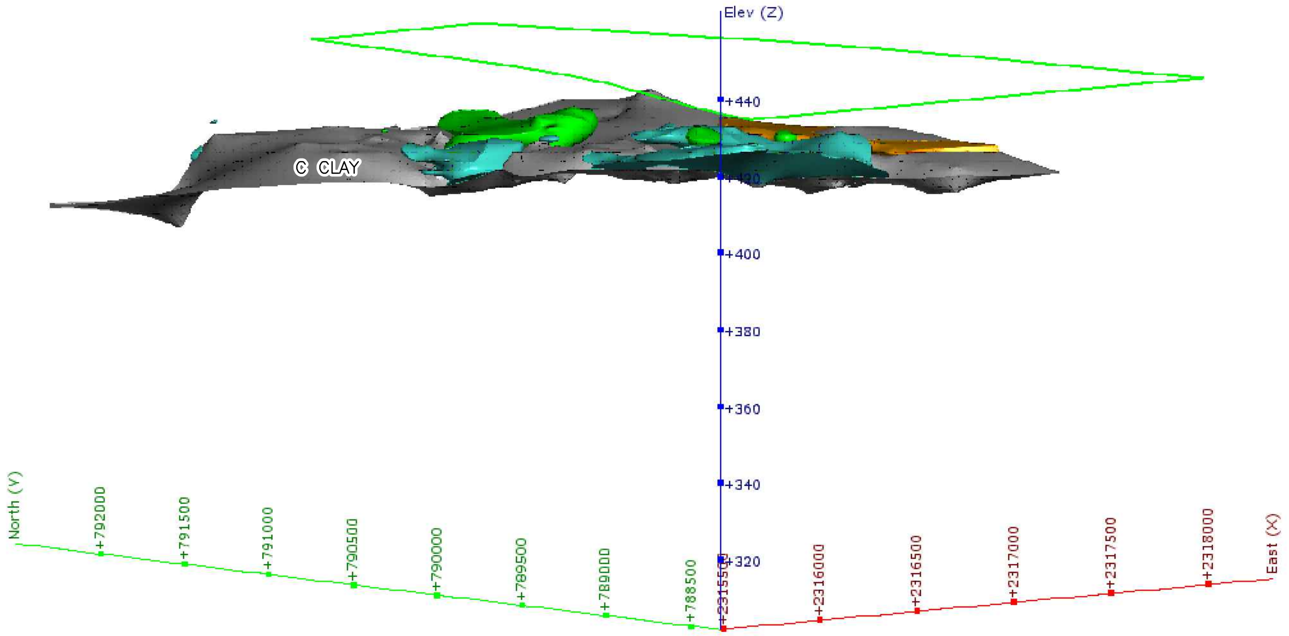
LNAPL DISTRIBUTION IN THE NORTH OLIVE STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

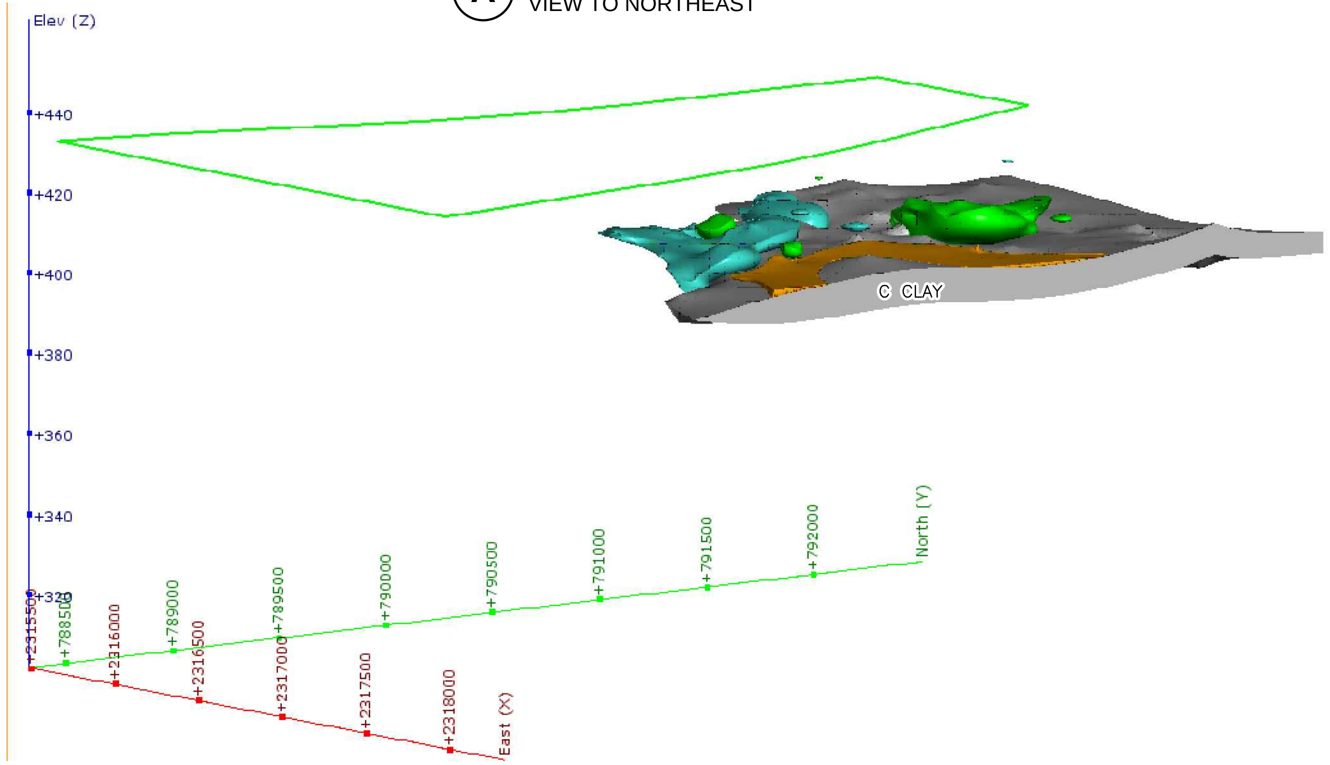
Drawn By: JGP	Checked By: BM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_LCSM_3D_

OVERVIEW MAPS





A **3D VIEW OF RAND STRATUM**
VIEW TO NORTHEAST



B **3D VIEW OF RAND STRATUM**
VIEW TO NORTHWEST

EXPLANATION

🟦	LIGHT–RANGE LNAPL
🟩	MID–RANGE LNAPL
🟧	HEAVY–RANGE LNAPL

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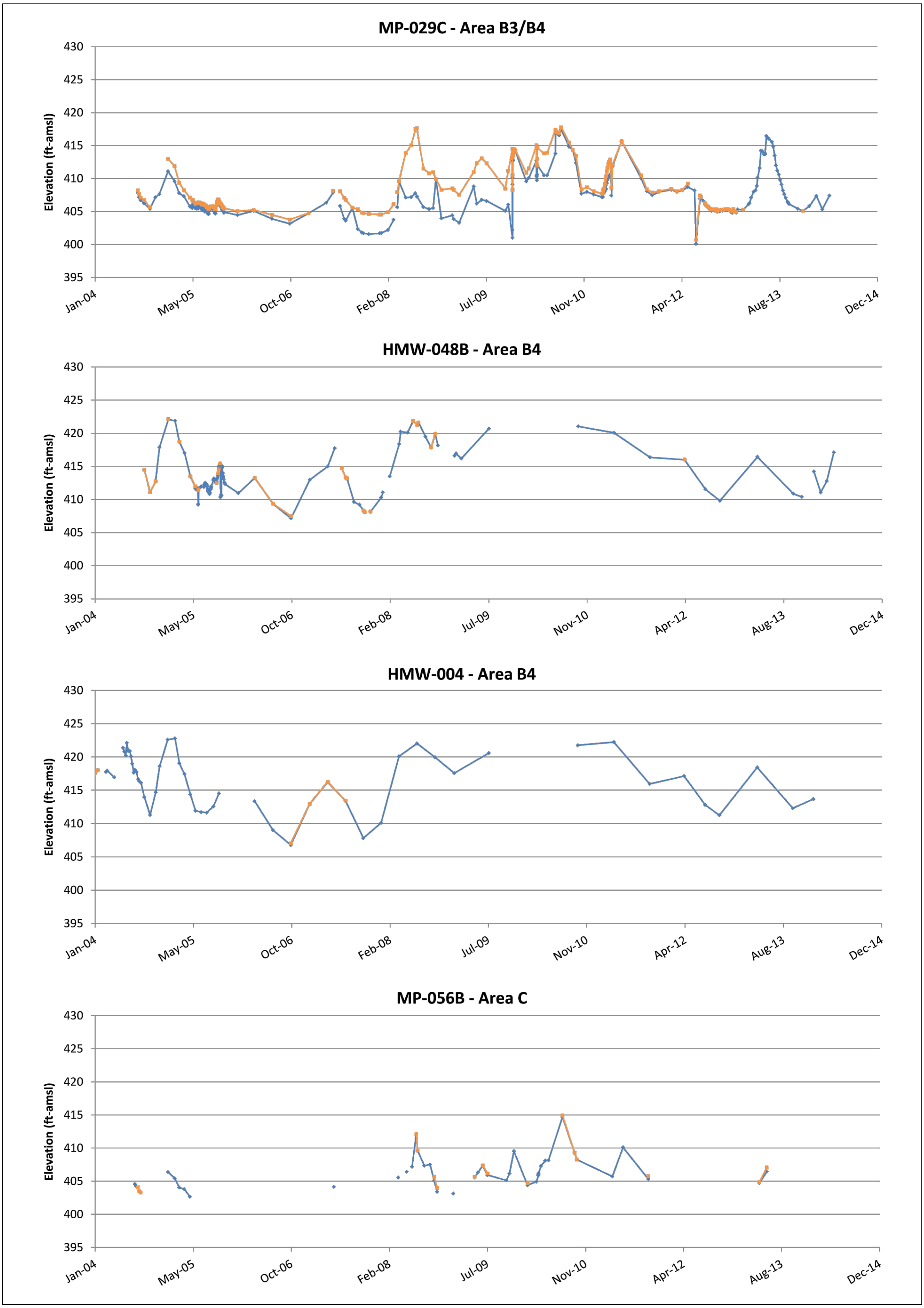
FIGURE 16

LNAPL DISTRIBUTION
IN THE RAND STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: BM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_LCSM_3D_



EXPLANATION

— Groundwater Elevation

— LNAPL Elevation

NOTE:

LOCATIONS WERE SELECTED BASED ON AVAILABILITY OF FLUID LEVEL DATA AND FREQUENCY OF GROUNDWATER AND LNAPL OCCURRENCE.

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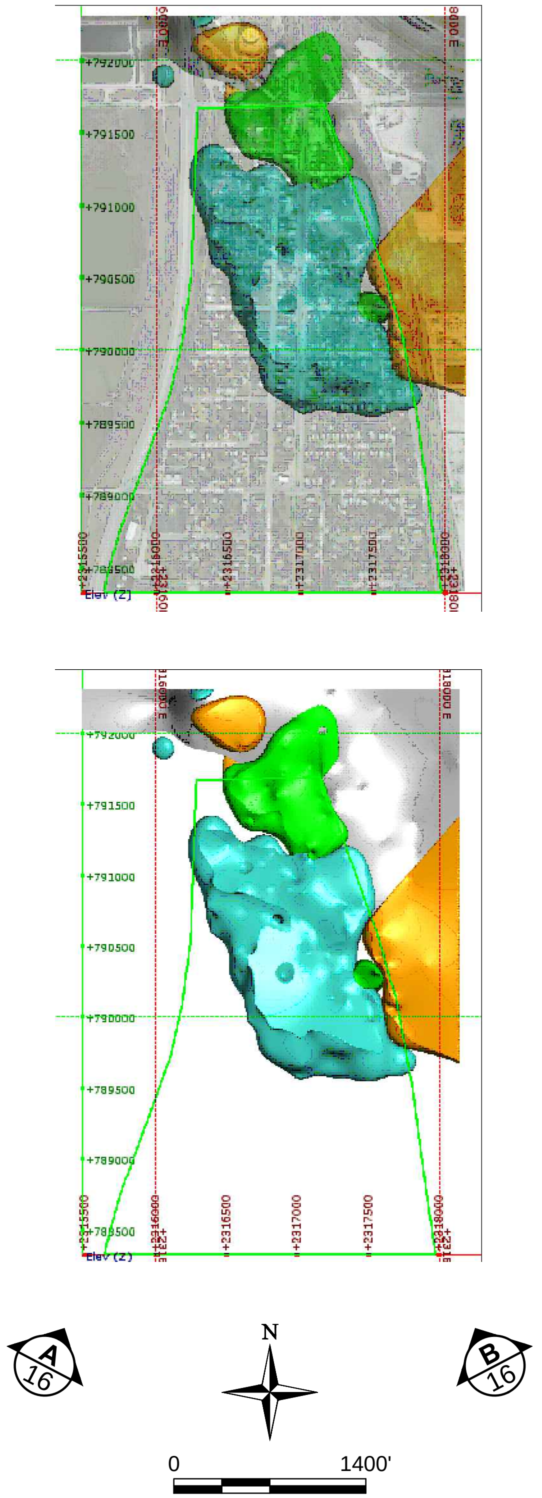
FIGURE 17

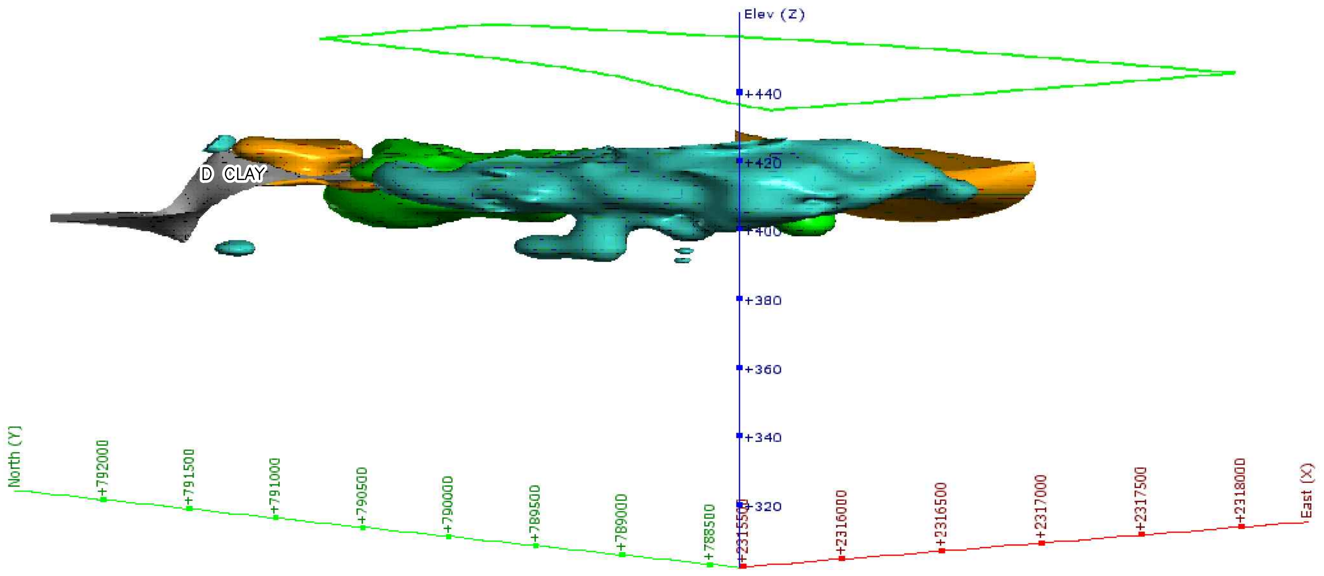
FLUID LEVEL ELEVATIONS WITHIN SELECT WELLS SCREENED IN THE RAND STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

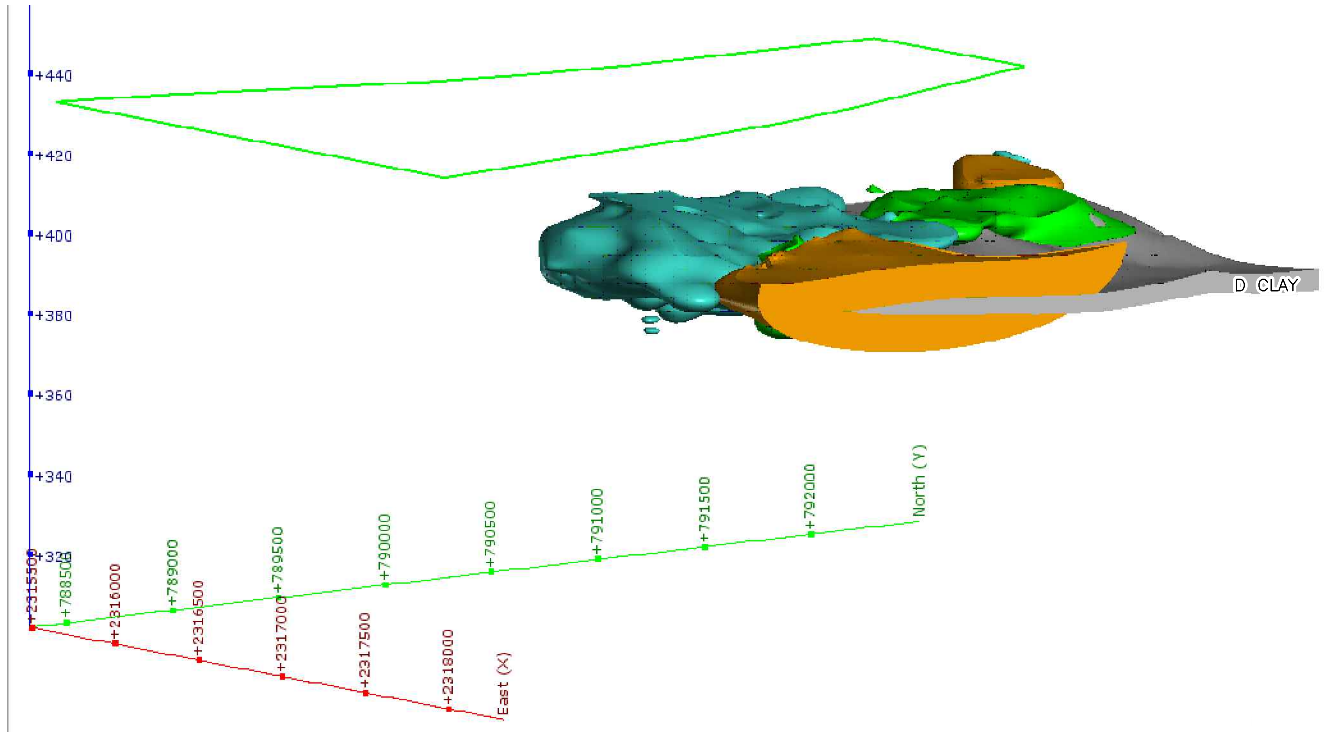
Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24S_RANDFLS201405

OVERVIEW MAPS





A 3D VIEW OF EPA AND MAIN SAND STRATA
VIEW TO NORTHEAST



B 3D VIEW OF EPA AND MAIN SAND STRATA
VIEW TO NORTHWEST

EXPLANATION

🟦	LIGHT–RANGE LNAPL
🟩	MID–RANGE LNAPL
🟧	HEAVY–RANGE LNAPL

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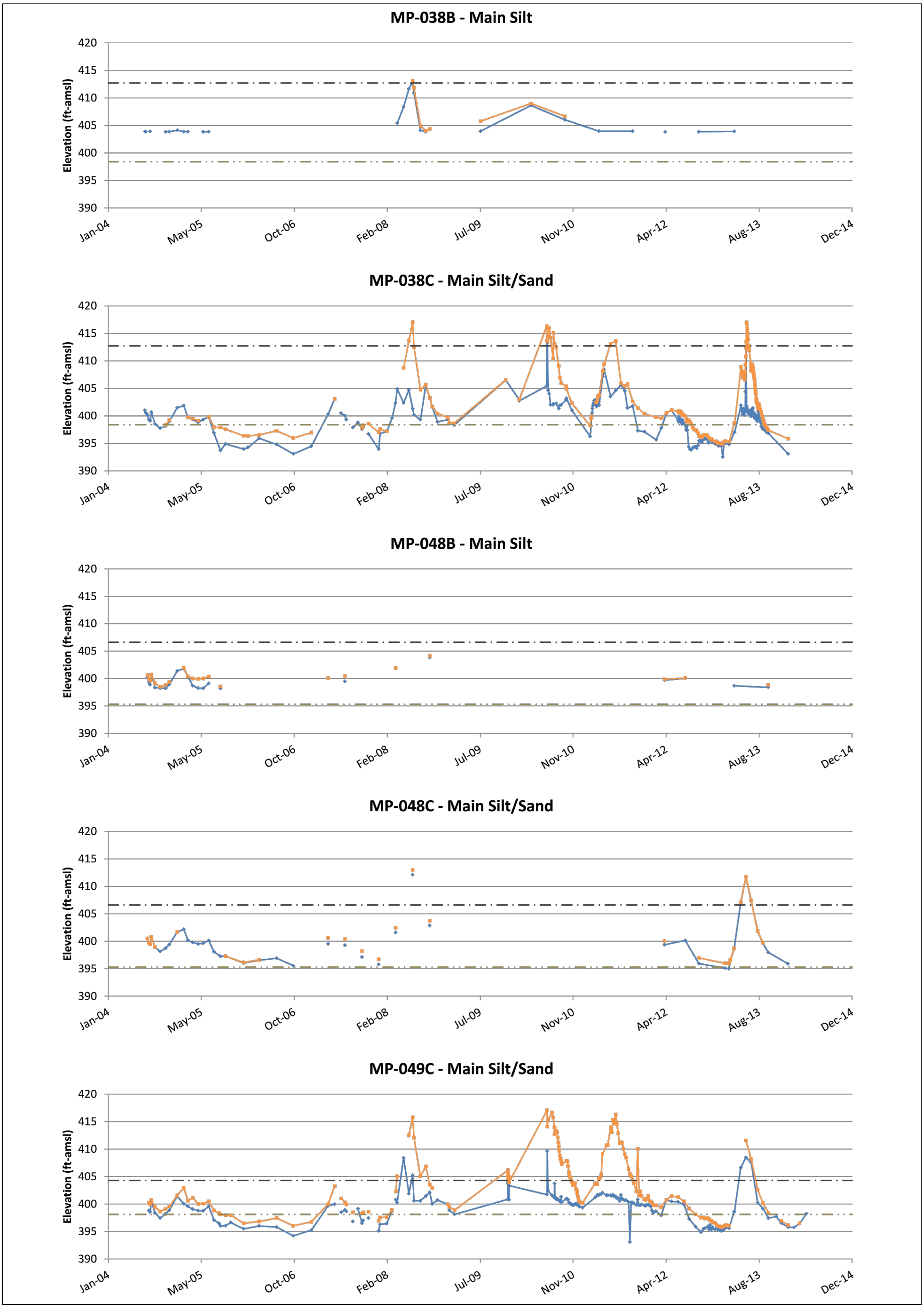
FIGURE 18

LNAPL DISTRIBUTION IN THE EPA AND MAIN SAND STRATA

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: BM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_LCSM_3D_



EXPLANATION

Groundwater Elevation

LNAPL Elevation

Top of Main Silt

Bottom of Main Silt

NOTE:

LOCATIONS WERE SELECTED BASED ON AVAILABILITY OF FLUID LEVEL DATA AND FREQUENCY OF GROUNDWATER AND LNAPL OCCURRENCE.

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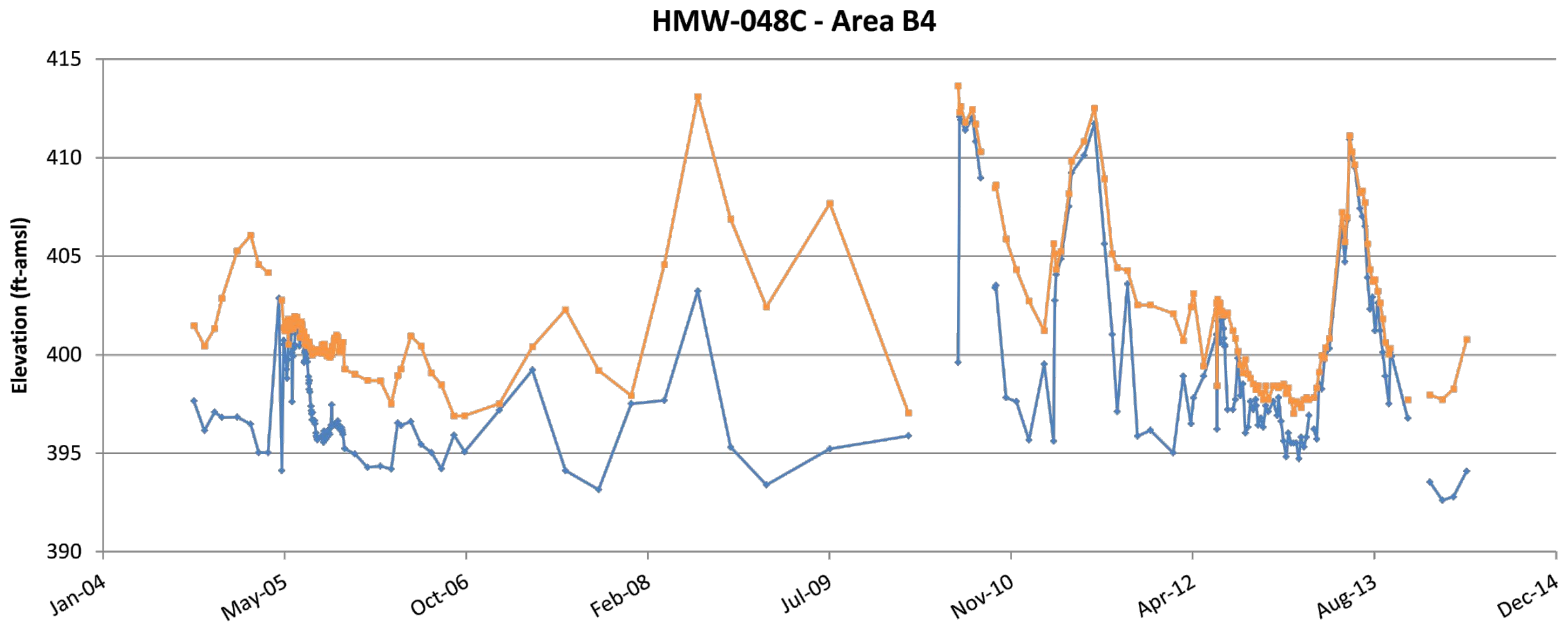
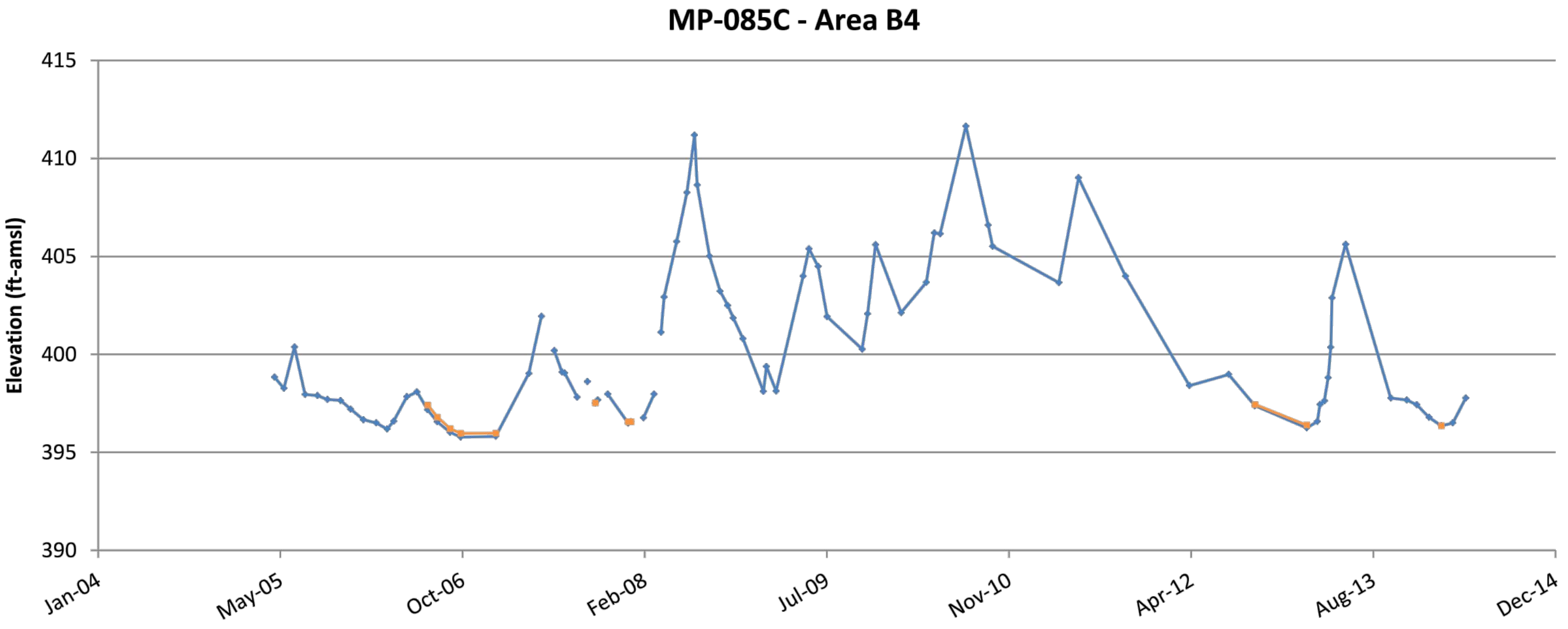
FIGURE 19

FLUID LEVEL ELEVATIONS WITHIN SELECT WELLS SCREENED WITHIN OR ACROSS THE MAIN SILT STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP | Checked By: PM | Scale: AS SHOWN | Date: 5/22/14 | File: 24S_MSILTFLSB_201405





EXPLANATION

──	Groundwater Elevation
──	LNAPL Elevation

NOTE:
LOCATIONS WERE SELECTED BASED ON AVAILABILITY OF FLUID LEVEL DATA AND FREQUENCY OF GROUNDWATER AND LNAPL OCCURRENCE.

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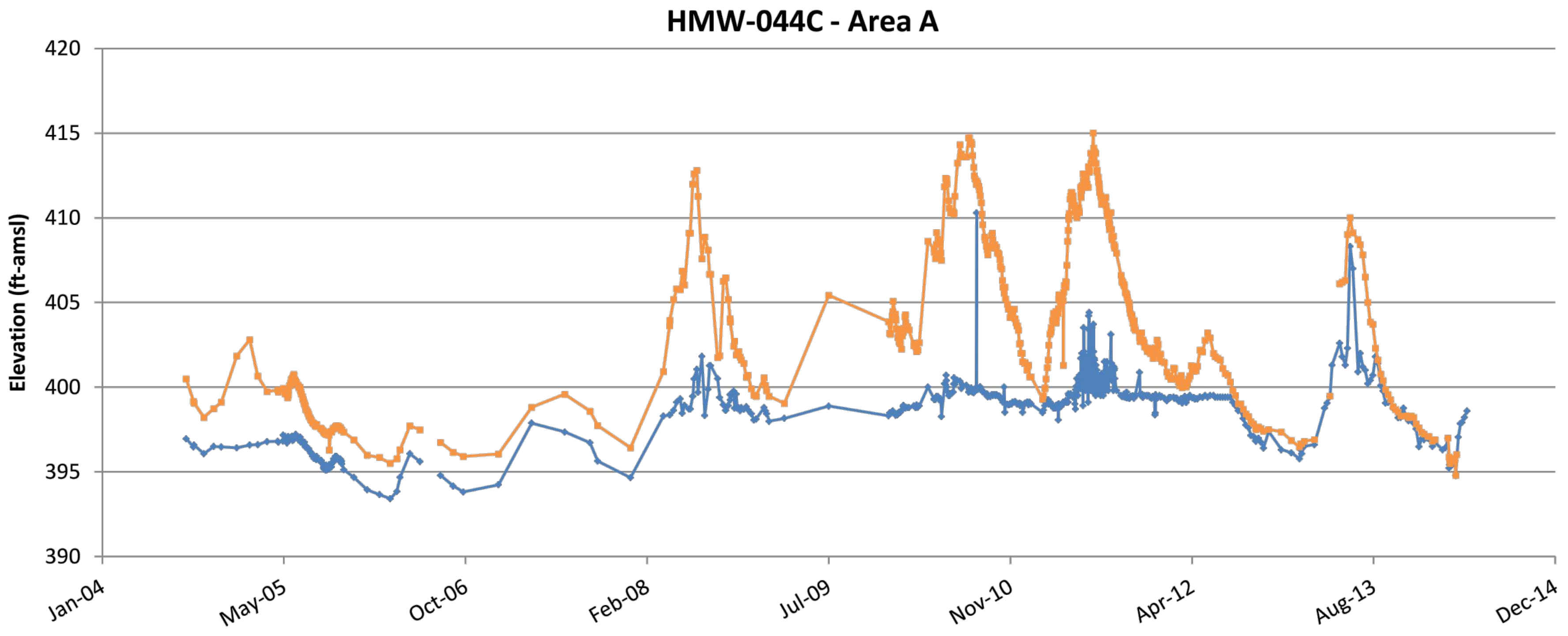
FIGURE 20

FLUID LEVEL ELEVATIONS WITHIN SELECT WELLS SCREENED IN THE EPA STRATUM

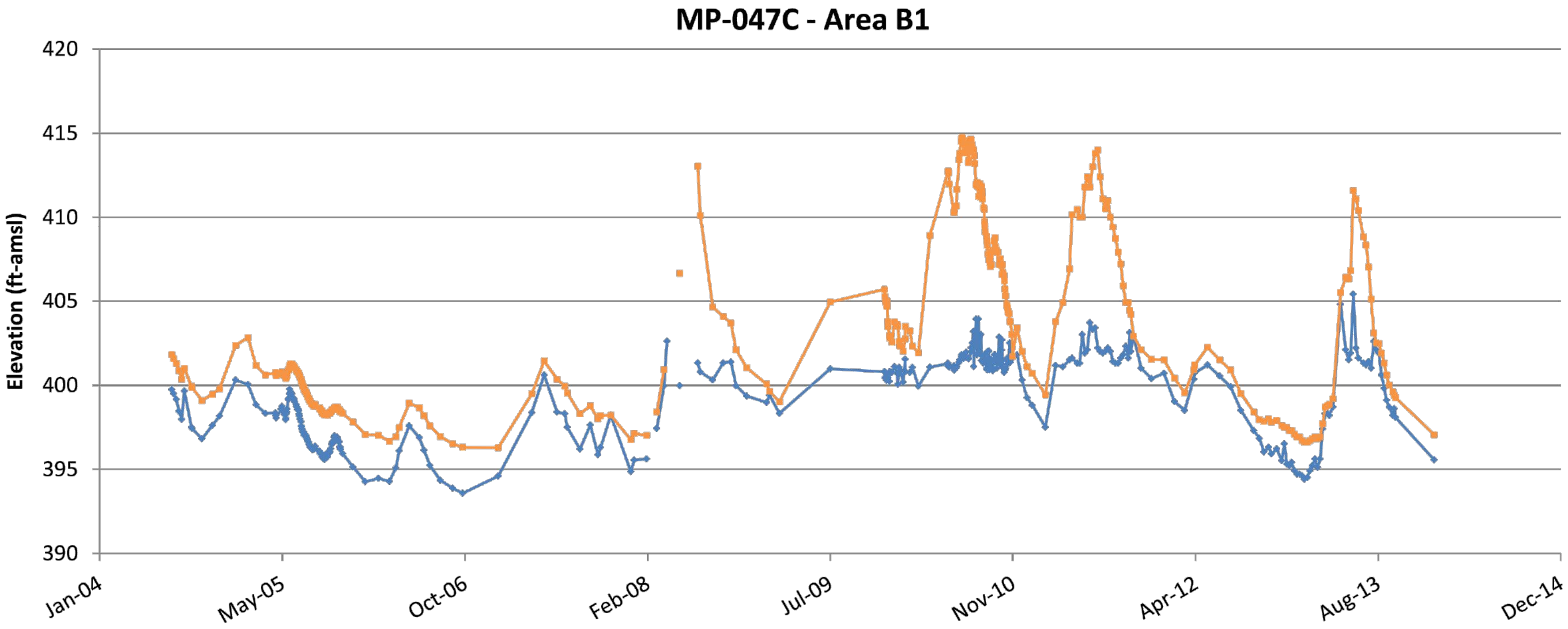
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24S_EPA_FLS201405

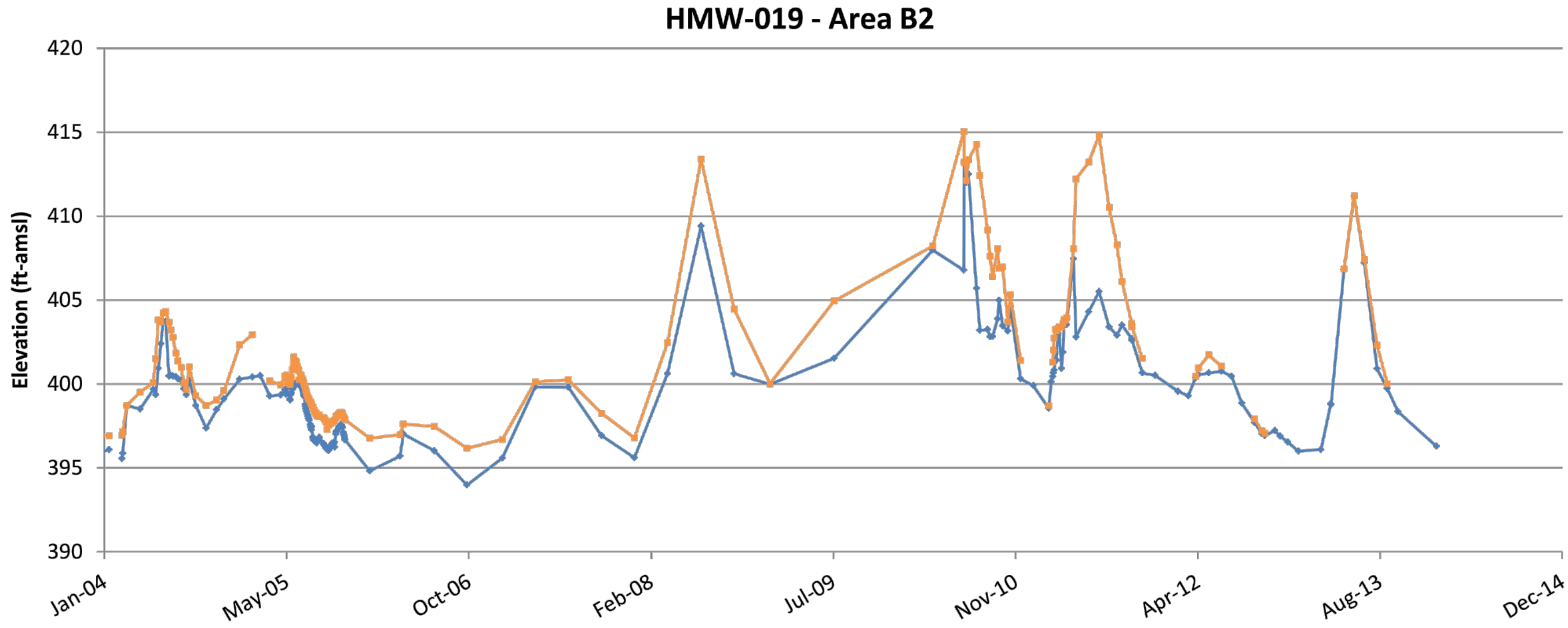
HMW-044C - Area A



MP-047C - Area B1



HMW-019 - Area B2



EXPLANATION

Groundwater Elevation

LNAPL Elevation

NOTE:

LOCATIONS WERE SELECTED BASED ON AVAILABILITY OF FLUID LEVEL DATA, FREQUENCY OF GROUNDWATER AND LNAPL OCCURRENCE, AND SPATIAL DISTRIBUTION ACROSS THE SITE.

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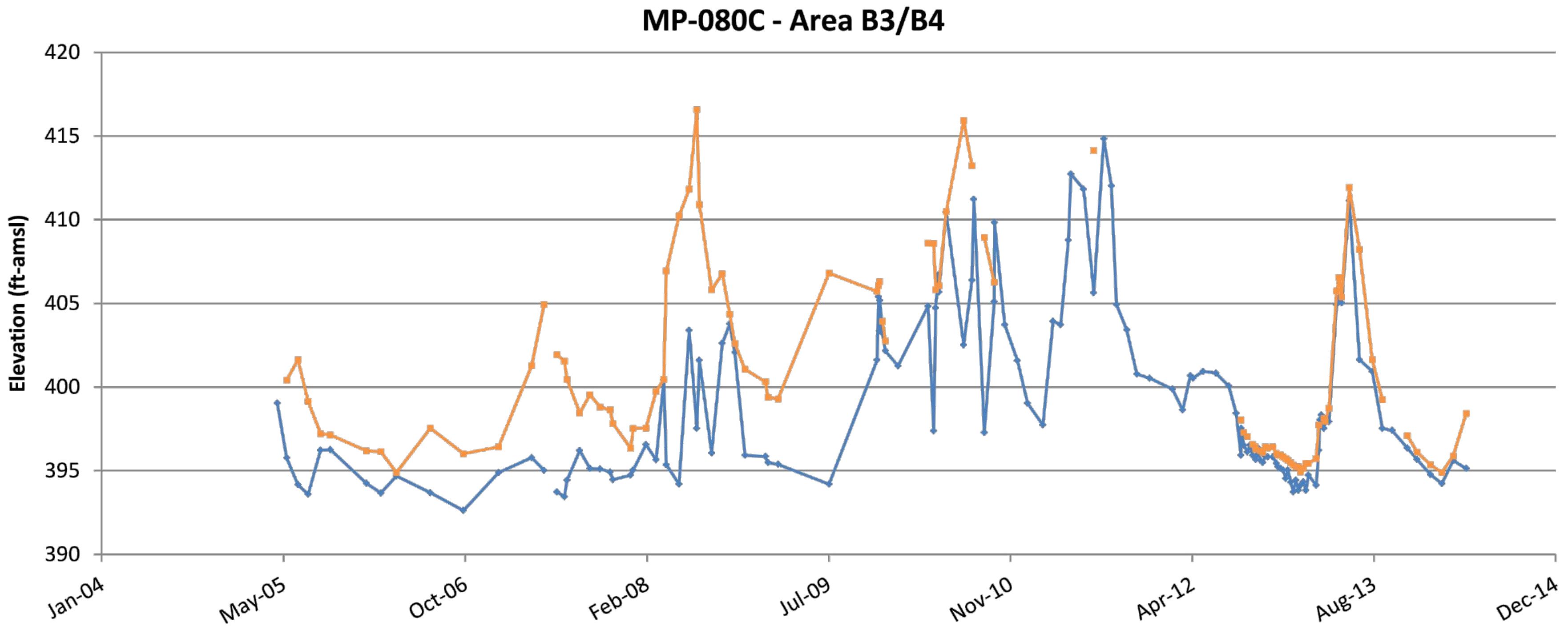
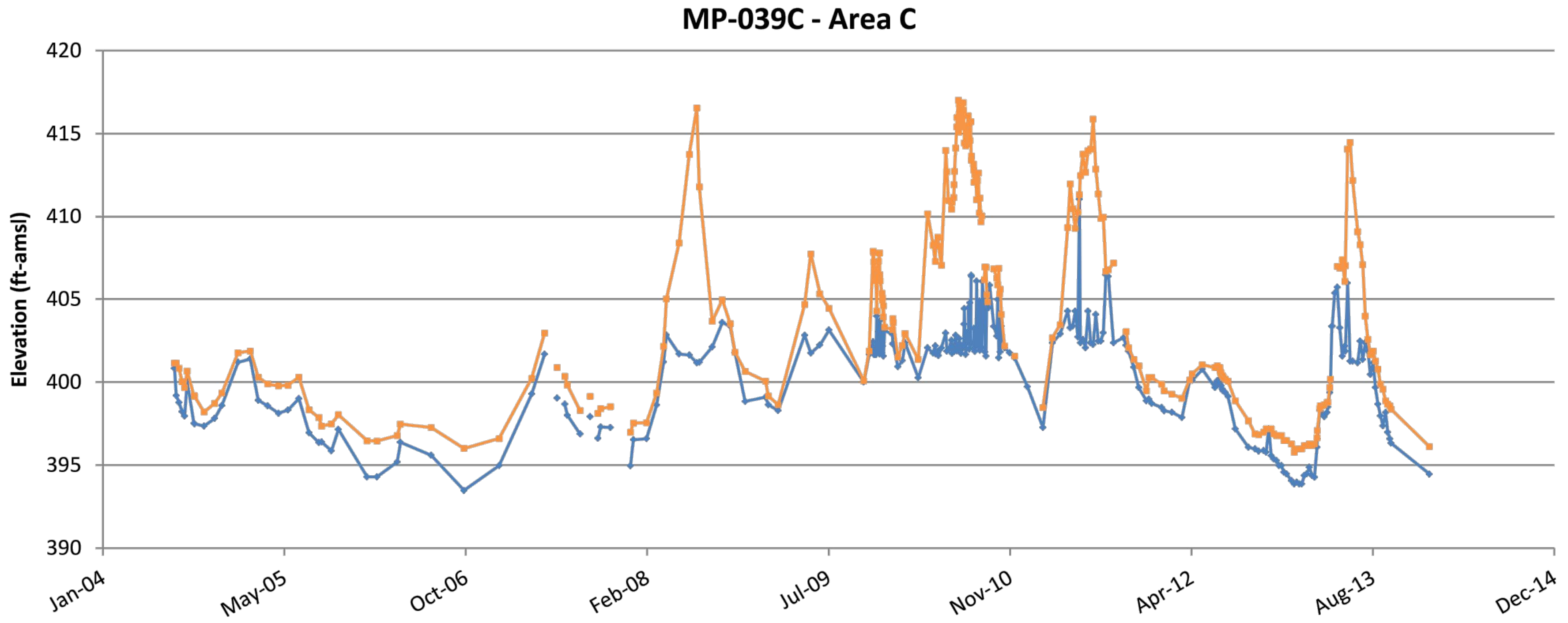
FIGURE 21A

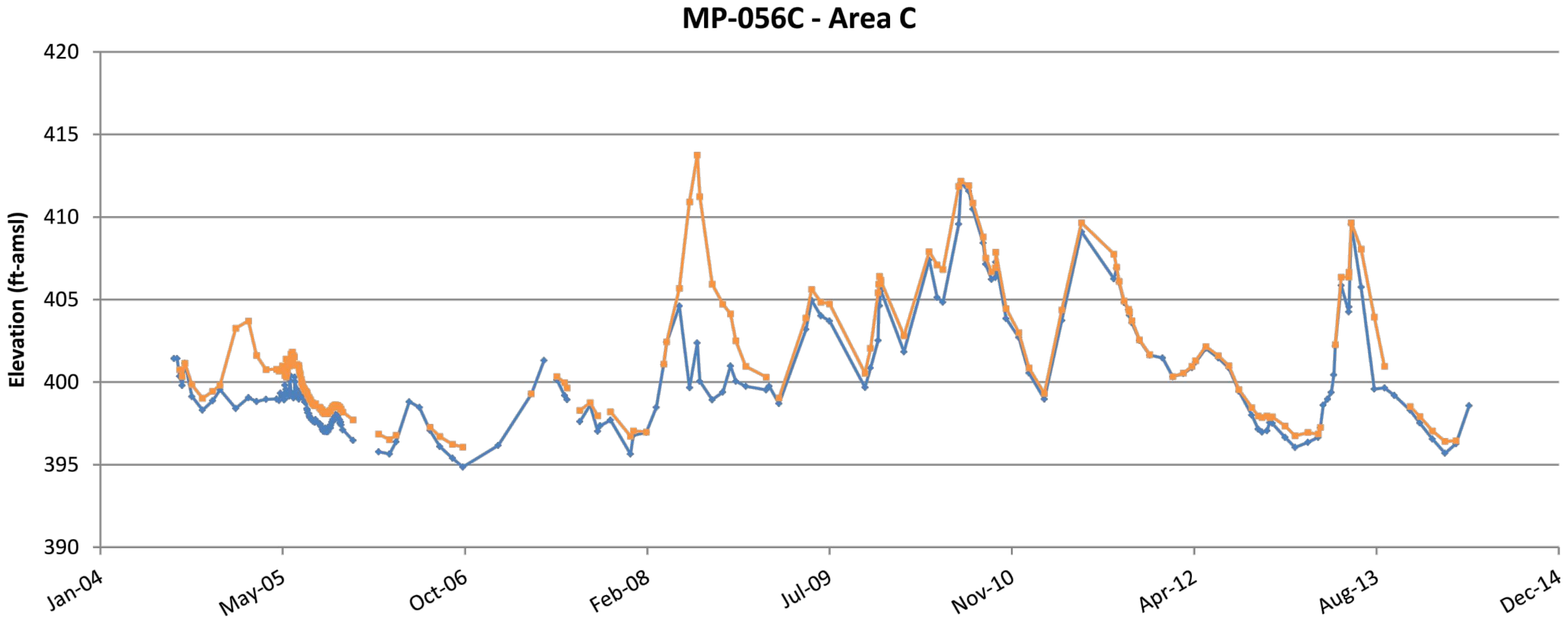
FLUID LEVEL ELEVATIONS WITHIN SELECT WELLS SCREENED IN THE MAIN SAND STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24S_MAINFLSA_201405







EXPLANATION

— Groundwater Elevation

— LNAPL Elevation

NOTE:

LOCATIONS WERE SELECTED BASED ON AVAILABILITY OF FLUID LEVEL DATA, FREQUENCY OF GROUNDWATER AND LNAPL OCCURRENCE, AND SPATIAL DISTRIBUTION ACROSS THE SITE.

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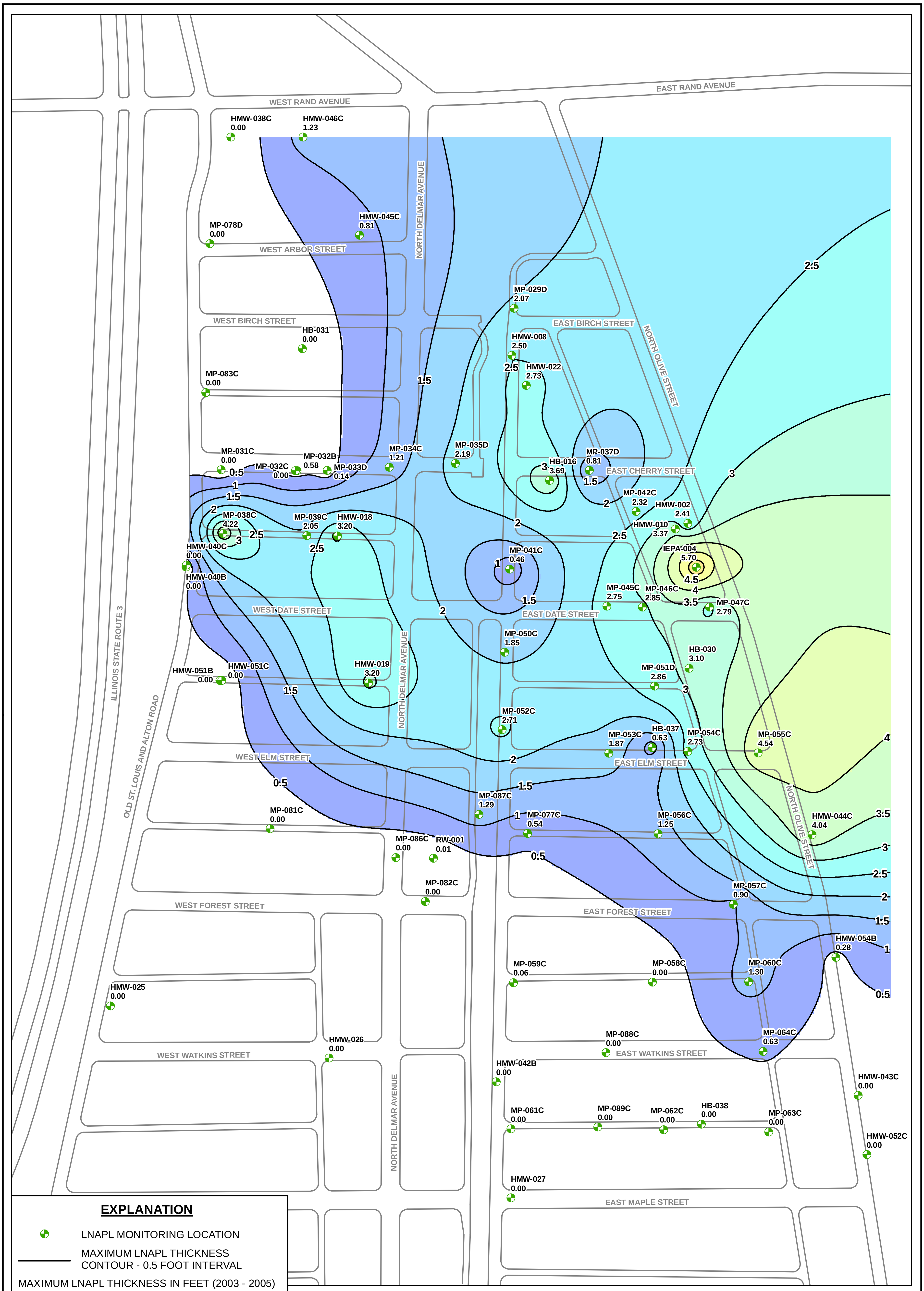
FIGURE 21B

FLUID LEVEL ELEVATIONS WITHIN SELECT WELLS SCREENED IN THE MAIN SAND STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24S_MAINFLSB_201405



EXPLANATION

● LNAPL MONITORING LOCATION

—— MAXIMUM LNAPL THICKNESS CONTOUR - 0.5 FOOT INTERVAL

MAXIMUM LNAPL THICKNESS IN FEET (2003 - 2005)

0 - 0.5, 0.5 - 1, 1 - 1.5, 1.5 - 2, 2 - 2.5, 2.5 - 3, 3 - 3.5, 3.5 - 4, 4 - 4.5, 4.5 - 5, 5 - 5.5, 5.5 - 6, 6 - 6.5, 6.5 - 7, 7 - 7.5

NOTE: Only data where the groundwater elevation was within the vertical extent of the well screen was used. The maximum thickness at each location over the time period shown was used for contour generation.

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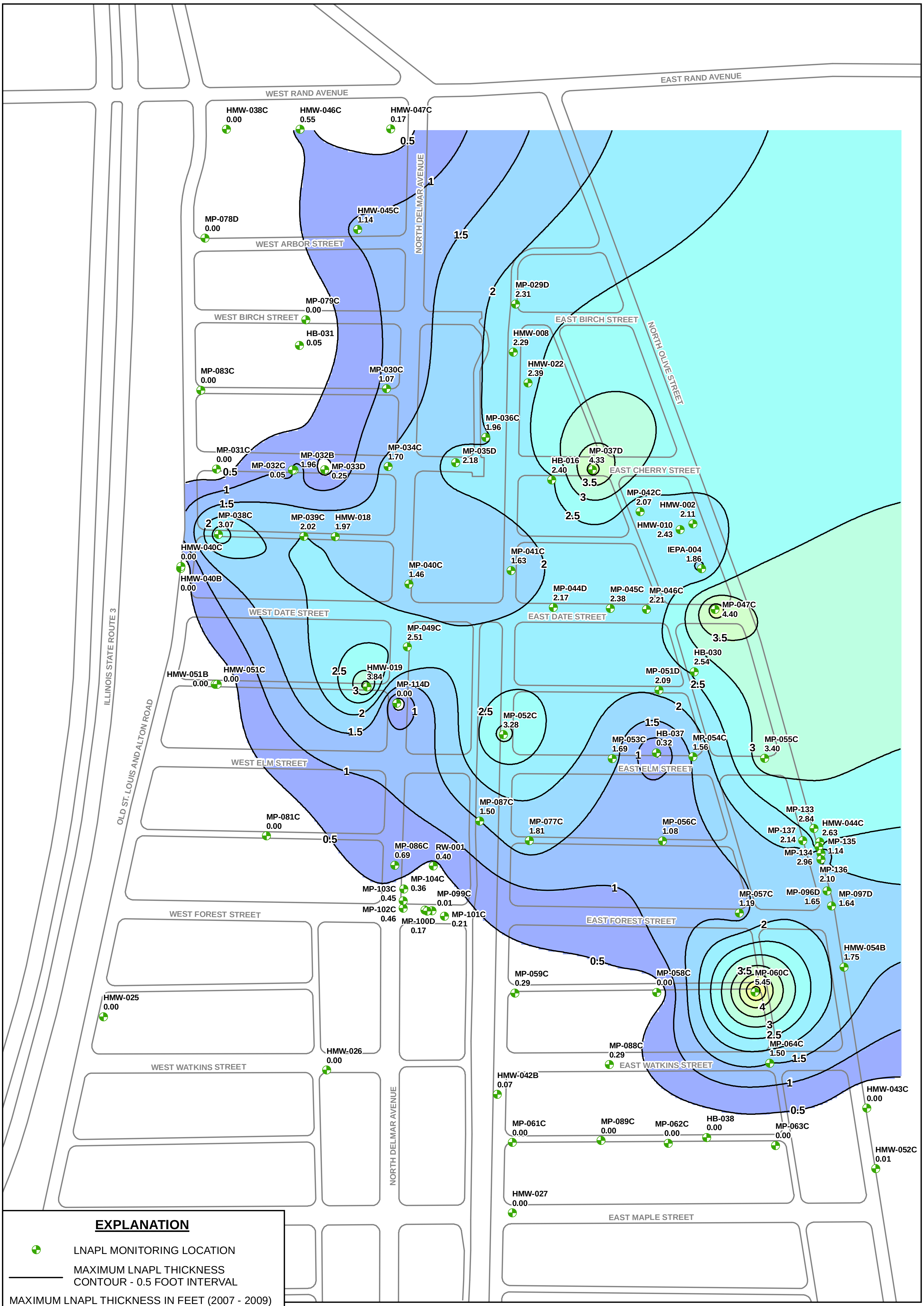
FIGURE 22

MAXIMUM LNAPL THICKNESS IN MAIN SAND 2003 - 2005

HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 200'	Date: 5/22/14	File: Fig22_AOC_LNAPL_2003_2005.mxd



EXPLANATION

●	LNAPL MONITORING LOCATION
——	MAXIMUM LNAPL THICKNESS CONTOUR - 0.5 FOOT INTERVAL

MAXIMUM LNAPL THICKNESS IN FEET (2007 - 2009)

0 - 0.5	0.5 - 1	1 - 1.5	1.5 - 2	2 - 2.5	2.5 - 3	3 - 3.5	3.5 - 4	4 - 4.5	4.5 - 5	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	7 - 7.5

NOTE: Only data where the groundwater elevation was within the vertical extent of the well screen was used. The maximum thickness at each location over the time period shown was used for contour generation.

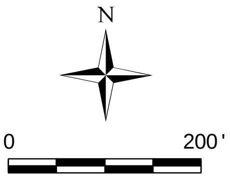


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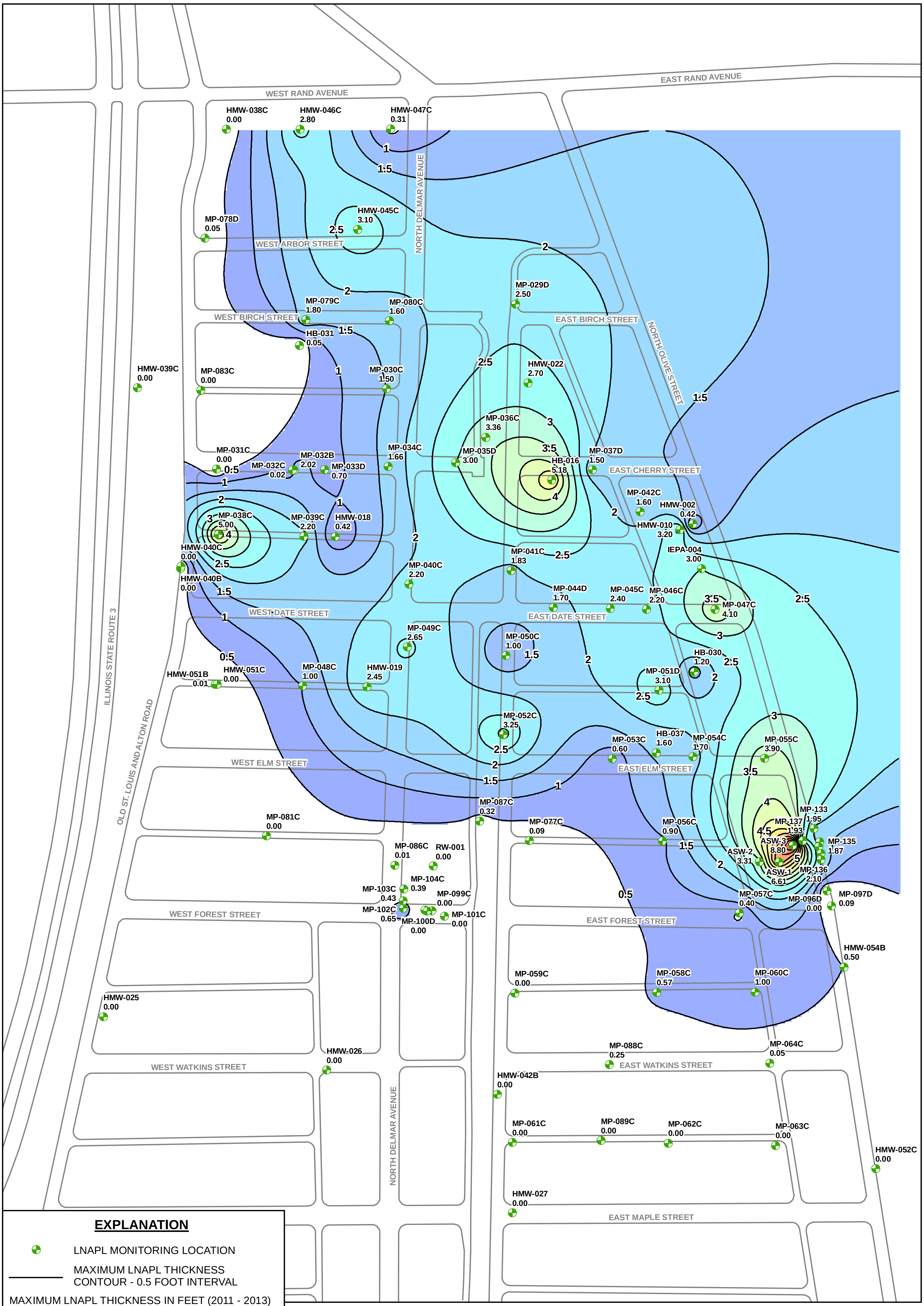
FIGURE 23

MAXIMUM LNAPL THICKNESS IN MAIN SAND 2007 - 2009

HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 200'	Date: 5/12/14	File: Fig22_AOC_LNAPL_2007_2009.mxd



EXPLANATION

● LNAPL MONITORING LOCATION

——— MAXIMUM LNAPL THICKNESS CONTOUR - 0.5 FOOT INTERVAL

MAXIMUM LNAPL THICKNESS IN FEET (2011 - 2013)

⬜	🟦	🟦	🟦	🟦	🟦	🟩	🟩	🟩	🟨	🟨	🟧	🟧	🟥	🟥
0 - 0.5	0.5 - 1	1 - 1.5	1.5 - 2	2 - 2.5	2.5 - 3	3 - 3.5	3.5 - 4	4 - 4.5	4.5 - 5	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	7 - 7.5

NOTE: Only data where the groundwater elevation was within the vertical extent of the well screen was used. The maximum thickness at each location over the time period shown was used for contour generation.

N

0 200 '

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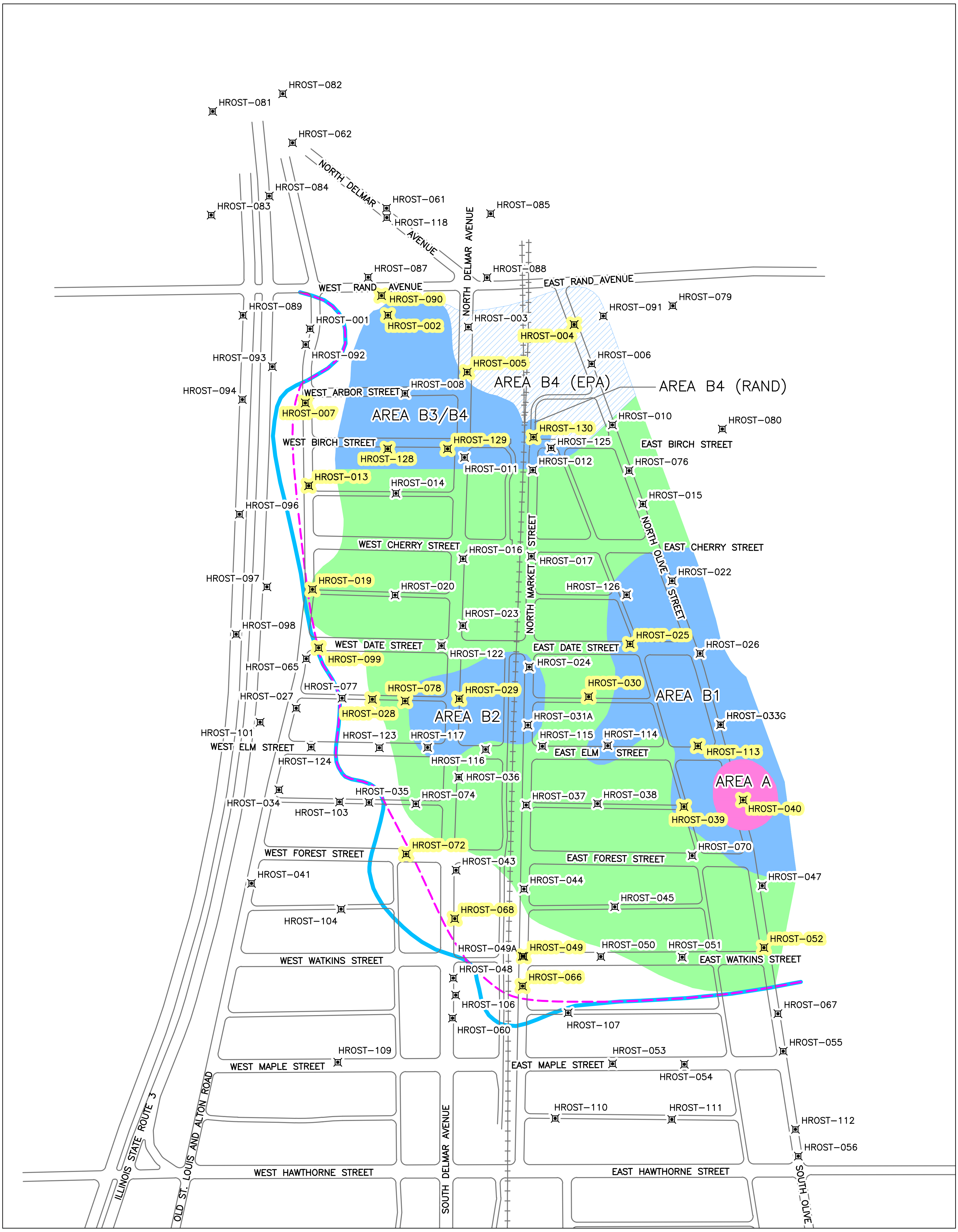
FIGURE 24

MAXIMUM LNAPL THICKNESS IN MAIN SAND
2011 - 2013

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 200'	Date: 5/12/14	File: Fig23_AOC_LNAPL_2011_2013.mxd



EXPLANATION

⊠ HROST−109 2004 AND 2005 LIF BORING AND DESIGNATION

⊠ HROST−066 2013 LIF BORING AND DESIGNATION

- - - INTERPRETED EXTENT OF LIF RESPONSE (ALL STRATA)

━ INTERPRETED EXTENT OF DISSOLVED PHASE BENZENE (2012, MAIN SAND)

🟪 AREA A

🟦 AREAS B1, B2, B3, AND B4

🟩 AREA C

┼┼┼┼ RAILROAD

── EDGE OF ROADWAY

N

0 300'

NOTE:

INTERPRETED EXTENT OF LIF RESPONSE AND AREA BOUNDARIES FROM APPENDIX A OF "ACTIVE LNAPL RECOVERY SYSTEM 90% DESIGN REPORT", CLAYTON GROUP SERVICES, INC., JULY 31, 2006, AND UPDATED USING 2013 LIF RESULTS.

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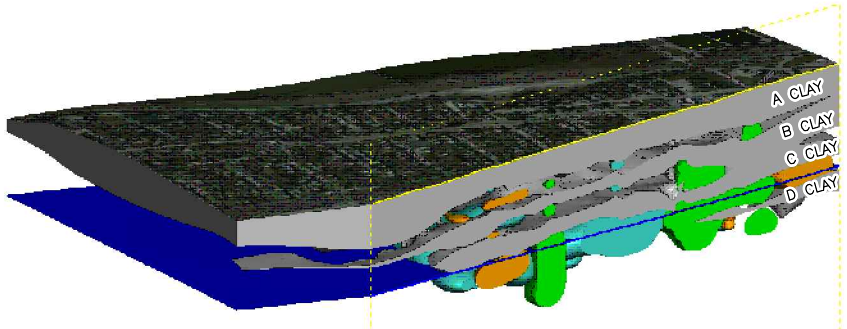
FIGURE 25

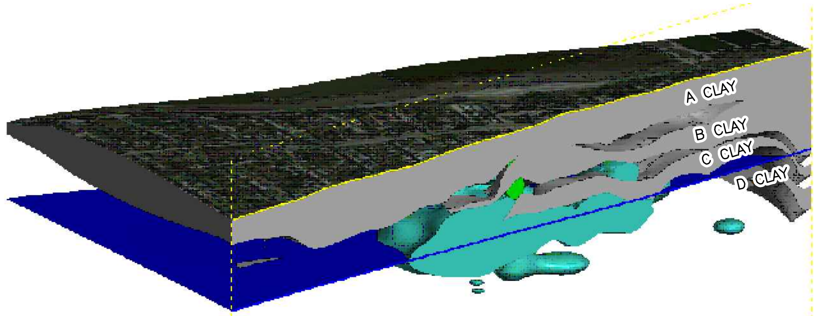
LASER INDUCED FLUORESCENCE BORING LOCATIONS

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

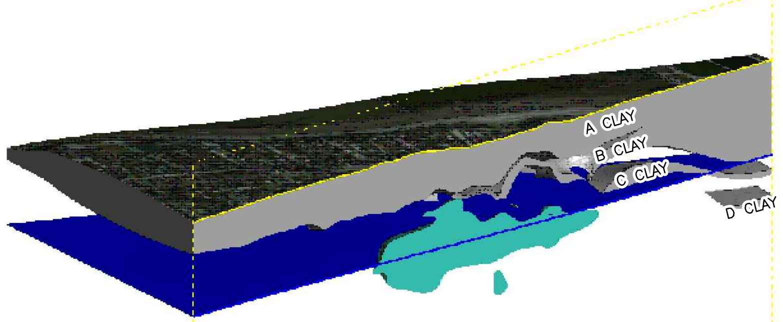
Drawn By: REP	Checked By: BM	Scale: 1" = 300'	Date: 5/22/14	File: 24S_BORLOCS201402



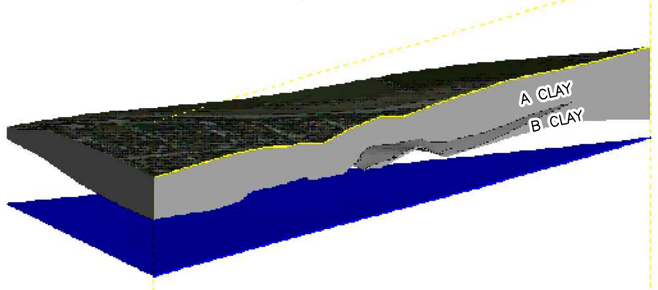
A OBLIQUE CUT 1
VIEW TO NORTHWEST



B OBLIQUE CUT 2
VIEW TO NORTHWEST

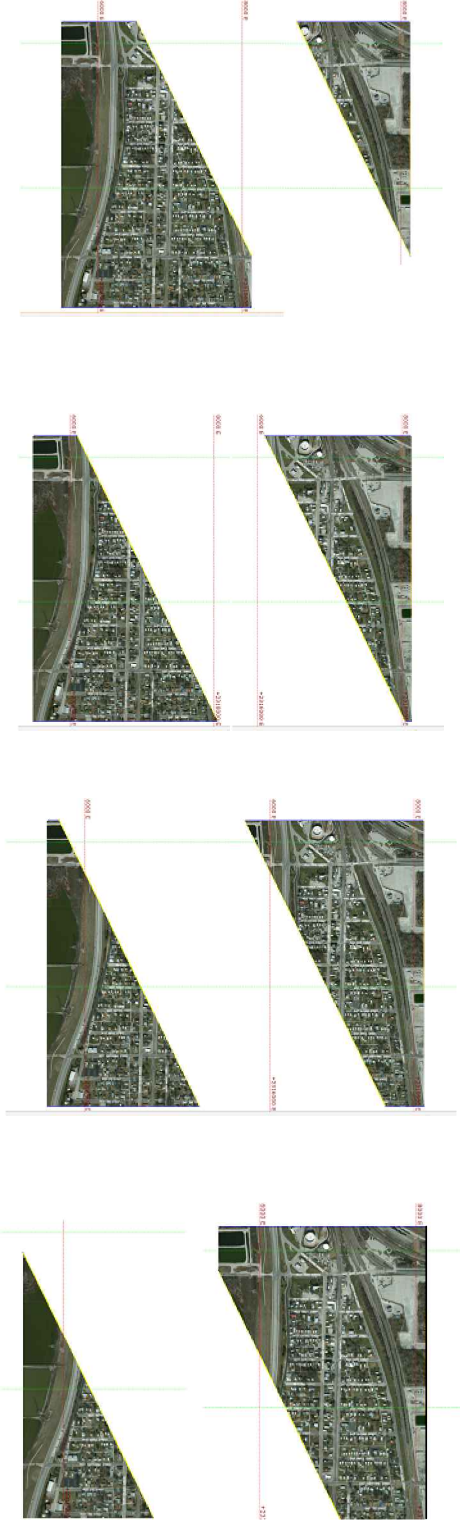


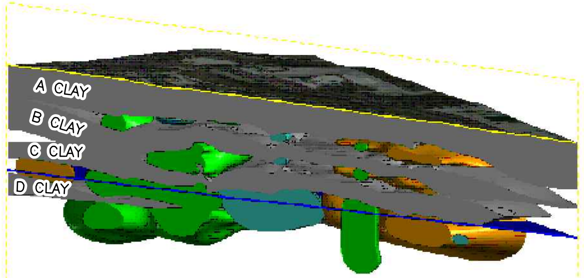
C OBLIQUE CUT 3
VIEW TO NORTHWEST



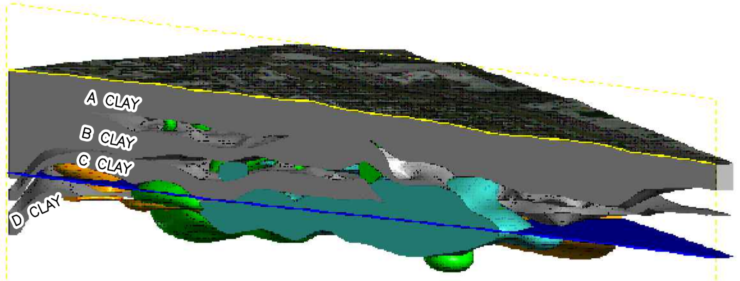
D OBLIQUE CUT 4
VIEW TO NORTHWEST

CUT ORIENTATION

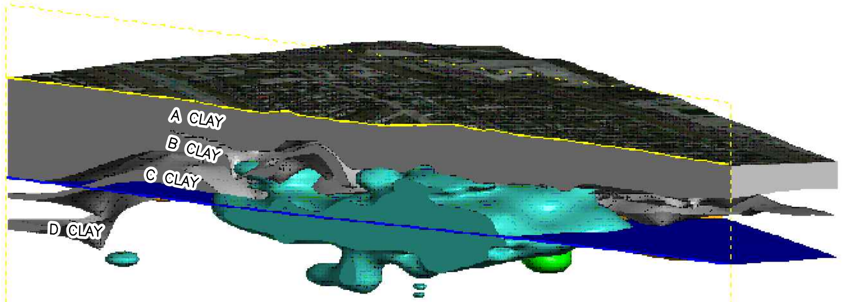




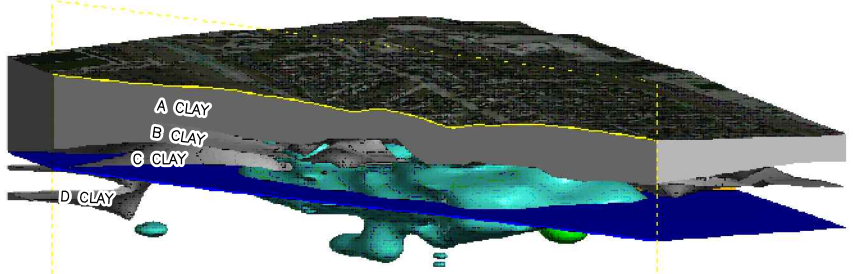
E OBLIQUE CUT 1
VIEW TO NORTHEAST



F OBLIQUE CUT 2
VIEW TO NORTHEAST



G OBLIQUE CUT 3
VIEW TO NORTHEAST



H OBLIQUE CUT 4
VIEW TO NORTHEAST

EXPLANATION

☐	POTENTIOMETRIC SURFACE ELEVATION (JANUARY 2004)
🟦	LIGHT–RANGE LNAPL
🟩	MID–RANGE LNAPL
🟧	HEAVY–RANGE LNAPL

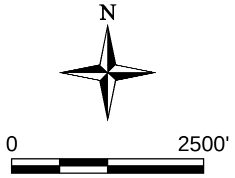


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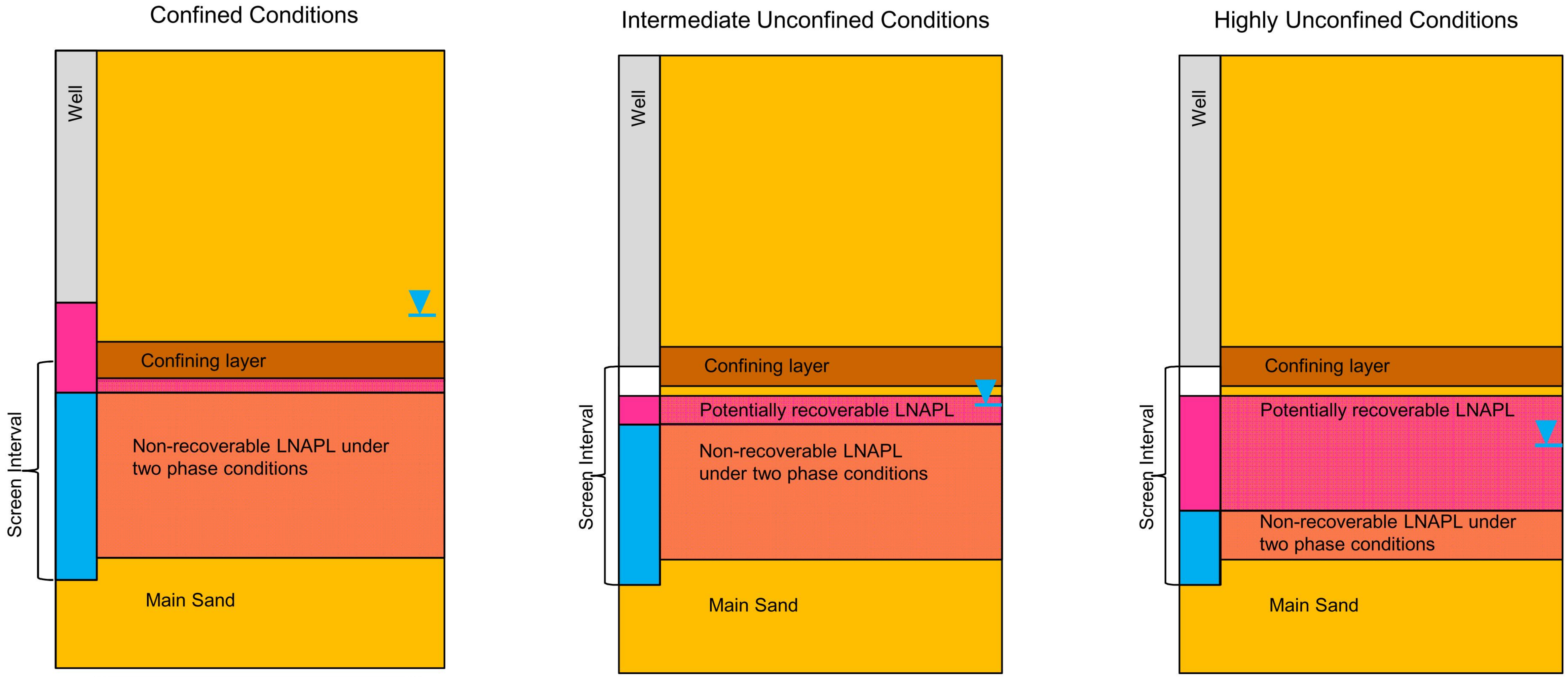
FIGURE 26

LNAPL DISTRIBUTION WITHIN THE HYDROSTRATIGRAPHIC UNITS

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP | Checked By: BM | Scale: AS SHOWN | Date: 5/21/14 | File: 24S_LCSM_3D_



Piezometric surface above the confining clay stratum. LNAPL is confined with an exaggerated thickness in the well. LNAPL can be recovered from thin interval at the top of the smear zone.

Piezometric surface slightly below clay stratum. LNAPL is unconfined and recoverable from interval at the top of the smear zone in the Main Sand Unit.

Water table far below clay stratum. LNAPL is unconfined and recoverable across large vertical interval of smear zone in the Main Sand Unit.

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FIGURE 27

SCHEMATIC DIAGRAM OF DUAL OPTIMAL LNAPL RESPONSE MODEL

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: REP	Checked By: BM	Scale: NONE	Date: 2/14/14	File: 24S_DOLRMODEL2014

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

EXPLANATION

⊗ HISTORICAL LNAPL CORE SAMPLE LOCATION

N

0 200 '

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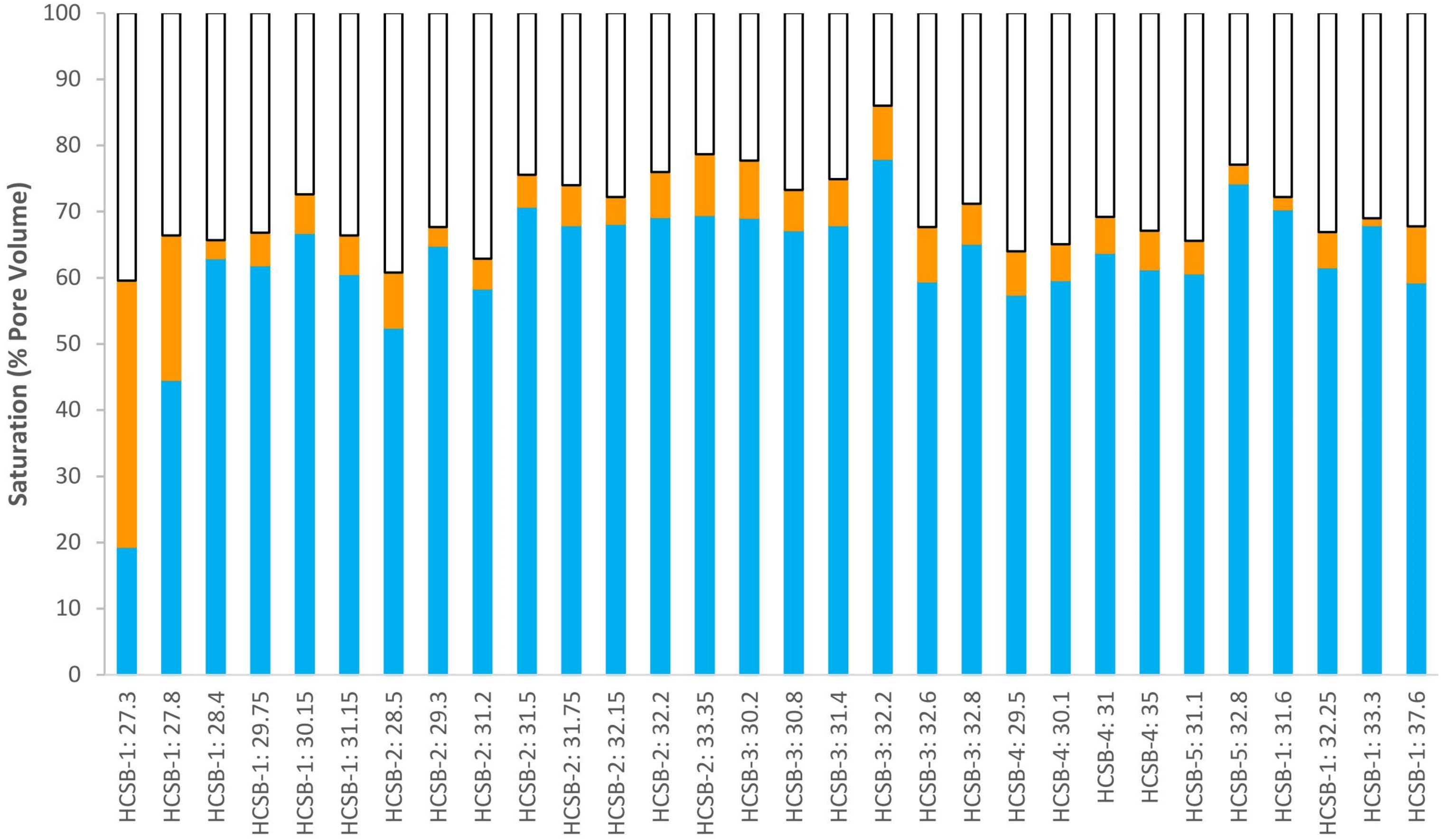
FIGURE 28

HISTORICAL LNAPL CORE SAMPLE LOCATIONS

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: BR	Checked By: TA	Scale: 1" = 200'	Date: 5/13/14	File: Fig28_AOC_HCSB_Locs.mxd



EXPLANATION

☐ Sa = AIR SATURATION, BASED ON 100% - Sn - Sw

🟧 Sn = LNAPL SATURATION, BASED ON LAB ANALYSIS

🟦 Sw = WATER SATURATION, BASED ON LAB ANALYSIS

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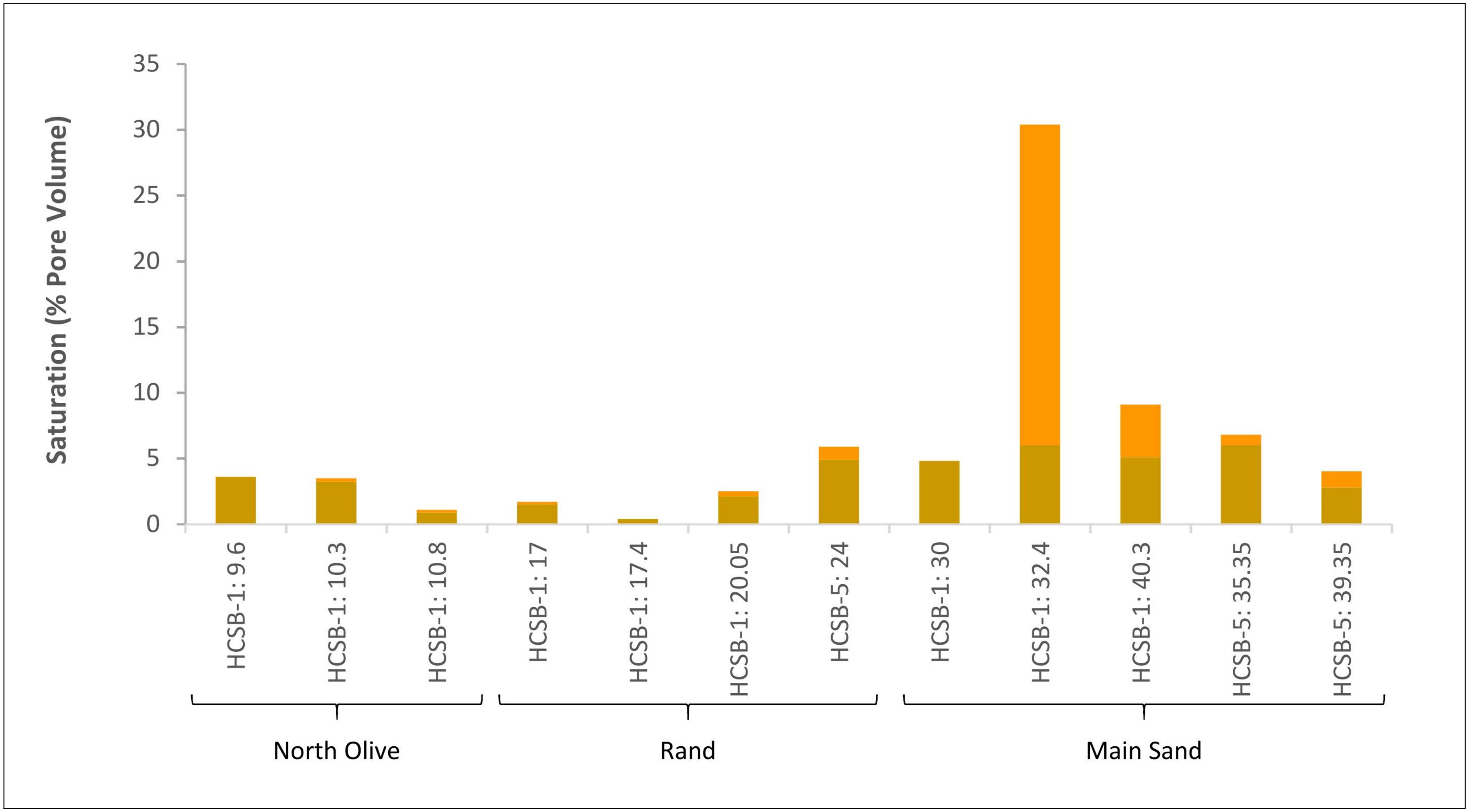
FIGURE 29

FLUID SATURATIONS FOR SOIL CORES BELOW WATER TABLE IN MAIN SAND

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP | Checked By: PM | Scale: NO SCALE | Date: 5/22/14 | File: 24S_FLUIDSAT_201405



EXPLANATION

🟧 Sn MOBILE - LNAPL SATURATION ABOVE RESIDUAL

🟨 Snr - RESIDUAL LNAPL SATURATION

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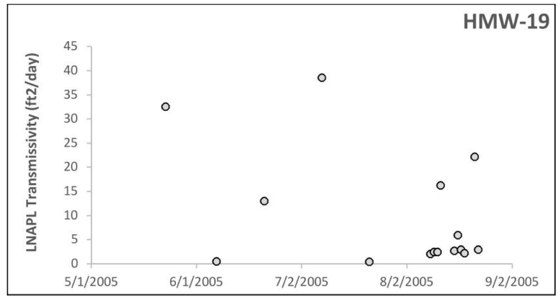
FIGURE 30

MOBILE AND RESIDUAL LNAPL SATURATIONS BASED ON LAB CENTRIFUGE

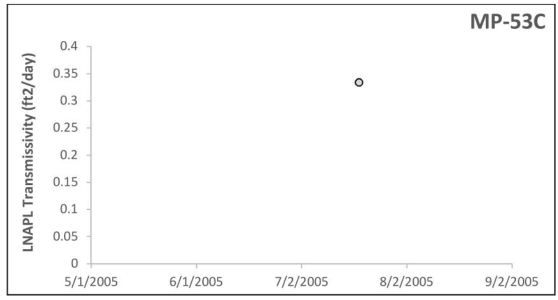
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: NO SCALE	Date: 5/22/14	File: 24S_MOBRESIDSAT_201405



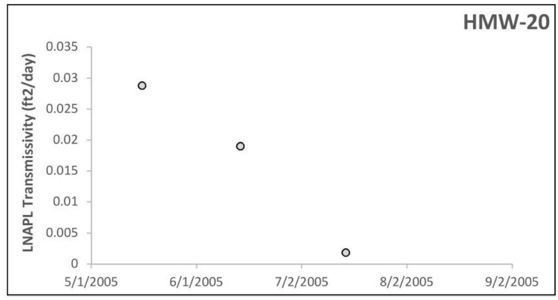
HMW-19 LNAPL Transmissivity Summary

Low Tn value (ft2/day)	3.2E-01
High Tn value (ft2/day)	3.9E+01
Low piezometric surface (ft msl)	397.69
High piezometric surface (ft msl)	400.96
Hydraulic conditions reported by HWG	Confined and unconfined
Range of Tn variation (approximate)	2 orders of magnitude
Range of piezometric surface variation (ft)	3.27



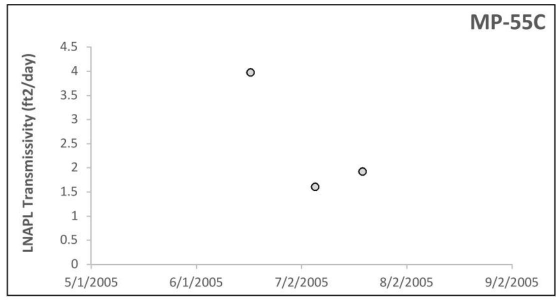
HMW-53C LNAPL Transmissivity Summary

Low Tn value (ft2/day)	NA - only one value
High Tn value (ft2/day)	
Low piezometric surface (ft msl)	
High piezometric surface (ft msl)	
Hydraulic conditions reported by HWG	Confined and unconfined
Range of Tn variation (approximate)	
Range of piezometric surface variation (ft)	



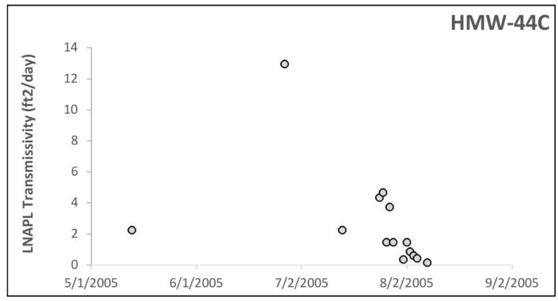
HMW-20 LNAPL Transmissivity Summary

Low Tn value (ft2/day)	1.8E-03
High Tn value (ft2/day)	2.9E-02
Low piezometric surface (ft msl)	399.91
High piezometric surface (ft msl)	400.61
Hydraulic conditions reported by HWG	Confined and above confined
Range of Tn variation (approximate)	1 order of magnitude
Range of piezometric surface variation (ft)	0.70



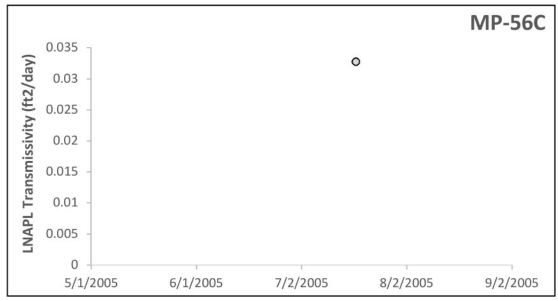
HMW-55C LNAPL Transmissivity Summary

Low Tn value (ft2/day)	1.6E+00
High Tn value (ft2/day)	4.0E+00
Low piezometric surface (ft msl)	399.83
High piezometric surface (ft msl)	400.89
Hydraulic conditions reported by HWG	Confined and unconfined
Range of Tn variation (approximate)	Factor of 2
Range of piezometric surface variation (ft)	1.07



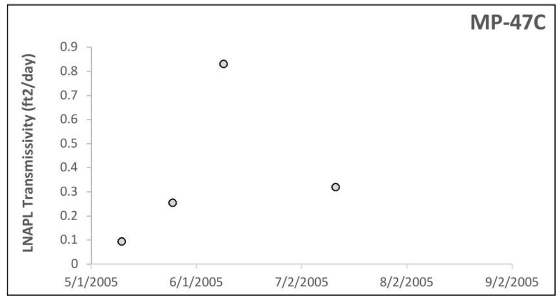
HMW-44C LNAPL Transmissivity Summary

Low Tn value (ft2/day)	1.3E-01
High Tn value (ft2/day)	1.3E+01
Low piezometric surface (ft msl)	397.73
High piezometric surface (ft msl)	399.64
Hydraulic conditions reported by HWG	Confined
Range of Tn variation (approximate)	2 orders of magnitude
Range of piezometric surface variation (ft)	1.91



HMW-56C LNAPL Transmissivity Summary

Low Tn value (ft2/day)	NA - only one value
High Tn value (ft2/day)	
Low piezometric surface (ft msl)	
High piezometric surface (ft msl)	
Hydraulic conditions reported by HWG	Confined and unconfined
Range of Tn variation (approximate)	
Range of piezometric surface variation (ft)	

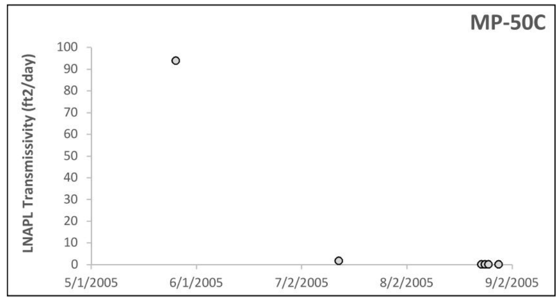


HMW-47C LNAPL Transmissivity Summary

Low Tn value (ft2/day)	9.3E-02
High Tn value (ft2/day)	8.3E-01
Low piezometric surface (ft msl)	400.03
High piezometric surface (ft msl)	400.82
Hydraulic conditions reported by HWG	Unconfined and confined
Range of Tn variation (approximate)	1 order of magnitude
Range of piezometric surface variation (ft)	0.80

RW-4A LNAPL Transmissivity Summary

Low Tn value (ft2/day)	1.5E-01
High Tn value (ft2/day)	4.5E-01
Low piezometric surface (ft msl)	397.68
High piezometric surface (ft msl)	397.77
Hydraulic conditions reported by HWG	Not reported
Range of Tn variation (approximate)	Factor of 3
Range of piezometric surface variation (ft)	0.09



HMW-50C LNAPL Transmissivity Summary

Low Tn value (ft2/day)	5.1E-03
High Tn value (ft2/day)	9.4E+01
Low piezometric surface (ft msl)	397.58
High piezometric surface (ft msl)	399.89
Hydraulic conditions reported by HWG	Confined and unconfined
Range of Tn variation (approximate)	4 orders of magnitude
Range of piezometric surface variation (ft)	2.30

RW-5 LNAPL Transmissivity Summary

Low Tn value (ft2/day)	NA - only one value
High Tn value (ft2/day)	
Low piezometric surface (ft msl)	
High piezometric surface (ft msl)	
Hydraulic conditions reported by HWG	Not reported
Range of Tn variation (approximate)	
Range of piezometric surface variation (ft)	

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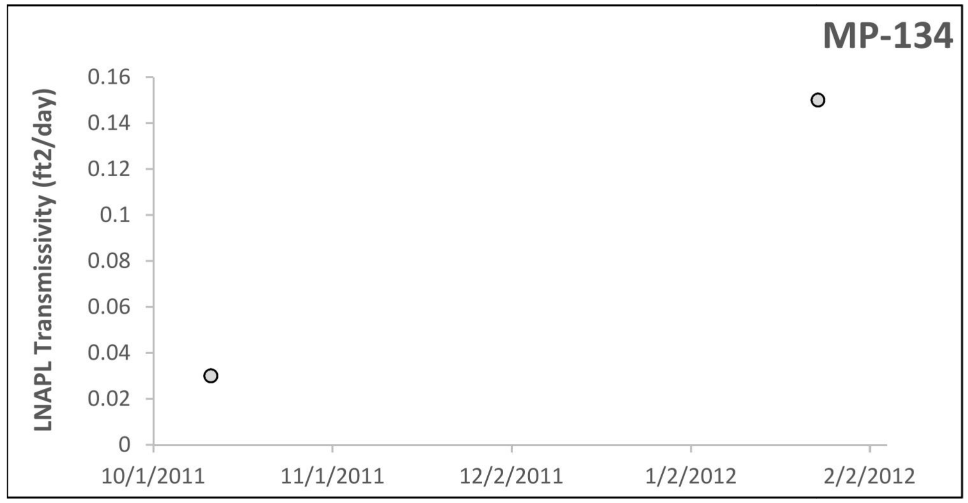
FIGURE 31

LNAPL TRANSMISSIVITY SUMMARY FOR 2005 HIGH VACUUM RECOVERY PILOT TESTS

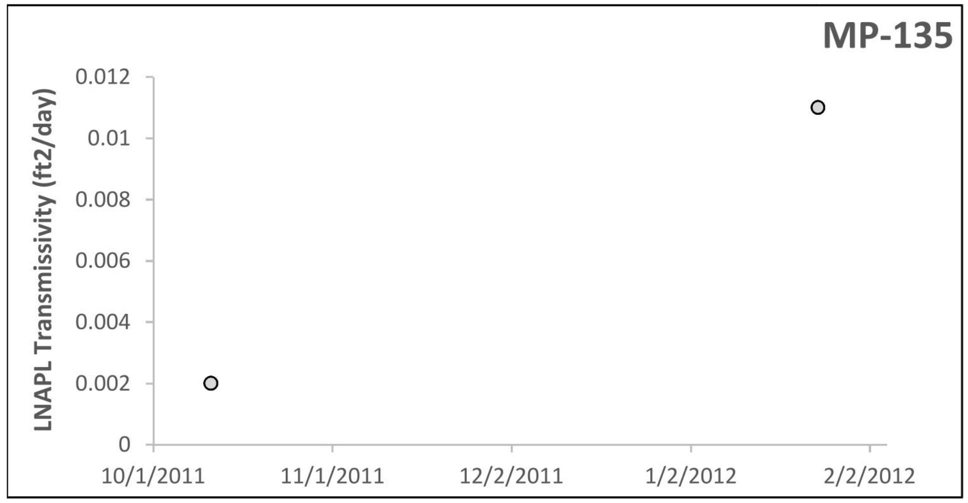
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: NO SCALE	Date: 5/22/14	File: 24S_TNSUMM2005_201405



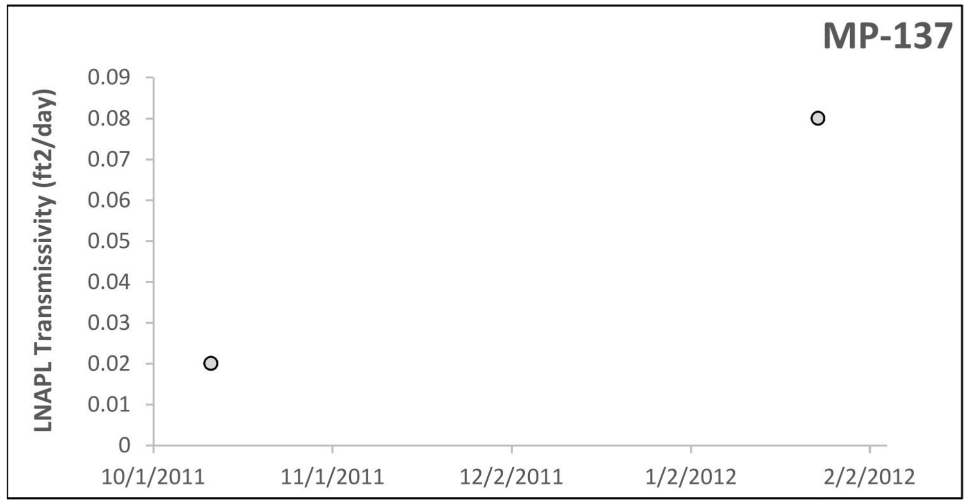
MP-134 LNAPL Transmissivity Summary

Low Tn value (ft2/day)	3.0E-02
High Tn value (ft2/day)	1.5E-01
Low piezometric surface (ft msl)	400.97
High piezometric surface (ft msl)	404.14
Hydraulic conditions reported by WSP	Confined (October 2011), Unconfined (January 2012)
Range of Tn variation (approximate)	Factor of 5
Range of piezometric surface variation (ft)	3.17



MP-135 LNAPL Transmissivity Summary

Low Tn value (ft2/day)	2.0E-03
High Tn value (ft2/day)	1.1E-02
Low piezometric surface (ft msl)	401.12
High piezometric surface (ft msl)	404.20
Hydraulic conditions reported by WSP	Confined (October 2011), Unconfined (January 2012)
Range of Tn variation (approximate)	Factor of 6
Range of piezometric surface variation (ft)	3.08



MP-137 LNAPL Transmissivity Summary

Low Tn value (ft2/day)	2.0E-02
High Tn value (ft2/day)	8.0E-02
Low piezometric surface (ft msl)	401.02
High piezometric surface (ft msl)	409.00
Hydraulic conditions reported by WSP	Confined (October 2011), Unconfined (January 2012)
Range of Tn variation (approximate)	Factor of 4
Range of piezometric surface variation (ft)	7.98

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FIGURE 32

LNAPL TRANSMISSIVITY SUMMARY FOR
2011 MULTIPHASE EXTRACTION PILOT TESTING

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: NO SCALE	Date: 5/22/14	File: 24S_TNSUMM2011_201405

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community, Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

EXPLANATION

● GROUNDWATER MONITORING WELL

● MULTIPURPOSE MONITORING POINT

● LNAPL RECOVERY WELL

N

0 150 '

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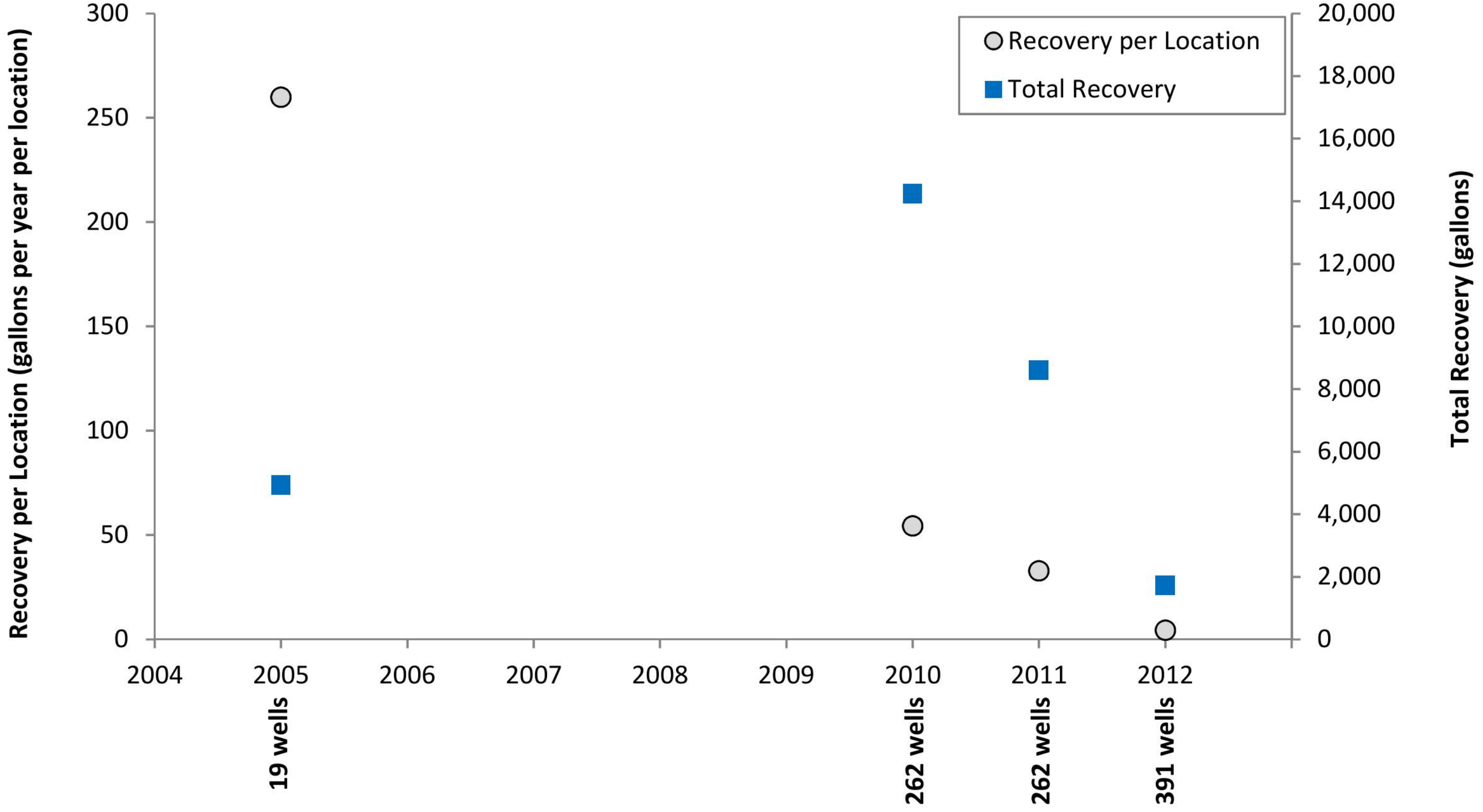
FIGURE 33

LOCATIONS CONSIDERED AS PART OF EVALUATING THE DUAL OPTIMAL LNAPL RESPONSE MODEL

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: BLM	Checked By: JP	Scale: 1 " = 150 '	Date: 5/13/14	File: AOCHrtfrd_RecoWells.mxd



NOTES:

1. LNAPL RECOVERY IN 2005 CONDUCTED FROM MAY 9 TO NOVEMBER 4 USING MULTIPHASE EXTRACTION
2. LNAPL RECOVERY BETWEEN 2010 AND 2012 CONDUCTED USING MANUAL SKIMMER PUMPS THROUGHOUT THE YEAR

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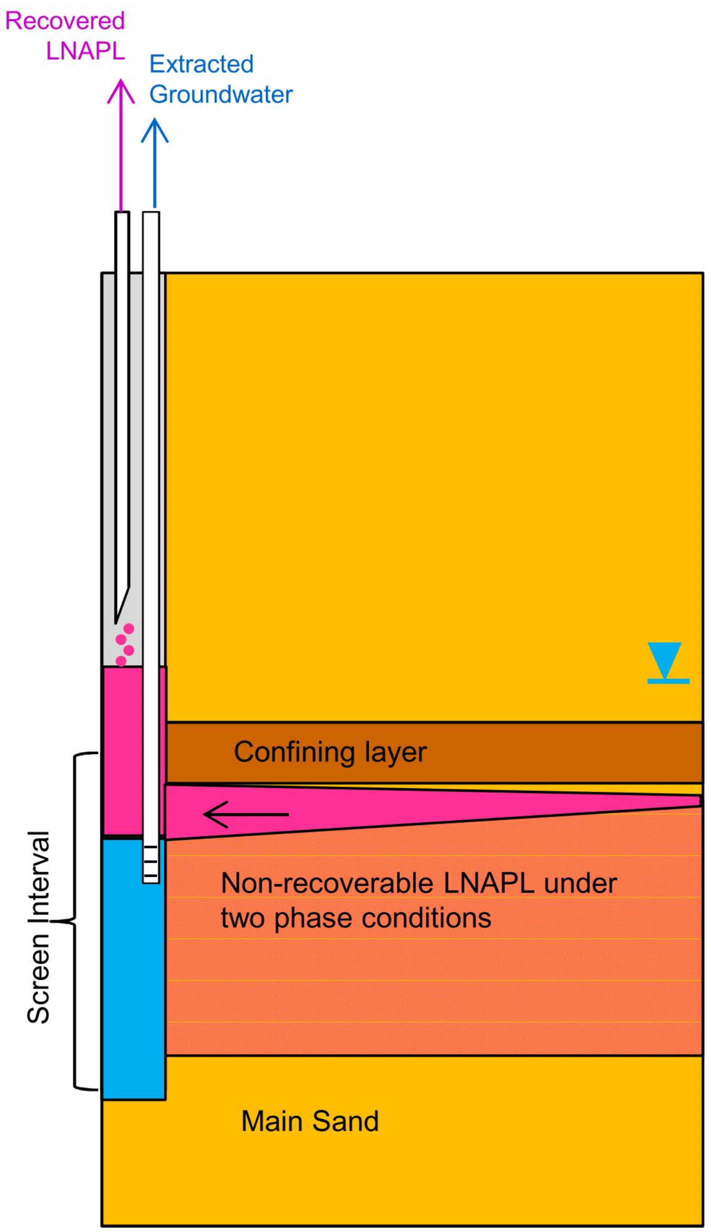
FIGURE 34

HISTORICAL LNAPL RECOVERY
FROM THE MAIN SAND STRATUM

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: REP	Checked By: BM	Scale: NONE	Date: 5/22/14	File: 24S_HSTRCLLNAPLREC2014

Low Flow Dual Phase Extraction

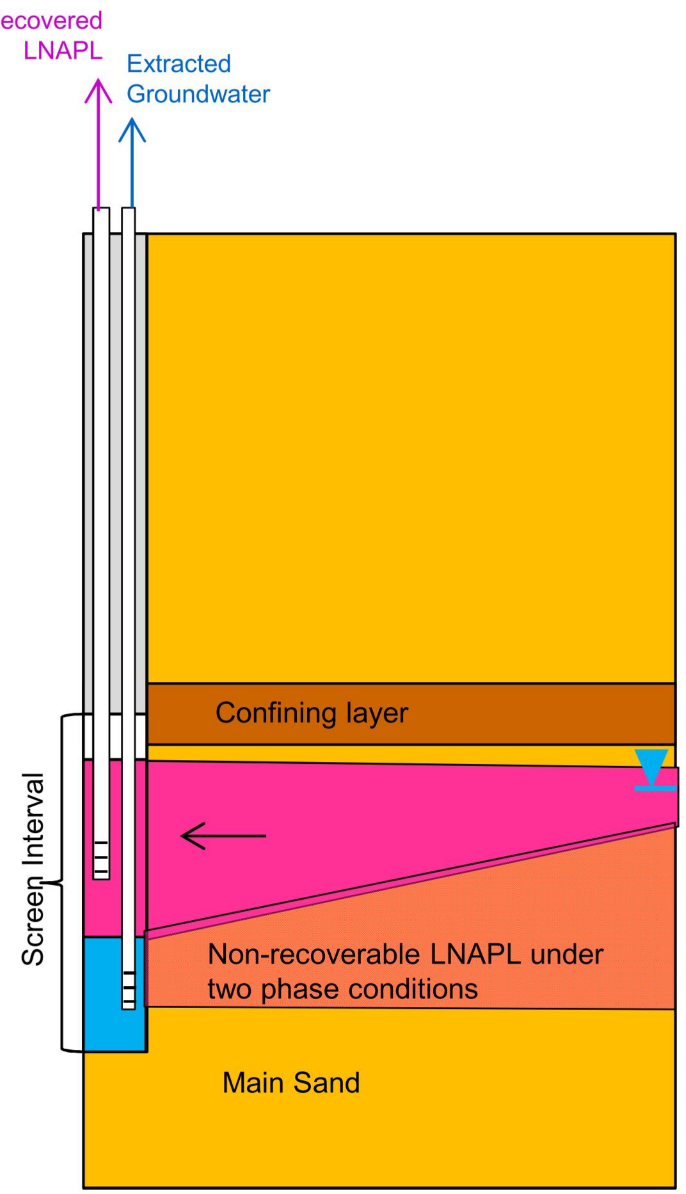


Low flow dual phase extraction lowers the LNAPL-water interface below the confining clay stratum while LNAPL remains confined.

Advantages
-Optimized under confined conditions.
-May reduce volume of groundwater extracted.

Limitations
-Small radius of recovery.
-Does not significantly change vertical interval of recoverable LNAPL.

Focused Pumping



Focused pumping lowers the water table in the formation by extracting large volumes of water. This increases the vertical interval of LNAPL recovery.

Advantages
-Large radius of influence for small number of production wells.
-Makes previously non-recoverable LNAPL recoverable.

Limitations
-Requires large water volume extraction.
-Optimized under unconfined conditions.

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FIGURE 35

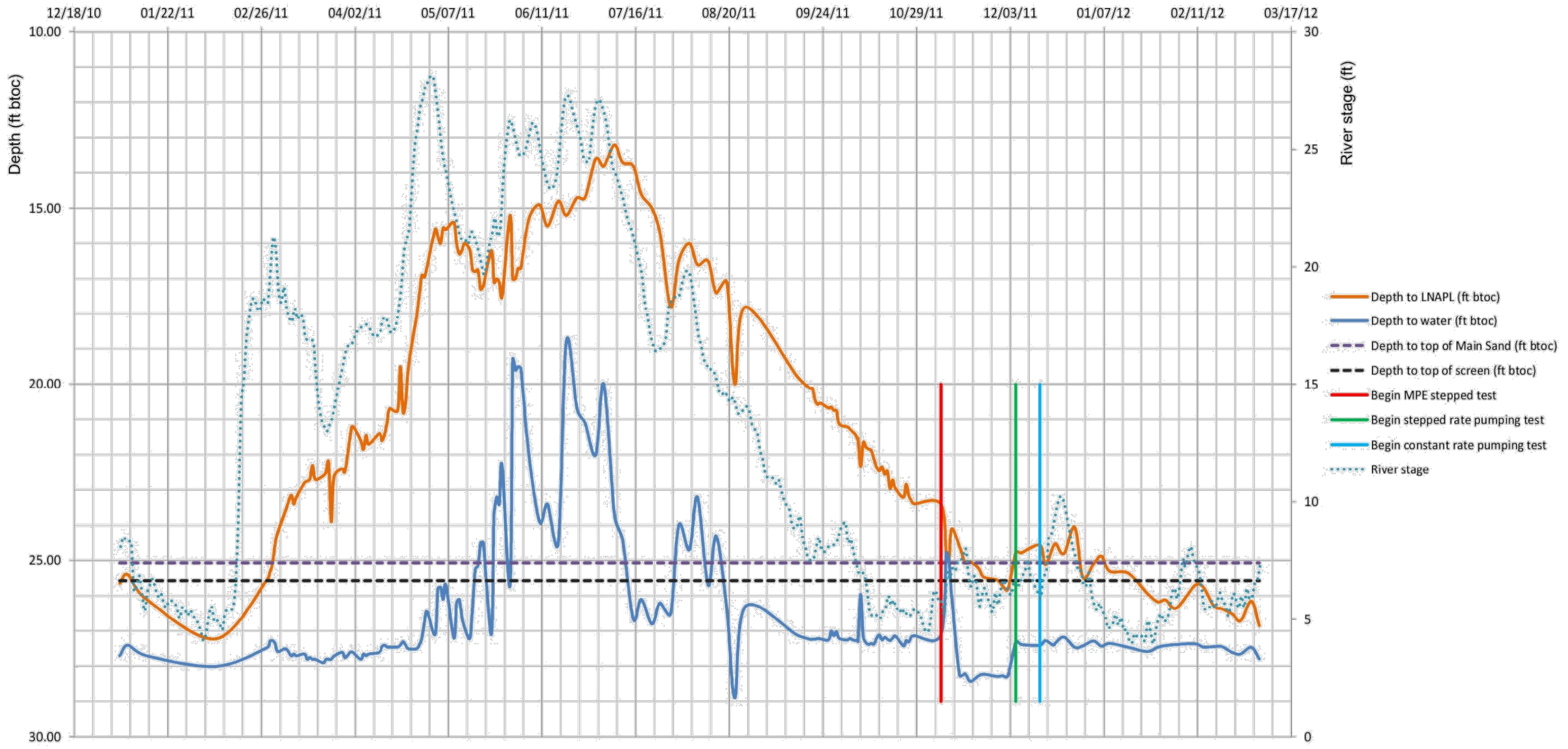
SCHEMATIC DIAGRAM OF LOW FLOW DUAL PHASE EXTRACTION AND FOCUSED PUMPING

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: REP	Checked By: BM	Scale: NONE	Date: 2/14/14	File: 24S_OSLNAPLREC2014

APPENDIX A

WATER AND LNAPL LEVELS IN WELL MPE-A001



Depth to Water/Depth to LNAPL Profile- MPE-A001
LNAPL Recovery Pilot Test
Hartford, Illinois

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A

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Reston, Virginia 20191
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www.wspenvironmental.com/usa

Figure 9

WATER AND LNAPL LEVELS IN
WELL MPE–A001

HARTFORD AREA HYDROCARBON PLUME SITE
HARTFORD, ILLINOIS
PREPARED FOR
APEX OIL COMPANY, INC
CLAYTON, MISSOURI

Drawn By: 03222012
Checked:
Approved:
DWG Name: 00021358–020

Note: Figure reproduced from Light Non–Aqueous Phase Liquid Pilot Test Interim Report (WSP 2012).

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FIGURE A-1

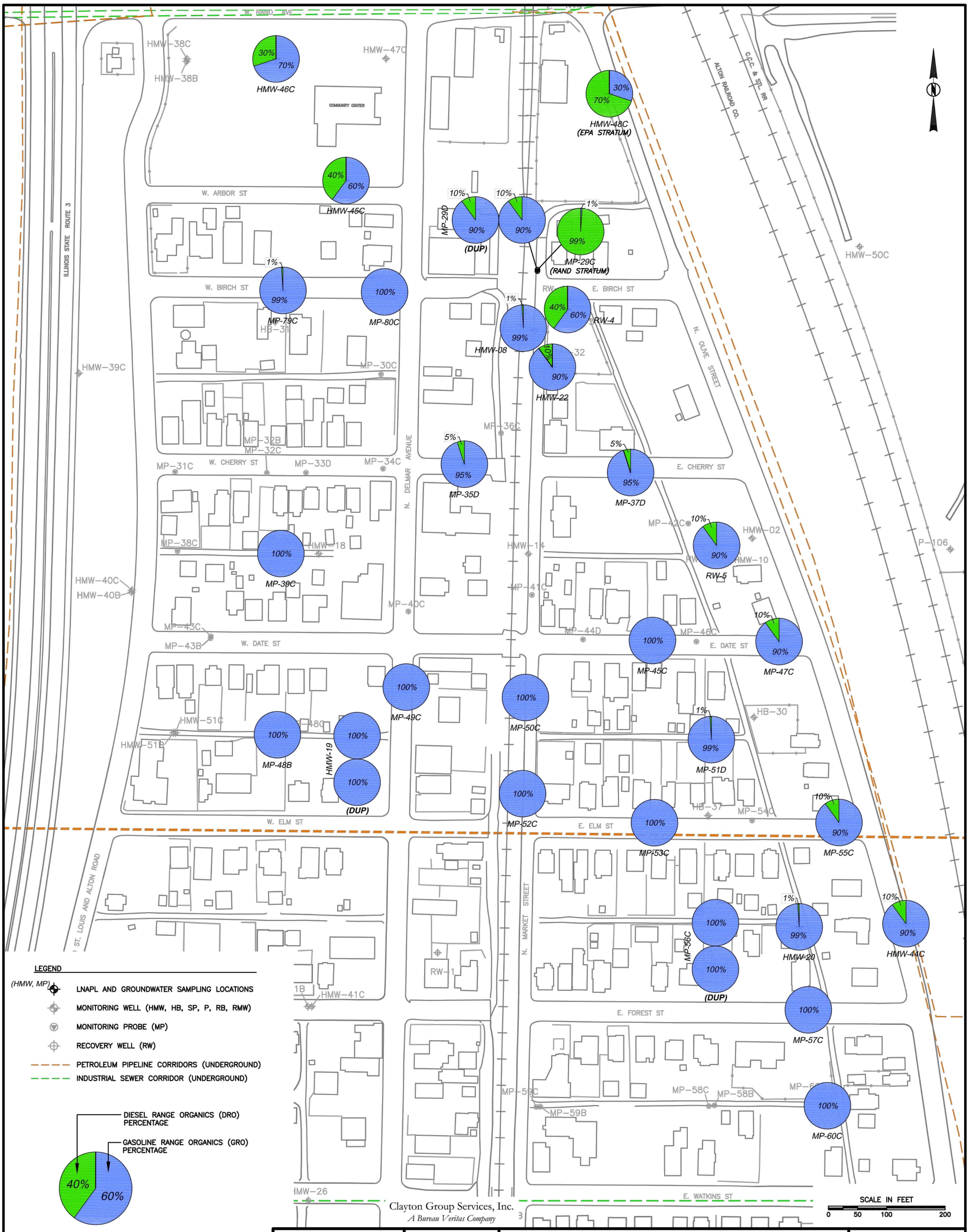
WATER AND LNAPL LEVELS IN WELL MPE-A001

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: NO SCALE	Date: 5/22/14	File: 24S_MPE-A001_201405

APPENDIX B

2005 LNAPL TYPE MAP



NOTES:

1. ALL LNAPL CHARACTERIZATION RESULTS ARE FROM THE MAIN SAND WITH THE EXCEPTION OF MP-29C AND HMW-48C. HMW-48C WAS OBTAINED FROM THE EPA STRATUM AND MP-29C WAS OBTAINED FROM THE RAND STRATUM.
2. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.

DESIGN BY:	
CHECKED BY:	BKM
DRAWN BY:	BCP/OS
DATE:	12-15-05
SCALE:	AS SHOWN
CAD NO.:	0309514007d25e
PROJECT NO.:	15-03095.14

BUREAU VERITAS

LNAPL CHARACTERIZATION

THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

FIGURE
3-2

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FIGURE B-1

2005 LNAPL TYPE MAP

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_LNAPLCHAR201402

APPENDIX C

2006 AND 2009 LNAPL ANALYTICAL RESULTS

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Methane	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C4	NA	NA	NA	0.02	NA	0.01	NA	NA	NA	NA	NA	0.01	0.03
Unknowns-C4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03	NA
Propene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutane	0.04	0.19	0.18	0.65	0.12	0.25	0.06	0.01	0.2	0.06	0.06	0.9	0.87
Methanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutene	0.01	0.03	0.04	0.12	0.02	0.03	<0.01	<0.01	0.03	0.01	<0.01	0.11	0.12
1-Butene	0.01	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.01	0.01	<0.01	0.09	0.08
1,3-Butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
n-Butane	2.19	1.43	1.39	3.06	0.91	1.53	0.34	0.11	1.31	0.45	0.49	8	7.8
trans-2-Butene	0.03	0.09	0.1	0.21	0.07	0.1	0.02	<0.01	0.09	0.04	<0.01	0.27	0.26
2,2-Dimethylpropane	0.02	0.03	0.02	0.07	0.02	0.03	<0.01	<0.01	0.02	<0.01	<0.01	0.05	0.05
cis-2-Butene	0.04	0.09	0.09	0.18	0.06	0.09	0.02	<0.01	0.08	0.03	<0.01	0.22	0.22
1,2-Butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethanol	1.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methyl-1-butene	0.03	0.05	0.05	0.19	0.1	0.04	0.02	<0.01	0.05	0.02	<0.01	0.11	0.11
Isopentane	8.03	5.68	5.91	7.97	4.94	5.15	3.72	0.71	5.45	2.41	3.78	9.11	8.96
1,4-Pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01
dimethylacetylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1-Pentene	0.13	0.17	0.18	0.24	0.15	0.15	0.09	<0.01	0.16	0.09	<0.01	0.35	0.34
Isopropanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methyl-1-butene	0.29	0.37	0.39	1.14	0.78	0.78	0.22	<0.01	0.36	0.16	0.16	0.66	0.64
n-Pentane	5.61	3.58	3.78	5.51	3.63	3.37	3.16	0.22	3.34	1.39	2.24	4.32	4.9
2-Methyl-1,3-butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02
trans-2-Pentene	0.38	0.47	0.5	0.6	0.44	0.42	0.3	<0.01	0.46	0.23	0.15	1.07	1.05
Unknowns-C6	NA	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA	0.01	NA
3,3-Dimethyl-1-butene	0.21	0.26	0.26	0.32	0.23	0.22	0.15	<0.01	0.24	0.13	0.06	0.54	0.53
cis-2-Pentene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
tert-Butanol	2.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methyl-2-butene	<0.01	1.32	1.4	1.71	1.33	1.21	0.96	0.09	1.28	0.41	0.77	2.06	1.36
trans-1,3-Pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.04
3-Methyl-1,2-butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Cyclopentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01	NA
cis-1,3-Pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
1,2-Pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.51	<0.01
2,2-Dimethylbutane	0.71	0.25	0.27	0.33	0.26	0.24	0.27	0.04	0.25	0.1	0.16	0.19	0.5
Cyclopentene	0.1	0.1	0.1	0.11	0.09	0.09	0.07	<0.01	0.09	0.06	0.08	<0.01	0.18
4-Methyl-1-pentene	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methyl-1-pentene	0.08	0.11	0.12	0.14	0.11	0.32	0.11	<0.01	0.11	0.06	0.09	0.12	0.12
n-Propanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyclopentane	0.74	0.34	0.36	0.42	0.35	<0.01	0.32	0.04	0.32	0.17	0.3	0.45	0.44
2,3-Dimethylbutane	1.13	1.02	1.1	1	0.99	1.02	0.93	0.13	1.09	0.76	0.98	1.07	1.09
Unknowns-C6	0.06	0.09	0.1	0.11	NA	0.11	0.08	NA	NA	NA	0.08	0.09	0.07
Methyl-tert-butylether	1.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	0.04	<0.01	<0.01	<0.01
2,3-Dimethyl-1-butene	<0.01	0.03	<0.01	0.18	0.13	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.04	0.03
cis-4-Methyl-2-pentene	<0.01	<0.01	0.03	<0.01	0.03	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methylpentane	5.29	3.6	3.87	3.83	3.51	3.36	3.64	0.32	3.72	2.48	3.59	3.97	3.93
trans-4-Methyl-2-pentene	0.14	0.16	0.17	0.19	0.16	0.14	0.11	<0.01	0.16	0.07	0.11	0.19	0.19
Methylethylketone	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methylpentane	3.39	2.43	2.6	0.14	*2.45*	2.33	2.48	0.29	2.5	1.71	2.46	2.46	2.43
4-Methyl-1-pentene	NA	NA	NA	<0.01	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylpentane	NA	NA	NA	2.61	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
C6-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methyl-1-pentene	0.18	0.26	0.28	0.32	0.27	0.24	0.23	<0.01	0.26	0.14	0.23	0.26	0.26
1-Hexene	0.04	0.07	0.08	0.1	0.08	0.07	0.1	<0.01	0.07	0.09	<0.01	0.08	0.08
Methyl-sec-butylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C6-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Butanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Ethyl-1-butene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
n-Hexane	3.4	3.06	3.24	3.71	3.31	2.91	3.59	0.08	3.11	2.19	3.31	2.09	2.07
cis-3-Hexene	0.12	0.17	0.18	0.2	*0.18*	0.15	0.17	<0.01	0.17	0.12	0.09	0.22	0.21
Diisopropylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
trans-3-Hexene+Hexadiene	0.25	0.35	0.37	0.4	0.36	0.31	0.36	<0.01	0.35	0.25	0.08	0.43	0.42
Unknowns-C7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.08	NA	NA
2-Methyl-2-pentene	0.25	0.38	0.4	0.45	*0.4*	0.35	0.42	0.02	0.38	0.25	0.47	0.35	0.34
3-Methylcyclopentene	<0.01	<0.01	<0.01	0.32	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	**Gasoline Check Standard**	**Sample Point**											
		MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
trans-3-Methyl-2-pentene	0.19	0.28	0.29	<0.01	0.3	0.26	0.3	<0.01	0.28	0.18	0.31	0.27	0.27
cis-2-Hexene	0.11	0.15	0.16	0.17	0.15	0.13	0.15	<0.01	0.15	0.11	0.1	0.18	0.17
3,3-Dimethyl-1-pentene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
cis-3-Methyl-2-pentene	0.27	0.39	0.4	0.43	*0.42*	0.35	0.41	0.01	0.38	0.26	0.43	0.35	0.35
Ethyl-tert-butylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3-Dimethyl-1,3-butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methylcyclopentane	1.58	1.74	1.86	1.93	*1.85*	1.77	1.9	0.22	1.88	<0.01	1.87	1.42	1.43
2,2-Dimethylpentane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.5	<0.01	<0.01	<0.01
4,4-Dimethyl-1-pentene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C7	0.01	0.04	0.04	0.05	0.04	0.03	0.05	NA	0.03	0.01	0.03	NA	0.02
Isobutanol	0.77	2.09	<0.01	1.48	2.13	0.04	1.47	0.22	2.59	<0.01	<0.01	1.01	0.58
2,3-Dimethyl-2-butene	<0.01	<0.01	1.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.8	1.43	<0.01	<0.01
2,4-Dimethylpentane	0.87	<0.01	<0.01	0.04	<0.01	1.48	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
1,3,5-Hexatriene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.01
2,2,3-Trimethylbutane	<0.01	0.05	0.04	<0.01	0.05	0.05	0.04	<0.01	0.04	0.03	0.03	<0.01	<0.01
Methylcyclopentadiene	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.02	0.02
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Unknowns-C7	NA	NA	0.02	NA	NA	0.02	NA	NA	NA	0.04	NA	NA	0.03
C7-Diolefin	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	<0.01	<0.01
4-Methylcyclopentene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methylenecyclopentane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzene	0.93	1.48	1.57	1.08	*1.47*	1.25	0.76	0.05	1.33	0.91	0.99	1.27	1.25
1-Methyl-1-cyclopentene	0.05	0.06	0.07	0.14	0.08	0.07	0.36	0.02	0.08	0.24	0.39	0.09	0.09
C7-Olefin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
cis-2-Methyl-3-hexene	0.01	0.02	0.02	<0.01	0.02	0.02	0.02	<0.01	<0.01	0.02	0.02	0.01	0.01
3,3-Dimethylpentane+5-Methyl-1-hexene	0.25	0.17	0.19	0.22	0.19	0.17	0.13	0.02	0.18	0.1	0.14	0.12	0.16
Cyclohexane	0.1	0.51	0.54	0.72	0.64	NA	0.79	0.13	0.54	0.45	0.66	0.21	0.2
trans-2-Methyl-3-hexene	0.03	0.16	<0.01	0.17	0.16	<0.01	0.17	<0.01	0.13	0.05	<0.01	0.03	0.03
3,3-Dimethyl-1,4-pentadiene	0.03	<0.01	0.15	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01	0.2	0.03	0.04
n-Butanol	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dimethylcyclopentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point										
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
trans-2-Ethyl-3-methyl-1-butene	0.04	0.07	0.06	0.07	0.07	0.06	0.08	<0.01	0.06	0.05	0.08	0.05	0.09
4-Methyl-1-hexene	0.01	0.02	0.02	0.02	0.03	0.02	0.03	<0.01	<0.01	0.02	0.03	0.01	0.03
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methyl-1-hexene	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	0.13	<0.01	<0.01	<0.01	<0.01	0.09	0.1
4-Methyl-2-hexene	0.07	0.11	<0.01	NA	0.12	0.13	<0.01	<0.01	0.13	0.09	0.14	<0.01	<0.01
2-Methylhexane+C7-Olefin	2.9	4.23	4.5	NA	4.38	4.96	3.67	0.49	4.98	6.35	5.23	2.2	2.19
2,3-Dimethylpentane	0.05	0.06	0.05	NA	<0.01	0.05	0.02	<0.01	0.06	0.01	0.03	0.05	0.06
Cyclohexene	<0.01	<0.01	<0.01	NA	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
tert-Amyl-methylether	1.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methylhexane	2.4	1.99	2.1	2.01	2.03	2.01	2.39	0.27	2.11	2.19	2.74	1.55	1.55
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
trans-1,3-Dimethylcyclopentane	0.31	0.46	0.48	0.49	0.47	0.46	0.52	0.1	0.48	0.47	0.55	0.38	0.37
cis-1,3-Dimethylcyclopentane	0.25	0.36	0.38	0.38	0.37	0.37	0.41	0.08	0.39	0.4	0.43	0.29	0.29
trans-1,2-Dimethylcyclopentane	0.18	0.38	0.78	0.47	0.42	*0.4*	0.45	0.17	0.4	0.37	0.43	0.22	0.22
3-Ethylpentane	0.23	0.16	0.04	0.16	0.17	0.17	0.14	<0.01	0.17	0.18	0.14	0.13	0.13
3-Methyl11hexene	0.04	0.06	0.02	0.09	0.06	<0.01	0.03	<0.01	<0.01	<0.01	0.01	0.03	0.03
2,2,4-Trimethylpentane	0.5	3.21	3.26	1.86	3.13	4.01	1.92	0.3	3.89	5.64	3.65	2.4	2.37
Unknowns-C7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03	NA
1-Heptene	0.06	0.06	0.03	0.08	0.07	0.06	0.04	<0.01	0.07	<0.01	0.05	0.04	0.07
C7-Olefin	<0.01	0.06	0.04	0.06	0.06	0.05	0.05	<0.01	0.05	<0.01	<0.01	<0.01	<0.01
2,4-Dimethyl-1,3-pentadiene	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Diolefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	0.04	0.06	0.06	0.07	0.1	0.06	0.07	<0.01	0.06	0.05	0.08	0.04	0.04
C7-Diolefin	<0.01	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Diolefin	0.06	0.1	0.12	<0.01	0.11	0.1	0.12	<0.01	0.11	0.08	0.14	0.08	0.08
C7-Olefin	0.13	0.2	0.2	0.26	0.22	0.19	0.22	<0.01	0.21	0.18	0.23	0.17	0.17
n-Heptane	1.5	1.62	1.7	2.16	1.98	1.71	2.15	0.16	1.85	2.03	2.6	1.01	1

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Unknowns-C8	NA	0.12	0.13	NA	NA	0.11	NA	NA	NA	0.02	0.03	0.09	0.09
cis-3-Heptene	0.09	0.16	0.16	0.2	0.17	0.15	0.16	<0.01	0.16	0.1	0.18	0.11	0.11
2-Methyl-2-hexene	0.07	0.11	0.11	0.14	0.12	0.11	0.12	<0.01	0.11	0.08	0.13	0.08	0.08
cis-3-Methyl-3-hexene	0.06	0.1	<0.01	0.13	0.1	0.09	0.11	<0.01	0.1	0.09	<0.01	0.08	0.08
trans-3-Heptene	0.03	0.05	0.1	0.06	0.05	0.04	0.05	<0.01	0.05	0.04	0.06	0.03	0.03
3-Ethyl-2-pentene	0.05	0.09	0.05	0.12	0.1	0.09	0.12	<0.01	0.09	0.07	0.11	0.06	0.06
1,5-Dimethylcyclopentene	<0.01	<0.01	0.09	0.16	0.15	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	0.07	0.07
trans-2-Methyl-3-hexene	0.07	0.14	0.14	<0.01	<0.01	0.13	0.16	<0.01	0.13	0.01	0.17	0.09	0.09
Unknowns-C8	NA	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA
C7-Diolefin+C7-Triolefin	0.01	0.02	0.03	<0.01	<0.01	0.02	0.02	<0.01	<0.01	0.13	0.02	<0.01	<0.01
2,3-Dimethyl-2-pentene	0.08	0.23	NA	0.03	0.02	0.2	0.29	<0.01	0.2	<0.01	0.22	0.07	0.1
3-Ethylpentene	<0.01	<0.01	NA	0.31	0.26	<0.01	<0.01	<0.01	<0.01	1.18	<0.01	<0.01	<0.01
Methylcyclohexane	0.49	1.12	1.19	1.41	1.29	1.26	1.54	0.54	1.16	<0.01	1.46	0.69	0.67
Unknowns-C8	0.01	0.03	NA	NA	NA	0.03	0.02	NA	NA	NA	NA	NA	NA
C7-Olefin	NA	<0.01	0.03	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	0.11	0.01	<0.01	NA
1,1,3-Trimethylcyclopentane	0.05	0.1	0.1	0.17	0.11	0.11	0.12	0.05	0.11	0.06	0.12	0.06	NA
2,2-Dimethylhexane	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.01	0.06	<0.01	0.07	0.03	NA
3,3-Dimethyl-1,5-hexadiene	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
C8-Diolefin	<0.01	0.02	<0.01	<0.01	0.01	0.01	0.02	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
C8-Diolefin	<0.01	0.01	<0.01	<0.01	0.01	0.06	0.01	<0.01	<0.01	0.28	<0.01	<0.01	<0.01
Ethylcyclopentane	0.15	0.21	0.21	0.24	0.23	0.21	0.28	0.07	0.22	<0.01	0.27	0.27	0.22
Unknowns -C8	0.01	0.27	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylcyclohexene	0.01	NA	0.12	0.03	0.02	0.02	<0.01	<0.01	<0.01	0.14	0.01	0.01	<0.01
Methylcyclohexadiene	0.01	NA	<0.01	0.03	<0.01	NA	<0.01	<0.01	0.06	<0.01	<0.01	0.11	<0.01
2,2,3-Trimethylpentane	<0.01	NA	0.08	0.08	0.12	NA	0.12	<0.01	<0.01	0.67	0.08	<0.01	0.11
2,5-Dimethylhexane+C8-Olefin	*0.18*	NA	0.47	0.44	0.46	NA	0.46	0.08	0.46	0.92	0.55	0.41	0.41
2,4-Dimethylhexane	0.25	NA	0.58	0.49	0.57	0.64	0.53	0.12	0.61	<0.01	0.73	0.48	0.48
C7-Triolefin+C8-Olefin	0.01	NA	<0.01	<0.01	<0.01	0.02	0.01	<0.01	<0.01	0.13	<0.01	<0.01	<0.01
Unknowns-C8	NA	NA	NA	0.03	0.03	NA	NA	NA	NA	NA	NA	NA	NA
trans,cis-1,2,4-Trimethyl-cyclopentane	0.09	<0.01	0.16	0.19	0.17	0.16	0.2	0.09	0.17	0.09	0.2	0.13	0.12
3,3-Dimethylhexane+C8-Olefin	0.05	NA	0.07	0.06	NA	0.07	0.07	0.03	0.08	<0.01	0.12	0.04	0.03

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point										
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Unknowns - C8	0.11	NA	NA	NA	0.02	NA	NA	NA	NA	NA	NA	NA	NA
C7-Triolefin+C8-Olefin	0.01	0.02	<0.01	0.03	<0.01	0.25	0.03	0.1	0.28	NA	<0.01	0.06	0.06
C8-Olefins	NA	<0.01	0.1	0.18	0.3	<0.01	0.18	<0.01	<0.01	<0.01	0.18	<0.01	<0.01
trans,cis-1,2,3-Trimethyl-cyclopentane	<0.01	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.21	<0.01	<0.01	0.07	<0.01	<0.01	<0.01
Unknowns - C8	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C8-Olefins	NA	0.12	0.13	<0.01	<0.01	0.11	<0.01	<0.01	0.11	<0.01	0.14	0.02	0.02
C8-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3,4-Trimethylpentane	0.19	1.19	1.24	0.22	0.14	1.49	0.81	0.13	1.33	2.09	1.47	1.03	1.02
C7-Diolefin	<0.01	0.12	0.15	0.75	1.06	<0.01	<0.01	<0.01	0.11	<0.01	0.04	0.1	0.11
Unknowns-C8	NA	NA	NA	0.2	NA	NA	0.22	NA	NA	NA	0.02	NA	NA
Toluene	7.06	4.99	5.21	4.17	4.48	4.4	0.83	0.11	4.93	4.45	0.79	*6.87*	6.73
2,3,3-Trimethylpentane	<0.01	0.7	*0.81*	0.54	0.73	0.84	0.45	<0.01	0.69	1.18	<0.01	0.62	0.74
C8-Olefin	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Diolefin	0.05	0.08	0.04	0.13	0.13	0.07	0.11	<0.01	0.08	0.06	0.1	0.05	0.05
C8-Olefin	<0.01	0.02	0.04	0.05	<0.01	0.02	0.04	<0.01	<0.01	0.01	0.02	0.02	0.02
C8-Olefin	0.05	0.09	<0.01	0.2	<0.01	0.09	0.13	0.04	<0.01	0.08	<0.01	0.05	0.05
C8-Olefin	<0.01	<0.01	0.08	0.14	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	0.11	<0.01	<0.01
C8-Olefin	NA	NA	NA	<0.01	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
C8-Diolefin+C8-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3-Dimethylhexane	0.26	0.61	0.63	0.41	0.59	0.63	0.47	0.15	0.66	0.85	0.78	0.42	0.42
Unknowns-C8	NA	NA	NA	0.17	NA	NA	0.16	NA	NA	NA	NA	0.06	0.06
2-Methyl-3-ethylpentane?	0.05	0.16	0.16	<0.01	0.18	0.14	0.31	<0.01	0.15	0.08	0.19	0.02	0.02
1,1,2-Trimethylcyclopentane+C7-Triolefin	<0.01	<0.01	<0.01	0.45	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Diolefin+C8-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefins	<0.01	0.02	<0.01	0.05	0.03	0.02	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
2-Methylheptane	0.56	0.87	1.19	0.98	0.9	0.91	1.05	0.31	0.94	1.21	1.27	0.81	0.66
4-Methylheptane	0.35	0.56	0.36	0.58	0.58	0.6	0.65	0.23	0.61	0.79	0.8	0.25	0.25
C8-Olefin+C7-Diolefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	**Gasoline Check Standard**	**Sample Point**											
		MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
cis-1,3-Dimethylcyclohexane	<0.01	<0.01	<0.01	0.36	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
trans-1,4-Dimethylcyclohexane	0.1	0.26	<0.01	<0.01	0.3	0.28	0.39	0.29	0.26	0.25	0.33	0.13	0.21
3-Methylheptane	<0.01	<0.01	0.41	<0.01	<0.01	<0.01	<0.01	0.57	<0.01	<0.01	<0.01	<0.01	<0.01
3-Ethylhexane	0.8	1.24	1.17	1.25	1.29	1.32	1.46	0.06	1.34	1.72	1.78	0.95	0.85
C8-Diolefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C8	0.01	0.01	NA	NA	NA	0.01	0.01	NA	NA	0.01	0.51	NA	NA
C8-Olefins	0.01	0.04	<0.01	0.05	0.04	0.04	0.06	<0.01	0.05	0.03	0.05	0.02	0.01
C8-Olefin	<0.01	<0.01	0.03	0.12	0.08	<0.01	<0.01	<0.01	0.04	0.02	0.06	<0.01	<0.01
1,1-Dimethylcyclohexane	<0.01	0.06	0.06	<0.01	<0.01	0.06	0.11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefin	<0.01	<0.01	<0.01	0.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,1-Dimethylcyclohexane	NA	NA	0.06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C8-Olefin	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C8-Olefin	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
cis-1-Ethyl-3-methylcyclopentane	0.17	<0.01	<0.01	<0.01	0.55	0.51	0.42	0.11	<0.01	0.54	<0.01	*0.48*	*0.48*
Unknowns - C8	NA	0.53	NA	NA	NA	NA	NA	NA	0.5	NA	NA	*NA*	*NA*
2,2,5-Trimethylhexane	0.06	0.08	0.51	0.08	0.08	0.08	0.16	0.08	0.08	0.17	0.18	*0.08*	0.08
trans-1-Ethyl-3-methyl-cyclopentane	0.04	0.06	0.08	0.08	0.07	0.06	0.12	0.12	0.06	0.11	0.15	0.05	0.05
trans-1-Ethyl-2-methylcyclopentane	0.01	0.02	0.07	0.04	0.03	0.02	0.04	<0.01	0.02	0.03	<0.01	0.01	<0.01
1-Methyl-1-ethylcyclopentane	0.01	0.02	0.02	0.03	0.02	0.02	0.04	<0.01	0.02	0.03	0.04	0.02	<0.01
1-Octene	0.05	0.12	0.02	0.17	0.14	0.13	0.2	0.24	0.13	0.13	0.19	0.06	0.01
C8-Olefin	0.03	<0.01	0.12	0.12	0.09	0.08	0.12	<0.01	0.08	0.07	<0.01	0.05	0.06
trans-1,2-Dimethylcyclohexane	<0.01	0.08	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	0.02
C8-Olefins	0.02	0.01	<0.01	0.01	0.01	0.01	0.05	<0.01	0.03	0.04	<0.01	0.03	0.03
C8-Olefins	<0.01	0.02	<0.01	0.03	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01
trans-3-Octene	0.05	0.12	<0.01	<0.01	<0.01	0.11	0.19	0.03	0.11	0.11	0.15	0.07	0.02
C8-Olefins	<0.01	<0.01	0.33	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.2

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
trans-1,3-Dimethylcyclohexane	0.11	<0.01	<0.01	0.17	0.14	<0.01	<0.01	<0.01	0.21	0.24	<0.01	<0.01	<0.01
cis-1,4-Dimethylcyclohexane	<0.01	0.2	<0.01	0.23	0.2	0.2	0.25	0.17	<0.01	<0.01	0.24	0.17	0.09
n-Octane	0.42	0.9	0.1	1.07	1.02	0.97	1.28	0.2	0.95	1.49	1.72	0.57	0.52
C8-Olefin	0.01	<0.01	0.87	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01	NA	NA
C8-Olefin	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.2	0.17	0.18	0.15	0.15
trans-1,3-Dimethyleyclohexane	NA	<0.01	NA	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
cis-1,4-Dimethyleyelohexane	NA	0.2	NA	NA	NA	0.2	NA	NA	NA	NA	NA	NA	NA
n-Octane	NA	0.9	NA	NA	NA	0.97	NA	NA	NA	NA	NA	NA	NA
C8-Olefin	NA	<0.01	NA	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
C8-Olefin	NA	<0.01	NA	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
trans-2-Octene	<0.01	0.2	<0.01	0.28	0.23	0.2	0.25	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Isopropylcyclopentane	0.04	0.06	0.18	0.07	0.06	0.06	0.07	<0.01	0.05	0.04	0.06	0.03	0.04
C9-Olefin	<0.01	0.01	0.05	<0.01	NA	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin	<0.01	<0.01	<0.01	0.01	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin?	0.01	0.03	<0.01	<0.01	0.06	0.03	0.04	<0.01	0.02	0.01	0.02	<0.01	<0.01
C9-Olefin?	<0.01	<0.01	<0.01	0.04	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2,4-Trimethylhexane	0.03	0.04	0.02	0.06	0.06	0.05	0.07	0.02	0.03	0.04	0.04	0.03	0.04
2,4,4-Trimethylhexane	0.01	0.01	<0.01	0.1	0.11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefins	0.01	0.12	0.13	0.02	<0.01	0.11	NA	NA	0.13	0.14	NA	0.11	0.11
Unknowns-C9	0.04	NA	0.05	NA	NA	NA	0.16	NA	NA	NA	0.02	NA	NA
2,3,5-Trimethylhexane	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefins	NA	NA	NA	NA	NA	NA	<0.01	0.07	NA	NA	0.14	NA	NA
cis-2-Octene	<0.01	0.02	<0.01	0.03	<0.01	0.02	0.06	<0.01	<0.01	0.01	0.03	<0.01	0.02
2,2,3,4-Tetramethylpentane	0.02	0.05	<0.01	0.06	0.05	0.05	<0.01	0.03	<0.01	0.05	0.06	0.03	0.03
2,2-Dimethylheptane	0.03	0.06	0.05	0.07	0.06	0.06	0.08	0.06	0.05	0.04	0.05	0.04	0.04
cis-1,2-Dimethylcyclohexane	0.05	0.12	0.06	<0.01	<0.01	0.13	0.14	0.11	0.06	0.15	0.15	0.08	0.08
2,4-Dimethylheptane	0.01	0.01	0.12	0.11	0.13	0.01	<0.01	0.01	0.13	0.01	0.01	0.01	0.01
C9-Olefin	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethylcyclohexane	<0.01	<0.01	<0.01	<0.01	0.18	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propylcyclopentane	0.1	0.17	<0.01	0.19	<0.01	0.18	0.28	0.5	<0.01	0.21	0.3	0.15	0.16
2-Methyl-4-Ethylhexane	<0.01	<0.01	0.18	<0.01	<0.01	0.03	<0.01	<0.01	0.18	<0.01	<0.01	<0.01	<0.01
2,6-Dimethylheptane	0.02	0.03	<0.01	0.03	0.03	0.14	<0.01	<0.01	<0.01	0.03	0.02	0.02	0.02
Unknowns-C9	0.06	0.14	NA	0.13	0.14	NA	0.18	0.26	0.03	0.17	0.18	0.1	0.1
C9-Olefin	<0.01	0.12	0.14	<0.01	<0.01	0.12	0.24	0.46	0.14	0.1	0.2	0.07	0.07
1,1,4-Trirnethylcyclohexane	0.07	<0.01	0.13	0.13	0.14	NA	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01
C9-Olefins	0.03	0.04	<0.01	0.03	<0.01	0.04	0.02	0.04	<0.01	0.01	0.02	0.02	<0.01
C9-Olefins	0.03	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	0.02
1,1,3-Trimethylcyclohexane	<0.01	<0.01	<0.01	0.16	0.28	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,5&3,5-Dimethylheptane	0.12	0.28	<0.01	0.3	<0.01	0.29	0.32	0.21	<0.01	0.4	0.4	0.18	0.18
C9-Olefins	0.04	0.08	0.29	0.08	0.28	0.09	0.1	0.09	0.3	0.12	0.13	0.06	0.06
3,3-Dimethylheptane	0.03	0.04	0.09	0.04	0.09	0.04	0.05	0.06	0.09	0.06	0.06	0.04	0.04
C9-Isoparaffin	0.02	0.04	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.05	0.06	0.03	0.04
C9-Olefins	0.01	0.01	0.04	0.02	0.06	0.01	0.02	<0.01	0.03	0.01	0.01	<0.01	<0.01
2,3,3-Trimethylhexane	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
C9-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethylbenzene	1.94	1.56	<0.01	1.5	1.52	1.38	1.88	0.06	1.54	1.81	1.92	1.6	1.61
trans-1,2,4-Trimethylcyclohexane	<0.01	<0.01	1.65	0.15	<0.01	<0.01	<0.01	0.1	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefins	<0.01	<0.01	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3,4-Trimethylhexane	0.08	0.14	<0.01	<0.01	<0.01	0.13	0.09	0.29	0.06	0.07	<0.01	0.08	0.09
C9-Olefins	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	<0.01
Unknowns-C9	0.01	0.02	0.02	NA	NA	0.02	NA	0.02	NA	NA	NA	0.03	0.02
3,3,4-Trimethylhexane?	0.04	0.05	0.05	0.06	0.06	0.05	0.04	<0.01	<0.01	0.02	0.03	0.02	0.03
m-Xylene	5.27	3.42	3.6	3.08	3.44	3.52	3.8	0.07	4.92	4.05	3.15	3.65	3.68
p-Xylene	2.06	1.42	1.59	1.28	1.42	1.41	2.04	0.04	0.41	2.17	1.82	1.53	1.51
2,3-Dimethylheptane	<0.01	0.18	0.19	0.17	0.19	0.19	0.06	0.21	<0.01	0.06	0.09	0.11	0.13
3,5-Dimethylheptane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	*<0.01*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3,4-Dimethylheptane	0.09	0.15	<0.01	0.15	0.16	0.15	0.09	0.14	<0.01	0.1	0.12	<0.01	0.09
C9-Olefin	<0.01	<0.01	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	<0.01
Unknowns - C9	0.02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point										
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
3-Methyl-3-ethylhexane	0.05	0.12	<0.01	<0.01	<0.01	0.12	0.07	0.13	0.07	0.1	0.11	0.09	0.09
C9-Olefin	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4-Ethylheptane	0.02	0.02	<0.01	0.12	0.12	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4-Methyloctane+C9-Olefin	0.13	0.28	0.02	0.27	0.31	0.3	0.31	NA	0.53	0.17	0.45	0.22	0.22
2-Methyloctane	0.19	0.39	0.29	0.42	0.46	0.47	0.44	0.35	0.2	0.76	0.7	0.31	0.31
C9-Olefin	0.04	0.06	0.4	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	0.03	<0.01
C9-Isoparaffin	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	0.03	0.03
C9-Olefin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Ethylheptane	0.05	0.11	<0.01	0.1	0.11	0.11	0.05	0.2	0.28	0.05	0.17	0.08	0.09
3-Methyloctane	0.21	0.43	0.11	0.38	0.44	0.46	0.51	0.67	0.37	0.68	0.71	0.35	0.35
C9-Isoparaffin	<0.01	<0.01	0.45	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
cis-1,2,4-Trimethylcyclohexane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,1,2-Trimethylcyclohexane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o-Xylene	2.72	1.88	1.96	1.66	1.9	1.94	2.2	0.13	1.88	2.43	0.29	2.07	2.08
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.05	<0.01	<0.01
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Isoparaffin	0.02	0.1	0.1	0.06	0.17	0.11	0.04	0.02	0.09	0.13	0.11	0.06	0.06
Unknowns-C9	0.04	0.07	NA	0.21	0.14	0.07	NA	NA	0.05	NA	NA	0.06	0.06
trans-1-Ethyl-4-methyl-cyclohexane?	0.06	0.13	0.07	NA	NA	0.13	0.26	0.6	0.11	0.06	0.24	0.09	0.09
cis-1-Ethyl-4-methyl-cyclohexane?	0.04	0.18	0.14	0.08	0.19	0.22	0.18	0.3	0.19	0.12	0.32	0.04	0.04
Unknowns-C9	NA	NA	NA	0.07	NA	NA	NA	NA	NA	NA	NA	NA	0.04
C9-Isoparaffin	0.02	0.04	0.19	0.05	0.04	0.04	0.04	0.03	0.06	0.28	0.02	0.02	0.02
1-Nonene	0.03	0.04	0.04	0.03	0.03	0.05	0.03	0.07	<0.01	0.03	0.05	0.04	0.05
Unknowns-C9	NA	NA	NA	NA	NA	NA	0.02	NA	NA	NA	0.1	0.05	0.02
Isobutylcyclopentane	<0.01	0.01	0.05	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01
C9-Isoparaffin	0.03	0.05	<0.01	<0.01	<0.01	0.04	0.05	<0.01	0.04	<0.01	0.07	0.03	0.04
trans-3-Nonene	0.01	0.02	0.04	0.05	0.05	0.02	0.02	<0.01	0.02	0.04	<0.01	0.02	0.02
cis-3-Nonene	0.04	0.06	0.02	0.03	0.03	0.06	0.04	0.05	0.05	0.02	0.09	0.03	0.03
C9-Isoparaffin	<0.01	<0.01	0.06	0.07	0.07	<0.01	<0.01	0.07	<0.01	0.02	<0.01	<0.01	<0.01
n-Nonane	0.17	0.53	0.55	0.5	0.58	0.59	0.73	0.14	0.56	1.09	1.04	0.35	0.36

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point										
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C10-Olefin	0.04	<0.01	0.1	0.1	0.1	0.1	0.1	<0.01	0.09	0.07	0.11	0.07	0.08
trans-2-Nonene	0.01	0.1	<0.01	0.04	<0.01	<0.01	<0.01	0.33	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl-1-ethylcyclohexane	0.02	0.03	0.03	0.01	0.04	0.03	0.04	0.12	0.03	0.02	0.04	0.03	0.04
Unknowns-C10	NA	0.01	NA	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA
1-Methyl-2-propylcyclopentane	0.13	0.17	0.17	0.16	0.01	0.16	0.2	0.13	0.22	0.16	0.16	0.13	0.13
C10-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	0.17	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isopropylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
cis-2-Nonene	0.03	0.09	0.08	0.07	0.09	0.09	0.12	0.38	0.05	0.11	0.16	0.06	0.06
tert-Butylcyclopentane	0.01	0.03	0.03	0.03	0.03	0.03	0.06	0.16	0.01	0.02	0.06	0.01	0.02
C9-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin	0.01	<0.01	<0.01	0.06	0.09	<0.01	0.08	<0.01	0.08	0.13	0.1	0.03	0.04
Isopropylcyclohexane	<0.01	<0.01	<0.01	0.07	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3,3,5-Trimethylheptane	<0.01	0.08	0.08	<0.01	<0.01	0.1	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01
2,2-Dimethyloctane	0.03	<0.01	<0.01	<0.01	<0.01	0.11	0.12	0.3	0.1	0.18	0.17	0.07	<0.01
2,4-Dimethyloctane	<0.01	0.1	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08
1-Methyl-4-isopropylcyclohexane?	0.01	0.05	0.05	0.06	0.06	0.05	0.07	0.07	0.04	0.03	0.05	<0.01	<0.01
sec-Butylcyclopentane	0.02	0.04	0.04	0.04	0.04	0.04	0.05	0.11	0.04	0.05	0.06	0.02	0.03
2,6-Dimethyloctane	0.07	0.16	0.16	0.18	0.2	0.17	0.23	0.77	0.19	0.23	0.37	0.1	0.11
2,5-Dimethyloctane?	<0.01	0.04	0.03	<0.01	0.15	0.03	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Butylcyclopentane	0.05	0.14	0.14	0.11	<0.01	0.08	<0.01	0.23	0.08	0.09	0.23	0.08	0.1
Propylcylohexane	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	0.18	0.14	0.07	0.09	<0.01	<0.01	<0.01
3,6-Dimethyloctane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl-2-ethylcyclohexane	0.07	0.18	0.18	0.15	0.19	0.18	0.28	0.93	0.17	0.24	0.36	0.08	0.1
C10-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propylbenzene	0.65	0.64	0.65	0.54	0.65	0.6	0.85	0.63	0.65	0.79	0.7	0.53	0.54
3,3-Dimethyloctane	0.02	0.06	0.06	0.08	0.06	0.06	0.04	0.74	0.05	0.03	0.17	0.02	0.03
3-Methyl-5-ethylheptane	0.02	0.05	0.05	<0.01	0.06	0.05	0.03	0.02	0.04	<0.01	0.08	<0.01	<0.01
C10-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	0.01	<0.01	<0.01	<0.01
1-Ethyl-3-methylbenzene	2.46	1.68	1.71	1.51	1.69	1.73	1.8	0.03	1.75	1.99	0.75	1.86	1.71

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
1-Ethyl-4-methylbenzene	1.15	0.81	0.82	0.69	0.83	0.83	0.9	0.21	0.83	0.94	0.73	0.59	0.82
C10-Naphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,3,5-Trimethylbenzene	1.45	1	1	0.79	1.03	1.04	1.36	0.95	1.02	1.42	1.14	0.85	0.9
2,3-Dimethyloctane	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01
5-Methylnonane	<0.01	<0.01	<0.01	0.06	0.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4-Methylnonane	0.05	0.13	0.13	<0.01	<0.01	0.14	0.07	0.32	0.12	0.07	0.08	0.05	0.06
2-Methylnonane	0.06	0.14	0.14	0.05	0.14	0.15	0.1	0.64	0.14	0.08	0.28	0.1	0.11
1-Ethyl-2-methylbenzene	0.91	0.93	0.93	0.35	0.94	1.08	0.99	0.37	1	1.42	1	0.77	0.79
3-Ethyloctane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Naphthene	0.02	0.06	0.06	<0.01	0.07	0.06	0.03	0.28	0.04	0.04	0.05	0.03	0.04
3-Methylnonane	0.1	0.22	0.22	0.12	0.23	0.24	0.35	0.82	0.21	0.36	0.48	0.14	0.19
C10-Olefin	0.01	<0.01	<0.01	<0.01	0.1	<0.01	0.02	0.25	<0.01	<0.01	0.03	<0.01	<0.01
C10-Isoparaffin	<0.01	0.08	0.08	0.02	<0.01	0.11	0.02	<0.01	0.06	0.16	0.02	0.01	0.03
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,2,4-Trimethylbenzene	3.94	2.7	2.65	2.32	2.77	2.83	4.44	0.26	2.78	4.57	2.6	2.68	2.71
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.35	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	0.24	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C10	NA	0.05	NA	NA	NA	NA	NA	NA	NA	NA	0.04	NA	NA
Isobutylcyclohexane	0.02	0.02	0.05	0.02	0.02	0.05	0.02	0.42	0.03	<0.01	0.01	0.01	0.04
C10-Isoparaffin	<0.01	0.01	0.02	<0.01	0.02	0.02	<0.01	0.11	<0.01	<0.01	<0.01	<0.01	0.02
C10-Isoparaffin	0.01	<0.01	<0.01	0.01	0.03	0.01	0.02	0.3	0.05	0.01	0.04	0.02	<0.01
1-Decene	0.01	0.02	0.03	0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.03
C10-Isoparaffin	<0.01	0.02	0.03	0.02	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	<0.01	0.02	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Aromatic	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01
C10-Naphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.13	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutylbenzene	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	0.02	<0.01
trans-1-Methyl-2-propyl-cyclohexane?	0.05	0.04	0.04	<0.01	0.05	0.06	0.03	<0.01	0.04	<0.01	<0.01	<0.01	0.03
C10-Isoparaffin	<0.01	0.1	0.1	0.07	0.12	0.12	0.1	0.28	0.1	0.13	0.07	0.04	<0.01
sec-Butylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06
n-Decane	0.15	0.37	0.36	0.26	0.34	0.35	0.43	0.59	0.35	0.54	0.74	0.22	0.24
C11-Isoparaffin	0.01	0.05	<0.01	<0.01	0.07	0.06	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C11-Isoparaffin	0.01	<0.01	0.04	0.03	<0.01	<0.01	0.02	0.13	<0.01	0.05	<0.01	<0.01	0.02

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Unknowns-C11	NA	NA	NA	NA	NA	NA	NA	0.15	NA	NA	NA	NA	NA
1,2,3-Trimethylbenzene	0.76	0.67	0.64	0.58	0.71	0.71	0.67	0.05	0.74	0.72	0.62	0.67	0.65
1-Methyl-3-isopropylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C11-lsoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.18	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl-4-isopropylbenzene	0.02	0.05	<0.01	0.03	0.05	0.05	0.04	0.12	0.02	0.04	0.03	0.02	0.03
C11-lsoparaffin	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C11-Isoparaffin?	0.02	0.05	0.05	0.03	0.08	0.06	0.05	0.32	0.03	0.05	0.05	0.02	0.03
2,3-Dihydroindene	0.3	0.33	0.33	0.25	0.34	0.36	0.3	0.34	0.33	0.36	0.24	0.37	0.4
Unknowns-C11	NA	NA	NA	NA	NA	0.02	NA	0.24	NA	NA	NA	NA	NA
sec-Butylcyclohexane	0.02	0.09	0.08	0.04	0.07	0.06	0.18	0.09	<0.01	<0.01	0.08	<0.01	<0.01
Unknowns-C11	NA	NA	NA	NA	NA	NA	NA	NA	0.05	NA	NA	0.03	0.04
C11-Isoparaffin	0.02	0.02	0.02	0.02	0.03	0.03	0.02	1.76	0.02	0.06	0.34	0.01	0.02
1-Methyl-2-isopropylbenzene	<0.01	0.03	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.01	<0.01	0.04	0.05
3-Ethylnonane	0.03	0.05	0.03	0.04	0.03	0.04	0.08	<0.01	0.07	0.03	0.12	0.03	0.04
C11-Isoparaffin	<0.01	0.04	0.05	0.02	0.1	0.1	0.09	0.09	<0.01	0.08	<0.01	0.01	<0.01
Unknowns-C11	0.01	NA	NA	NA	NA	NA	0.05	0.7	NA	NA	NA	NA	0.02
C10-Naphthene	NA	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.17	<0.01	<0.01
C11-Isoparaffin	<0.01	<0.01	<0.01	0.22	<0.01	<0.01	0.26	0.37	0.29	<0.01	0.09	<0.01	<0.01
1,3-Diethylbenzene	0.21	0.28	0.25	<0.01	0.29	0.29	<0.01	0.56	<0.01	0.3	0.24	0.32	0.23
1-Methyl-3-propylbenzene	0.41	0.56	<0.01	0.45	0.57	0.6	0.54	<0.01	0.59	<0.01	0.46	0.39	0.44
1,4-Diethylbenzene	<0.01	<0.01	0.54	<0.01	0.45	<0.01	<0.01	0.78	<0.01	0.58	<0.01	<0.01	<0.01
1-Methyl-4-propylbenzene	0.31	0.42	<0.01	0.35	<0.01	0.47	0.38	0.21	0.47	<0.01	0.32	0.3	0.32
Butylbenzene	<0.01	<0.01	0.4	<0.01	<0.01	<0.01	<0.01	0.16	<0.01	0.42	<0.01	<0.01	<0.01
3,5-Dimethyl-1-ethylbenzene	0.52	0.5	<0.01	0.44	0.53	0.54	0.49	<0.01	0.54	<0.01	0.44	0.39	0.41
Unknowns-C11	NA	NA	NA	NA	NA	NA	NA	0.35	NA	NA	NA	NA	NA
1,2-Diethylbenzene?	0.05	<0.01	0.48	0.05	0.08	0.08	0.07	0.38	0.07	0.49	0.02	0.04	0.05
C11-Isoparaffin	<0.01	0.08	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01
C10-Aromatic	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Aromatic	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Aromatic	0.01	0.03	0.02	<0.01	0.2	0.04	<0.01	<0.01	0.03	<0.01	<0.01	0.02	0.02
1-Methyl-2-propylbenzene	0.12	0.21	0.17	0.15	<0.01	0.2	0.26	0.98	0.2	0.01	0.32	0.14	0.14

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point										
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C10-Aromatic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.18	<0.01	<0.01	<0.01
5-Methyldecane	0.03	0.07	<0.01	0.04	0.07	0.07	0.1	0.58	0.07	<0.01	0.17	0.06	0.06
4-Methyldecane	<0.01	0.04	0.06	0.02	0.04	0.05	0.02	<0.01	0.04	0.05	<0.01	0.04	0.04
2-Methyldecane	0.03	0.08	0.03	0.05	0.08	0.08	0.11	0.54	0.08	0.02	0.15	0.06	0.06
C11-Isoparaffin	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01
1,4-Dimethyl-2-ethylbenzene	0.31	0.36	0.31	0.29	0.37	0.38	0.37	0.46	0.38	<0.01	0.36	0.34	0.34
1,3-Dimethyl-4-ethylbenzene	0.36	0.38	0.33	0.32	0.4	0.42	0.35	0.46	0.42	0.36	0.29	0.36	0.36
C11-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.37	<0.01	<0.01	<0.01
3-Methyldecane	0.04	0.09	0.08	0.05	*0.08*	0.09	0.11	0.37	0.09	<0.01	0.17	0.07	0.07
1,2-Dimethyl-4-ethylbenzene+C1-lndan	0.62	0.6	<0.01	0.55	0.69	0.71	0.55	0.65	0.71	0.07	0.71	0.59	0.6
C11-Isoparaffin	<0.01	<0.01	0.56	<0.01	<0.01	<0.01	<0.01	0.14	<0.01	0.89	0.02	<0.01	<0.01
Unknowns-C11	NA	NA	NA	NA	NA	NA	0.03	0.34	NA	NA	0.01	NA	NA
1,3-Dimethyl-2-ethylbenzene	0.04	0.11	0.08	0.06	0.09	0.09	0.11	0.39	0.07	0.06	0.05	0.07	0.07
C11-Isoparaffin	<0.01	0.03	<0.01	0.01	<0.01	<0.01	0.06	0.61	<0.01	0.01	0.07	<0.01	0.01
C11-Isoparaffin	0.01	0.04	0.02	0.02	0.03	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl-4-tert-butylbenzene	0.01	0.06	0.03	0.05	0.03	0.03	0.06	0.42	<0.01	0.01	0.03	0.04	0.01
Unknowns-C11	0.02	NA	NA	NA	0.07	NA	0.06	0.36	0.11	NA	0.01	NA	NA
1,2-Dimethyl-3-ethylbenzene	0.12	0.19	0.05	0.13	*0.18*	0.07	0.2	0.74	0.11	0.01	0.21	0.09	0.12
1-Ethyl-2-isopropylbenzene	<0.01	<0.01	0.16	<0.01	<0.01	0.19	<0.01	0.19	<0.01	0.2	<0.01	0.12	0.13
n-Undecane	0.13	0.41	0.34	0.14	0.22	0.22	0.38	0.48	0.2	*0.41*	0.6	0.15	0.16
Unknowns-C12	NA	NA	NA	NA	NA	NA	NA	0.49	NA	*NA*	NA	NA	NA
1-Ethyl-4-isopropylbenzene	0.01	0.03	0.02	<0.01	0.03	0.03	0.05	0.36	<0.01	<0.01	0.01	<0.01	0.01
C12-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,2,4,5-Tetramethylbenzene	0.28	<0.01	<0.01	<0.01	0.29	0.29	0.22	<0.01	0.28	0.28	<0.01	<0.01	0.23
2-Methylbutylbenzene	<0.01	0.25	0.21	<0.01	<0.01	<0.01	<0.01	0.46	<0.01	<0.01	0.17	0.25	<0.01

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
1,2,3,5-Tetramethylbenzene	0.43	0.36	0.3	0.51	0.44	0.46	0.33	0.51	0.41	0.48	0.25	0.33	0.35
C11-Aromatic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
C12-Isoparaffin	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C11-Aromatic	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	0.74	<0.01	<0.01	0.13	<0.01	<0.01
C11-Aromatic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C11-Aromatic	0.03	<0.01	<0.01	<0.01	0.08	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
1-tert-Butyl-2-methylbenzene	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	0.14	<0.01	<0.01	0.05	<0.01	0.04	<0.01
C11-Aromatic	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	1.12	<0.01	<0.01	0.19	<0.01	<0.01
Unknowns-C12	NA	NA	NA	NA	NA	NA	0.02	0.27	NA	NA	0.04	NA	NA
Unknowns-C12	NA	0.01	NA	NA	NA	NA	NA	0.33	NA	NA	0.05	NA	NA
1-Ethyl-2-propylbenzene	0.26	0.33	0.27	0.39	0.36	0.38	0.32	0.2	0.71	0.4	0.27	0.31	0.32
Unknowns-C12	NA	NA	NA	NA	NA	NA	NA	0.95	NA	NA	NA	NA	NA
C11-Aromatic	0.07	0.12	0.09	0.05	0.11	0.11	0.14	0.6	0.06	0.12	0.15	0.07	0.08
C11-Aromatic	0.08	0.12	0.1	0.07	0.13	0.14	0.12	0.48	0.1	0.14	0.11	0.09	0.1
C11-Aromatic	0.07	0.1	0.08	0.05	*0.08*	0.08	0.15	1.02	0.06	0.1	0.18	0.05	0.05
1-Methyl-3-butylbenzene	0.25	0.24	0.19	0.18	0.27	0.28	0.21	0.69	0.24	0.28	0.19	0.28	0.29
1,2,3,4-Tetramethylbenzene+C11-Aromatic	0.22	0.24	0.19	0.16	0.26	0.27	0.23	0.71	0.23	0.27	0.22	0.2	0.2
Pentylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.32	<0.01	<0.01	<0.01	<0.01	<0.01
trans-1-Methyl-2-(4-methylpentyl)	0.09	<0.01	0.1	0.06	0.14	0.15	0.15	0.36	0.09	0.15	0.16	0.07	<0.01
C11-Aromatic	<0.01	0.13	<0.01	<0.01	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	0.15
C11-Aromatic	0.09	0.14	0.11	0.08	0.09	0.15	0.16	0.61	0.11	0.15	0.16	0.1	0.1
C11-Aromatic	<0.01	0.12	NA	0.05	<0.01	<0.01	<0.01	1.32	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C12	0.06	NA	0.05	NA	NA	NA	0.2	NA	NA	NA	0.23	NA	0.07
C12-Isoparaffin	0.06	0.13	0.1	<0.01	<0.01	0.1	0.08	<0.01	0.07	0.12	0.07	0.07	0.08
1,2,3,4-Tetrahydronaphthalene	0.02	0.09	0.07	0.1	0.15	0.16	0.12	0.75	0.13	0.11	0.14	0.06	0.03
1-tert-Butyl-3,5-dimethylbenzene	0.09	0.07	0.12	0.09	0.15	0.16	0.21	0.96	<0.01	0.06	0.24	0.02	0.12
Naphthalene	0.45	0.16	0.24	0.14	0.37	0.4	0.3	0.83	0.13	0.17	0.26	0.1	0.35
C12-lsoparaffin?	<0.01	0.31	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.37	0.42	<0.01	0.34	<0.01

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C11-Aromatic	0.09	<0.01	0.06	<0.01	0.1	0.1	0.09	0.39	<0.01	<0.01	0.08	0.05	0.06
C11-Aromatic	0.11	0.08	0.08	0.01	0.13	0.13	0.11	0.62	0.07	0.03	0.11	0.1	0.12
C12-Isoparaffin	<0.01	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	0.12	<0.01	<0.01	<0.01
C12-Isoparaffin	0.06	<0.01	0.04	0.01	0.07	0.07	0.06	0.37	<0.01	<0.01	0.06	0.05	0.06
C11-Aromatic	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.06	0.07	<0.01	<0.01
Unknowns-C12	NA	NA	0.17	NA	NA	NA	0.06	0.49	NA	NA	NA	NA	NA
C12-lsoparaffin	0.06	0.04	0.03	0.03	0.09	0.1	0.07	0.49	<0.01	<0.01	0.08	0.05	0.07
1,3-Dipropylbenzene	0.22	0.24	0.03	0.16	0.25	0.26	0.29	1.46	0.07	0.09	0.27	0.17	0.2
Unknowns-C12	NA	0.04	0.02	NA	0.03	0.03	0.09	1.08	NA	NA	0.14	NA	0.01
n-Dodecane	0.16	0.36	0.27	0.11	0.19	0.2	0.36	1.02	0.23	0.27	0.61	0.11	0.13
C12-lsoparaffin?	0.01	0.02	0.01	<0.01	0.02	0.02	0.04	0.42	0.16	0.31	0.01	<0.01	<0.01
C11-Aromatic?	<0.01	0.02	0.01	<0.01	<0.01	<0.01	0.04	0.37	<0.01	<0.01	0.01	<0.01	0.02
C11-Aromatic	0.04	0.03	0.03	<0.01	0.06	0.06	0.05	0.37	<0.01	<0.01	0.02	0.03	0.02
Unknowns-C13	NA	0.01	NA	NA	NA	NA	0.03	0.29	NA	NA	NA	NA	0.04
1,3,5-Triethylbenzene	0.07	0.17	0.11	0.05	0.1	0.1	0.32	2.36	<0.01	0.02	0.36	0.06	0.07
C11-Aromatic?	0.04	0.04	0.03	0.02	0.04	0.05	0.07	0.63	0.07	0.12	0.08	0.03	<0.01
C11-Aromatic	0.07	0.06	0.04	0.04	0.07	0.08	0.08	0.54	0.03	0.05	0.08	0.05	0.06
1-tert-Butyl-4-ethylbenzene	0.02	0.03	0.01	0.02	0.04	0.04	0.04	0.36	0.06	0.07	0.05	0.02	0.02
Unknowns-C13	0.06	0.1	0.06	0.03	NA	0.07	0.18	0.63	0.02	0.03	0.1	0.03	0.04
1,2,4-Triethylbenzene	0.13	0.15	0.09	0.06	0.29	0.14	0.22	1.61	0.04	0.07	0.25	0.1	0.12
Unknowns-C13	0.03	0.05	0.03	0.04	NA	0.02	0.03	0.7	0.11	0.13	0.09	0.07	0.05
Unknowns-C13	0.05	0.04	0.02	NA	NA	0.05	0.09	0.35	NA	0.02	0.04	NA	0.02
Unknowns-C13	0.02	NA	NA	NA	NA	0.02	0.07	0.59	NA	0.05	0.1	NA	NA
1-Methyl-4-pentylbenzene	0.09	0.09	0.06	0.03	0.08	0.08	0.16	0.6	0.03	0.03	0.17	0.06	0.1
Unknowns-C13	0.02	0.05	0.03	0.02	NA	0.02	0.09	1.26	0.06	0.09	0.09	0.01	0.03
Unknowns-C13	0.04	0.03	0.02	NA	NA	0.04	0.05	0.87	0.02	0.04	0.12	0.01	0.03
Unknowns-C13	0.04	0.04	0.03	NA	NA	0.04	0.09	0.63	NA	0.03	0.05	0.01	0.02
Unknowns-C13	0.03	NA	NA	NA	NA	0.02	NA	NA	NA	NA	NA	NA	NA
Hexylbenzene	0.1	0.12	0.08	0.05	0.21	0.09	0.22	1.77	0.01	0.03	0.25	0.06	0.07
Unknowns-C13	0.02	0.02	NA	0.06	0.02	0.02	0.05	0.53	0.29	0.09	0.11	NA	0.01
2-Methylnaphthalene	0.32	0.22	0.13	0.19	0.27	0.32	0.25	NA	0.06	0.02	0.25	0.31	0.32
Unknowns-C13	0.04	0.06	0.03	NA	0.04	0.1	0.12	1.47	0.01	0.28	0.06	0.02	0.06
Unknowns-C13	0.11	0.22	0.14	NA	0.12	0.18	0.21	0.96	0.06	0.01	0.13	0.05	0.14
Unknowns-C13	0.13	0.12	0.03	NA	NA	NA	0.17	0.52	NA	0.12	0.23	0.12	NA

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Unknowns-C13	NA	NA	NA	NA	NA	NA	NA	0.31	NA	NA	0.17	NA	NA
Unknowns-C13	NA	NA	NA	NA	NA	NA	NA	1.14	NA	NA	NA	NA	NA
n-Tridecane	NA	0.02	0.07	0.07	0.08	0.04	0.06	0.64	<0.01	<0.01	0.07	<0.01	<0.01
1-Methylnaphthalene	0.02	0.03	0.02	<0.01	0.03	0.07	0.06	0.54	0.12	0.14	0.07	0.02	0.03
Unknowns-C14	0.01	0.04	NA	NA	0.01	0.01	0.09	0.76	NA	0.03	0.1	NA	0.01
Unknowns-C14	0.01	0.01	NA	NA	0.02	0.02	0.04	0.42	NA	0.02	0.05	NA	0.01
Unknowns-C14	0.01	0.03	NA	NA	0.01	0.01	0.02	0.24	NA	0.02	0.03	NA	0.01
Unknowns-C14	0.01	0.01	NA	NA	NA	NA	0.02	0.23	NA	0.02	0.11	NA	NA
Unknowns-C14	NA	0.04	NA	NA	NA	NA	0.07	0.71	NA	0.01	0.03	NA	NA
Unknowns-C14	NA	0.01	NA	NA	NA	NA	0.02	0.26	NA	0.02	0.03	NA	NA
Unknowns-C14	NA	0.02	NA	NA	NA	NA	0.03	0.32	NA	NA	0.13	NA	NA
Unknowns-C14	NA	0.02	NA	NA	NA	NA	0.1	0.93	NA	NA	0.05	NA	NA
Unknowns-C14	NA	NA	NA	NA	NA	NA	0.04	0.39	NA	NA	0.07	NA	NA
Unknowns-C14	NA	NA	NA	NA	NA	NA	0.06	0.64	NA	NA	NA	NA	NA
Unknowns-C14	NA	NA	NA	NA	NA	NA	0.06	0.42	NA	NA	NA	NA	NA
trans-7-Decene	NA	0.02	<0.01	<0.01	<0.01	<0.01	0.05	0.4	<0.01	0.01	0.07	<0.01	0.02
Unknowns-C14	NA	NA	NA	NA	NA	NA	0.03	0.37	NA	0.01	0.06	NA	NA
2,6-Dimethylnaphthalene	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.09	0.37	<0.01	0.02	0.04	<0.01	<0.01
2,7-Dimethylnaphthalene	<0.01	0.04	0.03	<0.01	<0.01	<0.01	<0.01	0.91	<0.01	0.01	0.11	<0.01	<0.01
Unknowns-C14	0.01	0.03	NA	NA	NA	0.06	0.02	0.25	NA	0.03	0.02	NA	0.03
Unknowns-C14	NA	NA	NA	NA	NA	NA	0.07	0.69	NA	NA	0.08	NA	NA
1,3-Dimethylnaphthalene	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.03
1,6-Dimethylnaphthalene	<0.01	0.06	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01
Unknowns-C14	0.01	NA	0.06	NA	NA	NA	0.09	NA	NA	0.02	0.07	NA	NA
n-Tetradecane	NA	0.11	0.07	<0.01	0.04	0.03	0.12	1.1	<0.01	0.03	0.13	0.02	0.01
1,5-Dimethylnaphthalene	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.39	<0.01	<0.01	<0.01	<0.01	<0.01
1,4-Dimethylnaphthalene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C15	0.01	0.01	0.03	NA	NA	0.02	0.09	0.85	<0.01	0.02	0.09	0.04	0.03
Acenaphthalene	NA	0.02	0.01	<0.01	<0.01	<0.01	0.06	0.7	NA	0.01	0.08	<0.01	0.02
Unknowns-C15	0.01	0.04	0.02	NA	NA	0.02	0.03	0.3	NA	NA	0.03	NA	NA
Unknowns-C15	0.01	NA	NA	NA	NA	0.01	0.04	0.56	NA	NA	0.05	NA	NA
1,2-Dimethylnaphthalene	NA	0.03	<0.01	<0.01	<0.01	<0.01	0.03	0.16	0.01	<0.01	0.04	<0.01	0.01
Unknowns-C15	NA	0.01	0.02	NA	NA	NA	0.04	0.13	NA	NA	0.05	NA	NA
Unknowns-C15	NA	0.01	NA	NA	NA	NA	0.03	0.38	NA	NA	0.03	NA	NA
Unknowns-C15	NA	0.04	NA	NA	NA	NA	0.07	0.3	NA	NA	0.08	NA	NA

Table 1(a)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Weight %)
Apex Oil, Hartford, Illinois

Component	Gasoline Check Standard	Sample Point											
		MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Unknowns-C15	NA	0.01	NA	NA	NA	NA	0.03	0.99	NA	NA	0.04	NA	NA
Unknowns-C15	NA	0.02	NA	NA	NA	NA	0.01	0.18	NA	NA	0.01	NA	NA
Unknowns-C15	NA	NA	NA	NA	NA	NA	0.02	0.24	NA	NA	0.01	NA	NA
Unknowns-C15	NA	NA	NA	NA	NA	NA	NA	0.33	NA	NA	0.03	NA	NA
n-Pentadecane	<0.01	0.08	0.04	<0.01	<0.01	<0.01	0.06	0.41	<0.01	0.01	0.04	<0.01	<0.01
C15+(Balance)	NA	NA	NA	NA	NA	NA	NA	3.46	NA	NA	NA	NA	NA
Total	**99.99**	**99.72**	**99.9**	**97.27**	**100.08**	**100.27**	**99.14**	**99.75**	**100.07**	**99.87**	**99.64**	**100.05**	**99.95**

Notes:
Detection Limit 0.01
<: Not detect values
NA: Not available
The identification of components is based on relative retention time data. Identification in some cases is speculative.
Data obtained from Maxxam Analytics Laboratory reports (January 2006)

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	**Sample Point**											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Methane	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C4	NA	NA	0.03	NA	0.01	NA	NA	NA	NA	NA	0.01	0.04
Unknowns-C4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04	NA
Propene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutane	0.25	0.24	0.84	0.16	0.33	0.08	0.02	0.26	0.08	0.08	1.16	1.13
Methanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutene	0.04	0.05	0.15	0.02	0.04	<0.01	<0.01	0.03	0.01	<0.01	0.14	0.15
1-Butene	0.02	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.01	0.01	<0.01	0.11	0.09
1,3-Butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
n-Butane	1.82	1.76	3.82	1.17	1.95	0.44	0.14	1.67	0.58	0.62	9.92	9.69
trans-2-Butene	0.11	0.12	0.25	0.09	0.12	0.02	<0.01	0.11	0.05	<0.01	0.32	0.32
2,2-Dimethylpropane	0.03	0.02	0.08	0.02	0.03	<0.01	<0.01	0.02	<0.01	<0.01	0.07	0.06
cis-2-Butene	0.11	0.1	0.21	0.07	0.11	0.02	<0.01	0.1	0.04	<0.01	0.26	0.25
1,2-Butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methyl-1-butene	0.05	0.05	0.17	0.1	0.05	0.02	<0.01	0.05	0.02	<0.01	0.12	0.12
Isopentane	6.77	6.97	9.29	5.94	6.14	4.47	0.9	6.5	2.87	4.47	10.55	10.39
1,4-Pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01
dimethylacetylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1-Pentene	0.2	0.2	0.27	0.17	0.18	0.1	<0.01	0.19	0.1	<0.01	0.39	0.38
Isopropanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methyl-1-butene	0.43	0.44	1.05	0.74	0.73	0.25	<0.01	0.41	0.19	0.19	0.73	0.71
n-Pentane	4.23	4.41	6.36	4.32	3.98	3.76	0.27	3.95	1.67	2.63	4.96	5.48
2-Methyl-1,3-butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.03
trans-2-Pentene	0.54	0.56	0.67	0.5	0.47	0.34	<0.01	0.52	0.27	0.17	1.18	1.16
Unknowns-C6	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA	0.01	NA
3,3-Dimethyl-1-butene	0.29	0.29	0.35	0.26	0.25	0.18	<0.01	0.27	0.15	0.07	0.6	0.59
cis-2-Pentene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C- G- 0106-007	MP-47C- G- 0106-008	MP-79C- G- 01 06-0 13	MP-38C- G- 0106-019	MP-39C- G- 0106-020	MP-29D- G- 0106-024	MP-29C- G- 0106-025	MP-60C- G- 0106-033	MP-46C- G- 0106-037	MP-46C- G- 016-044	RSI-G- 0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
tert-Butanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methyl-2-butene	1.24	1.3	1.57	1.25	1.13	0.91	0.09	1.2	0.4	0.85	1.87	1.24
trans-1,3-Pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.04
3-Methyl-1,2-butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyclopentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.02	NA
cis-1,3-Pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
1,2-Pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.56	<0.01
2,2-Dimethylbutane	0.29	0.3	0.34	0.28	0.25	0.32	0.04	0.29	0.12	0.18	0.18	0.55
Cyclopentene	0.09	0.1	0.1	0.09	0.08	0.06	<0.01	0.09	0.05	0.07	<0.01	0.17
4-Methyl-1-pentene	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methyl-1-pentene	0.12	0.13	0.15	0.13	0.35	0.12	<0.01	0.12	0.07	0.09	0.13	0.13
n-Propanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyclopentane	0.34	0.35	0.45	0.39	<0.01	0.32	0.04	0.32	0.17	0.01	0.44	0.42
2,3-Dimethylbutane	1.14	1.21	1.09	1.12	1.14	1.05	0.15	1.21	0.87	1.09	1.16	1.18
Unknowns-C6	0.1	0.11	0.11	NA	0.11	0.09	NA	NA	NA	0.08	0.1	0.08
Methyl-tert-butylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	0.05	<0.01	<0.01	<0.01
2,3-Dimethyl-1-butene	0.03	<0.01	0.17	0.13	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.03	0.03
cis-4-Methyl-2-pentene	<0.01	0.03	<0.01	0.03	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methylpentane	4.08	4.33	4.13	3.91	3.72	4.16	0.38	4.21	2.86	4.02	4.37	4.33
trans-4-Methyl-2-pentene	0.18	0.18	0.21	0.18	0.16	0.13	<0.01	0.18	0.08	0.12	0.2	0.21
Methylethylketone	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methylpentane	2.71	2.86	0.15	*2.75*	2.6	2.79	0.34	2.79	1.94	2.71	2.67	2.64
4-Methyl-1-pentene	NA	NA	<0.01	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylpentane	NA	NA	2.84	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
C6-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methyl-1-pentene	0.29	0.3	0.33	0.3	0.26	0.25	<0.01	0.28	0.16	0.24	0.28	0.27
1-Hexene	0.08	0.08	0.1	0.08	0.07	0.11	<0.01	0.08	0.11	<0.01	0.08	0.08
Methyl-sec-butylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C6-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
2-Butanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Ethyl-1-butene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
n-Hexane	3.43	3.59	3.89	3.58	3.13	4.06	0.1	3.49	2.5	3.67	2.28	2.26
cis-3-Hexene	0.19	0.19	0.21	*0.19*	0.17	0.18	<0.01	0.19	0.14	0.1	0.23	0.23
Diisopropylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
trans-3-Hexene+Hexadiene	0.38	0.39	0.43	0.39	0.34	0.39	<0.01	0.38	0.28	0.09	0.46	0.45
Unknowns-C7	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.09	NA	NA
2-Methyl-2-pentene	0.41	0.42	0.47	*0.44*	0.37	0.46	0.02	0.41	0.27	0.5	0.37	0.36
3-Methylcyclopentene	<0.01	<0.01	0.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
trans-3-Methyl-2-pentene	0.3	0.3	<0.01	0.32	0.28	0.32	<0.01	0.3	0.2	0.33	0.28	0.28
cis-2-Hexene	0.16	0.17	0.18	0.16	0.14	0.16	<0.01	0.16	0.13	0.11	0.18	0.18
3,3-Dimethyl-1-pentene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
cis-3-Methyl-2-pentene	0.41	0.42	0.45	*0.45*	0.37	0.44	0.01	0.4	0.28	0.45	0.36	0.36
Ethyl-tert-butylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3-Dimethyl-1,3-butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methylcyclopentane	1.72	1.81	1.86	*1.84*	1.75	1.89	0.23	1.86	<0.01	0.3	1.36	1.53
2,2-Dimethylpentane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.68	<0.01	<0.01	<0.01
4,4-Dimethyl-1-pentene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C7	0.04	0.04	0.06	0.05	0.03	0.06	NA	0.04	0.01	0.04	NA	0.02
Isobutanol	1.93	<0.01	1.33	1.98	0.04	1.37	0.22	2.39	<0.01	<0.01	0.91	0.58
2,3-Dimethyl-2-butene	<0.01	1.34	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.92	1.48	<0.01	<0.01
2,4-Dimethylpentane	<0.01	<0.01	0.05	<0.01	1.63	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
1,3,5-Hexatriene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.01
2,2,3-Trimethylbutane	0.05	0.04	<0.01	0.06	0.05	0.05	<0.01	0.04	0.03	0.03	<0.01	<0.01
Methylcyclopentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.02	0.02
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Unknowns-C7	NA	0.02	NA	NA	0.02	NA	NA	NA	0.04	NA	NA	0.03

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point										
	MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C7-Diolefin	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	<0.01
4-Methylcyclopentene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methylenecyclopentane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzene	1.25	1.31	0.89	*1.25*	1.05	0.65	0.05	1.12	0.78	0.82	1.04	1.02
1-Methyl-1-cyclopentene	0.06	0.07	0.13	0.07	0.07	0.35	0.02	0.07	0.23	0.36	0.08	0.09
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
cis-2-Methyl-3-hexene	0.02	0.02	<0.01	0.03	0.02	0.03	<0.01	<0.01	0.02	0.02	0.01	0.01
3,3-Dimethylpentane+5-Methyl-1-hexene	0.18	0.2	0.22	0.21	0.19	0.14	0.02	0.19	0.11	0.14	0.12	0.16
Cyclohexane	0.48	0.51	0.67	0.61	NA	0.76	0.13	0.51	0.43	1.83	0.19	0.19
trans-2-Methyl-3-hexene	0.17	<0.01	0.18	0.17	<0.01	0.19	<0.01	0.13	0.05	<0.01	0.03	0.03
3,3-Dimethyl-1,4-pentadiene	<0.01	0.16	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01	0.21	0.03	0.04
n-Butanol	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dimethylcyclopentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
trans-2-Ethyl-3-methyl-1-butene	0.07	0.07	0.07	0.07	0.06	0.08	<0.01	0.06	0.06	0.08	0.05	0.1
4-Methyl-1-hexene	0.02	0.02	0.03	0.03	0.02	0.03	<0.01	<0.01	0.02	0.03	0.01	0.03
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methyl-1-hexene	<0.01	0.15	<0.01	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	0.09	0.1
4-Methyl-2-hexene	0.12	<0.01	NA	0.12	0.14	<0.01	<0.01	0.14	0.09	0.15	<0.01	<0.01
2-Methylhexane+C7-Olefin	4.61	4.84	NA	4.81	5.41	4.04	0.56	5.42	7.04	5.64	2.33	2.32
2,3-Dimethylpentane	0.07	0.06	NA	<0.01	0.05	0.03	<0.01	0.06	0.01	0.03	0.05	0.06
Cyclohexene	<0.01	<0.01	NA	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
tert-Amyl-methylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Methylhexane	2.15	2.23	2.11	2.2	2.17	2.6	0.31	2.27	2.4	2.93	1.63	1.62
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	**Sample Point**											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
trans-1,3-Dimethylcyclopentane	0.45	0.48	0.5	0.5	0.48	0.52	0.1	0.48	0.48	0.62	0.36	0.36
cis-1,3-Dimethylcyclopentane	0.36	0.37	0.37	0.37	0.37	0.4	0.09	0.39	0.4	0.54	0.28	0.28
trans-1,2-Dimethylcyclopentane	0.38	0.76	0.45	0.42	*0.39*	0.45	0.17	0.4	0.37	0.42	0.21	0.21
3-Ethylpentane	0.17	0.04	0.16	0.18	0.18	0.15	<0.01	0.18	0.19	0.14	0.13	0.13
3-Methyl11hexene	0.06	0.02	0.09	0.07	<0.01	0.04	<0.01	<0.01	<0.01	0.01	0.03	0.03
2,2,4-Trimethylpentane	3.43	3.44	1.94	3.37	4.29	2.07	0.34	4.16	6.14	3.86	2.49	2.46
Unknowns-C7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03	NA
1-Heptene	0.07	0.03	0.08	0.08	0.07	0.04	<0.01	0.08	<0.01	0.05	0.04	0.07
C7-Olefin	0.06	0.04	0.06	0.06	0.05	0.06	<0.01	0.05	<0.01	<0.01	<0.01	<0.01
2,4-Dimethyl-1,3-pentadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Diolefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Olefin	0.06	0.06	0.07	0.11	0.06	0.08	<0.01	0.06	0.05	0.08	0.04	0.04
C7-Diolefin	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C7-Diolefin	0.11	0.12	<0.01	0.12	0.11	0.13	<0.01	0.11	0.09	0.14	0.08	0.08
C7-Olefin	0.21	0.2	0.26	0.23	0.2	0.23	<0.01	0.22	0.19	0.23	0.18	0.17
n-Heptane	1.75	1.82	2.27	2.16	1.85	2.35	0.19	2	2.24	2.78	1.07	1.05
Unknowns-C8	0.13	0.13	NA	NA	0.11	NA	NA	NA	0.02	0.03	0.09	0.09
cis-3-Heptene	0.17	0.17	0.21	0.19	0.16	0.17	<0.01	0.16	0.11	0.18	0.11	0.11
2-Methyl-2-hexene	0.12	0.12	0.15	0.13	0.11	0.13	<0.01	0.12	0.09	0.13	0.08	0.08
cis-3-Methyl-3-hexene	0.1	<0.01	0.13	0.11	0.09	0.12	<0.01	0.1	0.1	<0.01	0.08	0.08
trans-3-Heptene	0.05	0.1	0.06	0.05	0.05	0.06	<0.01	0.05	0.04	0.07	0.04	0.04
3-Ethyl-2-pentene	0.09	0.05	0.12	0.1	0.09	0.12	<0.01	0.09	0.07	0.12	0.06	0.06
1,5-Dimethylcyclopentene	<0.01	0.08	0.15	0.14	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	0.08	0.07
trans-2-Methyl-3-hexene	0.14	0.14	<0.01	<0.01	0.12	0.17	<0.01	0.14	0.01	0.18	0.09	0.09
Unknowns-C8	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA
C7-Diolefin+C7-Triolefin	0.02	0.03	<0.01	<0.01	0.02	0.02	<0.01	<0.01	0.14	0.02	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
2,3-Dimethyl-2-pentene	0.23	NA	0.03	0.02	0.21	0.29	<0.01	0.2	<0.01	0.23	0.07	0.1
3-Ethylpentene	<0.01	NA	0.32	0.27	<0.01	<0.01	<0.01	<0.01	1.16	<0.01	<0.01	<0.01
Methylcyclohexane	1.08	1.13	1.33	1.25	1.21	1.49	0.56	1.12	<0.01	0.42	0.64	0.63
Unknowns-C8	0.03	NA	NA	NA	0.03	0.03	NA	NA	NA	NA	NA	NA
C7-Olefin	<0.01	0.03	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	0.11	0.01	<0.01	NA
1,1,3-Trimethylcyclopentane	0.1	0.1	0.17	0.11	0.11	0.12	0.06	0.11	0.07	0.12	0.06	NA
2,2-Dimethylhexane	0.06	0.06	0.06	0.06	0.06	0.07	0.02	0.06	<0.01	0.08	0.04	NA
3,3-Dimethyl-1,5-hexadiene	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
C8-Diolefin	0.02	<0.01	<0.01	0.01	0.01	0.02	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
C8-Diolefin	0.01	<0.01	<0.01	0.01	0.06	0.01	<0.01	<0.01	0.27	<0.01	<0.01	<0.01
Ethylcyclopentane	0.21	0.2	0.23	0.22	0.2	0.27	0.07	0.21	<0.01	1.39	0.25	0.21
Unknowns -C8	0.28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylcyclohexene	NA	0.11	0.03	0.02	0.01	<0.01	<0.01	<0.01	0.15	0.01	0.01	<0.01
Methylcyclohexadiene	NA	<0.01	0.03	<0.01	NA	<0.01	<0.01	0.06	<0.01	<0.01	0.11	<0.01
2,2,3-Trimethylpentane	NA	0.08	0.08	0.12	NA	0.12	<0.01	<0.01	0.73	0.08	<0.01	0.11
2,5-Dimethylhexane+C8-Olefin	NA	0.5	0.45	0.5	NA	0.49	0.09	0.49	0.99	0.58	0.43	0.42
2,4-Dimethylhexane	NA	0.61	0.5	0.61	0.68	0.57	0.13	0.65	<0.01	0.77	0.49	0.49
C7-Triolefin+C8-Olefin	NA	<0.01	<0.01	<0.01	0.02	0.02	<0.01	<0.01	0.13	<0.01	<0.01	<0.01
Unknowns-C8	NA	NA	0.03	0.03	NA	NA	NA	NA	NA	NA	NA	NA
trans,cis-1,2,4-Trimethyl-cyclopentane	<0.01	0.16	0.18	0.17	0.16	0.2	0.09	0.17	0.09	0.26	0.12	0.12
3,3-Dimethylhexane+C8-Olefin	NA	0.07	0.07	NA	0.07	0.08	0.03	0.08	<0.01	0.12	0.04	0.03
Unknowns - C8	NA	NA	NA	0.02	NA	NA	NA	NA	NA	NA	NA	NA
C7-Triolefin+C8-Olefin	0.02	<0.01	0.03	<0.01	0.26	0.03	0.11	0.29	NA	<0.01	0.06	0.06
C8-Olefins	<0.01	0.11	0.18	0.32	<0.01	0.2	<0.01	<0.01	<0.01	0.18	<0.01	<0.01
trans,cis-1,2,3-Trimethyl-cyclopentane	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.2	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point										
	MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C8-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	0.23	<0.01	<0.01	0.07	<0.01	<0.01	<0.01
Unknowns - C8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C8-Olefins	0.13	0.13	<0.01	<0.01	0.12	<0.01	<0.01	0.12	<0.01	0.15	0.02	0.02
C8-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3,4-Trimethylpentane	1.23	1.29	0.22	0.15	1.53	0.84	0.14	1.37	2.19	1.49	1.05	1.02
C7-Diolefin	0.12	0.16	0.77	1.11	<0.01	<0.01	<0.01	0.12	<0.01	0.04	0.1	0.12
Unknowns-C8	NA	NA	0.21	NA	NA	0.24	NA	NA	NA	0.02	NA	NA
Toluene	3.99	4.24	3.82	3.62	3.65	0.72	0.1	4.06	3.64	0.67	*5.51*	5.43
2,3,3-Trimethylpentane	0.67	*0.8*	0.59	0.72	0.76	0.47	<0.01	0.69	1.17	<0.01	0.6	0.72
C8-Olefin	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Diolefin	0.09	0.04	0.13	0.14	0.08	0.12	<0.01	0.08	0.07	0.11	0.05	0.05
C8-Olefin	0.02	0.04	0.05	<0.01	0.02	0.04	<0.01	<0.01	0.01	0.02	0.02	0.02
C8-Olefin	0.09	<0.01	0.21	<0.01	0.09	0.13	0.04	<0.01	0.09	<0.01	0.05	0.05
C8-Olefin	<0.01	0.09	0.14	<0.01	<0.01	<0.01	<0.01	0.12	<0.01	0.12	<0.01	<0.01
C8-Olefin	NA	NA	<0.01	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
C8-Diolefin+C8-Olefin	<0.01	<0.01	<0.01	<0.01	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3-Dimethylhexane	0.64	0.65	0.42	0.62	0.66	0.49	0.17	0.69	0.9	0.08	0.43	0.42
Unknowns-C8	NA	NA	0.17	NA	NA	0.17	NA	NA	NA	NA	0.06	0.06
2-Methyl-3-ethylpentane?	0.16	0.17	<0.01	0.19	0.15	0.32	<0.01	0.15	0.09	0.2	0.02	0.02
1,1,2-Trimethylcyclopentane+C7-Triolefin	<0.01	<0.01	0.46	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Diolefin+C8-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefins	0.02	<0.01	0.05	0.03	0.02	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
2-Methylheptane	0.93	1.25	0.99	0.94	0.94	1.13	0.35	1	1.3	1.33	0.84	0.68
4-Methylheptane	0.59	0.37	0.59	0.62	0.63	0.69	0.25	0.64	0.84	0.83	0.25	0.25
C8-Olefin+C7-Diolefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	**Sample Point**											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
cis-1,3-Dimethylcyclohexane	<0.01	<0.01	0.27	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
trans-1,4-Dimethylcyclohexane	0.25	<0.01	<0.01	0.28	0.26	0.37	0.29	0.25	0.24	<0.01	0.12	0.22
3-Methylheptane	<0.01	0.42	<0.01	<0.01	<0.01	<0.01	0.64	<0.01	<0.01	<0.01	<0.01	<0.01
3-Ethylhexane	1.29	1.2	1.16	1.35	1.37	1.53	0.07	1.39	1.81	1.83	0.95	0.87
C8-Diolefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C8	0.01	NA	NA	NA	0.01	0.01	NA	NA	0.01	0.01	NA	NA
C8-Olefins	0.04	<0.01	0.05	0.04	0.04	0.06	<0.01	0.05	0.04	0.05	0.02	0.01
C8-Olefin	<0.01	0.03	0.12	0.09	<0.01	<0.01	<0.01	0.04	0.03	0.06	<0.01	<0.01
1,1-Dimethylcyclohexane	0.06	0.06	<0.01	<0.01	0.06	0.11	<0.01	<0.01	<0.01	0.31	<0.01	<0.01
C8-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C8-Olefin	<0.01	<0.01	0.51	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,1-Dimethylcyclohexane	NA	0.06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C8-Olefin	NA	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C8-Olefin	NA	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
cis-1-Ethyl-3-methylcyclopentane	<0.01	<0.01	<0.01	0.57	0.53	0.41	0.12	<0.01	0.58	<0.01	*0.44*	*0.49*
Unknowns - C8	0.56	NA	NA	NA	NA	NA	NA	0.52	NA	NA	*NA*	*NA*
2,2,5-Trimethylhexane	0.08	0.53	0.08	0.08	0.08	0.17	0.08	0.09	0.18	<0.01	*0.08*	0.08
trans-1-Ethyl-3-methyl-cyclopentane	0.06	0.08	0.07	0.06	0.06	0.12	0.12	0.06	0.11	0.14	0.05	0.05
trans-1-Ethyl-2-methylcyclopentane	0.02	0.06	0.03	0.03	0.02	0.04	<0.01	0.02	0.03	<0.01	0.01	<0.01
1-Methyl-1-ethylcyclopentane	0.02	0.02	0.03	0.02	0.02	0.04	<0.01	0.02	0.03	0.04	0.01	<0.01
1-Octene	0.13	0.02	0.17	0.15	0.14	0.21	0.26	0.13	0.14	0.19	0.07	0.01
C8-Olefin	<0.01	0.12	0.12	0.09	0.08	0.13	<0.01	0.08	0.07	<0.01	0.05	0.06
trans-1,2-Dimethylcyclohexane	0.07	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	<0.01	0.02
C8-Olefins	0.01	<0.01	0.01	0.01	0.01	0.05	<0.01	0.03	0.04	<0.01	0.03	0.03

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	**Sample Point**											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C8-Olefins	0.02	<0.01	0.03	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01
trans-3-Octene	0.12	<0.01	<0.01	<0.01	0.12	0.19	0.03	0.12	0.11	0.16	0.07	0.02
C8-Olefins	<0.01	0.34	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.2
trans-1,3-Dimethylcyclohexane	<0.01	<0.01	0.17	0.15	<0.01	<0.01	<0.01	0.2	0.23	<0.01	<0.01	<0.01
cis-1,4-Dimethylcyclohexane	0.19	<0.01	0.21	0.19	0.19	0.23	0.17	<0.01	<0.01	0.23	0.16	0.08
n-Octane	0.94	0.09	1.1	1.09	1.02	1.36	0.23	1.01	1.6	1.8	0.59	0.53
C8-Olefin	<0.01	0.91	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C8	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.53	NA	NA
C8-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.2	0.18	0.18	0.15	0.15
trans-1,3-Dimethyleyclohexane	<0.01	NA	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
cis-1,4-Dimethyleyelohexane	0.19	NA	NA	NA	0.19	NA	NA	NA	NA	NA	NA	NA
n-Octane	0.94	NA	NA	NA	1.02	NA	NA	NA	NA	NA	NA	NA
C8-Olefin	<0.01	NA	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
C8-Olefin	<0.01	NA	NA	NA	<0.01	NA	NA	NA	NA	NA	NA	NA
trans-2-Octene	0.21	<0.01	0.28	0.24	0.21	0.26	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Isopropylcyclopentane	0.05	0.19	0.07	0.06	0.06	0.07	<0.01	0.05	0.04	0.06	0.03	0.03
C9-Olefin	0.01	0.05	<0.01	NA	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin	<0.01	<0.01	0.01	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin?	0.03	<0.01	<0.01	0.06	0.03	0.05	<0.01	0.02	0.01	0.02	<0.01	<0.01
C9-Olefin?	<0.01	<0.01	0.04	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2,4-Trimethylhexane	0.05	0.03	0.06	0.06	0.05	0.08	0.02	0.04	0.04	0.18	0.03	0.04
2,4,4-Trimethylhexane	0.01	<0.01	0.1	0.11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefins	0.12	0.13	0.02	<0.01	0.12	NA	NA	0.13	0.15	NA	0.11	0.11
Unknowns-C9	NA	0.05	NA	NA	NA	0.16	NA	NA	NA	0.02	NA	NA
2,3,5-Trimethylhexane	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefins	NA	NA	NA	NA	NA	<0.01	0.07	NA	NA	0.14	NA	NA
cis-2-Octene	0.02	<0.01	0.03	<0.01	0.02	0.06	<0.01	<0.01	0.01	0.03	<0.01	0.02

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
2,2,3,4-Tetramethylpentane	0.05	<0.01	0.06	0.05	0.05	<0.01	0.04	<0.01	0.05	<0.01	0.03	0.03
2,2-Dimethylheptane	0.06	0.05	0.07	0.06	0.06	0.08	0.07	0.05	0.05	0.06	0.04	0.04
cis-1,2-Dimethylcyclohexane	0.11	0.06	<0.01	<0.01	0.13	0.13	0.11	0.06	0.15	0.13	0.07	0.07
2,4-Dimethylheptane	0.01	0.11	0.11	0.14	0.01	<0.01	0.01	0.12	0.01	0.05	0.01	0.01
C9-Olefin	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethylcyclohexane	<0.01	<0.01	<0.01	0.17	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propylcyclopentane	0.16	<0.01	0.18	<0.01	0.17	0.27	0.51	<0.01	0.2	0.29	0.14	0.14
2-Methyl-4-Ethylhexane	<0.01	0.17	<0.01	<0.01	0.03	<0.01	<0.01	0.17	<0.01	0.01	<0.01	<0.01
2,6-Dimethylheptane	0.03	<0.01	0.03	0.03	0.14	<0.01	<0.01	<0.01	0.03	<0.01	0.02	0.02
Unknowns-C9	0.14	NA	0.13	0.15	NA	0.18	0.28	0.03	0.18	0.19	0.1	0.1
C9-Olefin	0.12	0.15	<0.01	<0.01	0.11	0.24	0.5	0.15	0.1	0.2	0.07	0.07
1,1,4-Trirnethylcyclohexane	<0.01	0.13	0.13	0.14	NA	<0.01	<0.01	0.11	<0.01	<0.01	<0.01	<0.01
C9-Olefins	0.04	<0.01	0.03	<0.01	0.04	0.02	0.04	<0.01	0.01	0.02	0.02	<0.01
C9-Olefins	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	0.02
1,1,3-Trimethylcyclohexane	<0.01	<0.01	0.14	0.18	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,5&3,5-Dimethylheptane	0.28	<0.01	0.3	<0.01	0.3	0.33	0.23	<0.01	0.42	0.02	0.18	0.18
C9-Olefins	0.08	0.29	0.08	0.29	0.09	0.1	0.1	0.31	0.13	0.13	0.05	0.06
3,3-Dimethylheptane	0.04	0.09	0.04	0.09	0.04	0.05	0.07	0.09	0.06	0.41	0.04	0.04
C9-Isoparaffin	0.04	0.05	0.04	0.04	0.04	0.05	0.05	0.04	0.05	0.06	0.03	0.04
C9-Olefins	0.02	0.04	0.02	0.06	0.01	0.02	<0.01	0.03	0.01	0.01	<0.01	<0.01
2,3,3-Trimethylhexane	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.06	<0.01	<0.01
C9-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethylbenzene	1.33	<0.01	1.27	1.31	1.18	1.62	0.05	1.31	1.58	1.62	1.32	1.33
trans-1,2,4-Trimethylcyclohexane	<0.01	1.39	0.15	<0.01	<0.01	<0.01	0.1	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefins	<0.01	<0.01	<0.01	0.13	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C- G- 0106-007	MP-47C- G- 0106-008	MP-79C- G- 01 06-0 13	MP-38C- G- 0106-019	MP-39C- G- 0106-020	MP-29D- G- 0106-024	MP-29C- G- 0106-025	MP-60C- G- 0106-033	MP-46C- G- 0106-037	MP-46C- G- 016-044	RSI-G- 0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
2,3,4-Trimethylhexane	0.14	<0.01	<0.01	<0.01	0.13	0.09	0.31	0.06	0.08	<0.01	0.08	0.09
C9-Olefins	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.11	<0.01	<0.01
Unknowns-C9	0.02	0.02	NA	NA	0.02	NA	0.02	NA	NA	NA	0.03	0.02
3,3,4-Trimethylhexane?	0.05	0.05	0.06	0.06	0.05	0.04	<0.01	<0.01	0.02	<0.01	0.02	0.03
m-Xylene	2.93	3.05	2.58	2.97	3.01	3.28	0.08	4.21	3.53	2.67	3.04	3.07
p-Xylene	1.22	1.62	1.07	1.23	1.21	1.77	0.04	0.35	1.9	1.55	1.28	1.26
2,3-Dimethylheptane	0.19	0.16	0.17	0.2	0.2	0.06	0.23	<0.01	0.07	0.03	0.11	0.12
3,5-Dimethylheptane	<0.01	<0.01	<0.01	<0.01	<0.01	*<0.01*	<0.01	<0.01	<0.01	0.09	<0.01	<0.01
3,4-Dimethylheptane	0.15	<0.01	0.15	0.16	0.16	0.1	0.15	<0.01	0.1	<0.01	<0.01	0.09
C9-Olefin	<0.01	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.08	<0.01
Unknowns - C9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3-Methyl-3-ethylhexane	0.12	<0.01	<0.01	<0.01	0.12	0.07	0.14	0.07	0.1	0.12	0.08	0.09
C9-Olefin	<0.01	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4-Ethylheptane	0.02	<0.01	0.12	0.12	0.02	0.02	<0.01	<0.01	<0.01	0.11	<0.01	<0.01
4-Methyloctane+C9-Olefin	0.29	0.02	0.27	0.32	0.31	0.32	7:55 AM	0.55	0.17	<0.01	0.22	0.22
2-Methyloctane	0.4	0.3	0.42	0.48	0.49	0.46	0.39	0.21	0.81	0.46	0.31	0.32
C9-Olefin	0.06	0.42	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	0.03	<0.01
C9-Isoparaffin	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	0.72	0.03	0.03
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Ethylheptane	0.11	<0.01	0.1	0.11	0.11	0.05	0.21	0.28	0.05	<0.01	0.08	0.08
3-Methyloctane	0.44	0.11	0.38	0.46	0.43	0.53	0.73	0.38	0.71	0.17	0.34	0.35
C9-Isoparaffin	<0.01	0.46	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.72	<0.01	<0.01
cis-1,2,4-Trimethylcyclohexane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,1,2-Trimethylcyclohexane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o-Xylene	1.58	1.63	1.36	1.61	1.63	1.87	0.12	1.58	2.08	0.24	1.69	1.7
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.05	<0.01	<0.01
C9-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Isoparaffin	0.1	0.1	0.06	0.17	0.12	0.04	0.02	0.09	0.14	<0.01	0.06	0.06

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Unknowns-C9	0.07	NA	0.19	0.13	0.07	NA	NA	0.05	NA	NA	0.06	0.06
trans-1-Ethyl-4-methyl-cyclohexane?	0.12	0.07	NA	NA	0.12	0.24	0.59	0.1	0.07	0.22	0.08	0.08
cis-1-Ethyl-4-methyl-cyclohexane?	0.17	0.12	0.07	0.18	0.2	0.17	0.29	0.18	0.12	0.29	0.04	0.04
Unknowns-C9	NA	NA	0.07	NA	NA	NA	NA	NA	NA	NA	NA	0.04
C9-Isoparaffin	0.04	0.19	0.05	0.04	0.04	0.04	0.04	0.06	0.29	0.11	0.02	0.02
1-Nonene	0.04	0.04	0.03	0.03	0.05	0.04	0.07	<0.01	0.03	0.05	0.04	0.05
Unknowns-C9	NA	NA	NA	NA	NA	0.02	NA	NA	NA	0.11	0.05	0.02
Isobutylcyclopentane	0.01	0.05	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01
C9-Isoparaffin	0.05	<0.01	<0.01	<0.01	0.04	0.05	<0.01	0.04	<0.01	0.02	0.03	0.03
trans-3-Nonene	0.03	0.04	0.05	0.05	0.02	0.02	<0.01	0.02	0.04	<0.01	0.02	0.02
cis-3-Nonene	0.06	0.02	0.03	0.03	0.06	0.04	0.06	0.05	0.02	0.09	0.03	0.03
C9-Isoparaffin	<0.01	0.06	0.07	0.07	<0.01	<0.01	0.07	<0.01	0.02	0.07	<0.01	<0.01
n-Nonane	0.55	0.56	0.5	0.6	0.61	0.76	0.15	0.58	1.15	1.06	0.35	0.36
C10-Olefin	<0.01	0.1	0.1	0.1	0.1	0.1	<0.01	0.09	0.08	0.11	0.07	0.08
trans-2-Nonene	0.1	<0.01	0.04	<0.01	<0.01	<0.01	0.35	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl-1-ethylcyclohexane	0.03	0.03	0.01	0.04	0.03	0.03	0.11	0.03	0.02	0.03	0.02	0.04
Unknowns-C10	0.01	NA	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA
1-Methyl-2-propylcyclopentane	0.16	0.16	0.14	0.01	0.16	0.19	0.13	0.21	0.15	0.15	0.11	0.12
C10-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	<0.01	<0.01	<0.01	0.18	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isopropylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
cis-2-Nonene	0.09	0.08	0.07	0.09	0.09	0.12	0.41	0.05	0.12	0.16	0.05	0.06
tert-Butylcyclopentane	0.03	0.03	0.03	0.03	0.03	0.05	0.16	0.01	0.02	0.05	0.01	0.02
C9-Olefins	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C9-Olefin	<0.01	<0.01	0.06	0.09	<0.01	0.09	<0.01	0.08	0.14	0.1	0.03	0.03
Isopropylcyclohexane	<0.01	<0.01	0.07	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C- G- 0106-007	**MP-47C- G- 0106-008**	**MP-79C- G- 01 06-0 13**	**MP-38C- G- 0106-019**	**MP-39C- G- 0106-020**	**MP-29D- G- 0106-024**	**MP-29C- G- 0106-025**	**MP-60C- G- 0106-033**	**MP-46C- G- 0106-037**	**MP-46C- G- 016-044**	**RSI-G- 0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
3,3,5-Trimethylheptane	0.08	0.08	<0.01	<0.01	0.1	<0.01	0.08	<0.01	<0.01	<0.01	<0.01	<0.01
2,2-Dimethyloctane	<0.01	<0.01	<0.01	<0.01	0.1	0.12	0.33	0.1	0.16	<0.01	0.07	<0.01
2,4-Dimethyloctane	0.1	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.17	<0.01	0.08
1-Methyl-4-isopropylcyclohexane?	0.04	0.04	0.06	0.06	0.05	0.07	0.07	0.04	0.03	0.05	<0.01	<0.01
sec-Butylcyclopentane	0.04	0.04	0.03	0.04	0.04	0.05	0.11	0.04	0.05	0.06	0.02	0.03
2,6-Dimethyloctane	0.16	0.16	0.17	0.2	0.17	0.23	0.83	0.2	0.24	<0.01	0.1	0.11
2,5-Dimethyloctane?	0.04	0.03	0.01	0.15	0.03	0.06	<0.01	<0.01	<0.01	0.37	<0.01	<0.01
Butylcyclopentane	0.13	0.13	0.11	<0.01	0.08	<0.01	0.23	0.07	0.09	0.21	0.08	0.09
Propylcylohexane	<0.01	<0.01	<0.01	<0.01	0.07	0.17	0.14	0.07	0.09	<0.01	<0.01	<0.01
3,6-Dimethyloctane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl-2-ethylcyclohexane	0.16	0.16	0.13	0.17	0.16	0.28	0.9	0.15	0.23	0.32	0.08	0.09
C10-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propylbenzene	0.55	0.55	0.45	0.56	0.51	0.74	0.58	0.56	0.69	0.59	0.48	0.45
3,3-Dimethyloctane	0.06	0.06	0.08	0.06	0.06	0.04	0.79	0.05	0.03	<0.01	0.02	0.03
3-Methyl-5-ethylheptane	0.05	0.05	<0.01	0.06	0.05	0.03	0.02	0.04	<0.01	0.17	<0.01	<0.01
C10-Olefin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	0.01	<0.01	<0.01	<0.01
1-Ethyl-3-methylbenzene	1.44	1.44	1.48	1.46	1.48	1.55	0.03	1.5	1.73	0.64	1.55	1.42
1-Ethyl-4-methylbenzene	0.69	0.69	0.58	0.72	0.71	0.78	0.19	0.71	0.82	0.62	0.58	0.69
C10-Naphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,3,5-Trimethylbenzene	0.86	0.85	0.66	0.89	0.89	1.17	0.87	0.87	1.24	0.97	0.7	0.75
2,3-Dimethyloctane	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	0.08	<0.01	<0.01
5-Methylnonane	<0.01	<0.01	0.06	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4-Methylnonane	0.13	0.13	<0.01	<0.01	0.14	0.07	0.35	0.12	0.08	<0.01	0.05	0.06
2-Methylnonane	0.14	0.14	0.05	0.14	0.15	0.1	0.69	0.14	0.09	0.08	0.1	0.11
1-Ethyl-2-methylbenzene	0.78	0.77	0.29	0.79	1.08	0.84	0.33	0.84	1.22	0.83	0.63	0.65
3-Ethyloctane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.29	<0.01	<0.01
C10-Naphthene	0.06	0.06	<0.01	0.06	0.06	0.03	0.28	0.04	0.04	0.04	0.03	0.04
3-Methylnonane	0.22	0.22	0.12	0.23	0.25	0.36	0.88	0.21	0.37	<0.01	0.14	0.19
C10-Olefin	<0.01	<0.01	<0.01	0.1	<0.01	0.02	0.27	<0.01	<0.01	0.03	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C10-Isoparaffin	0.09	0.08	0.02	<0.01	0.11	0.02	<0.01	0.07	0.16	0.48	0.01	0.03
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
1,2,4-Trimethylbenzene	2.28	2.21	1.91	2.36	2.39	3.78	0.28	2.35	3.93	2.61	2.2	2.22
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.38	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	0.26	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C10	0.05	NA	NA	NA	NA	NA	NA	NA	NA	0.04	NA	NA
Isobutylcyclohexane	0.02	0.05	0.02	0.02	0.05	0.02	0.45	0.03	<0.01	0.01	0.01	0.04
C10-Isoparaffin	0.01	0.02	<0.01	0.02	0.02	<0.01	0.11	<0.01	<0.01	<0.01	<0.01	0.02
C10-Isoparaffin	<0.01	<0.01	0.01	0.03	0.01	0.02	0.32	0.05	0.01	<0.01	0.02	<0.01
1-Decene	0.02	0.03	0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02
C10-Isoparaffin	0.02	0.03	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01
C10-Isoparaffin	0.02	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Aromatic	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Naphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutylbenzene	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	0.02	<0.01
trans-1-Methyl-2-propyl-cyclohexane?	0.04	0.04	<0.01	0.05	0.05	0.03	<0.01	0.04	<0.01	<0.01	<0.01	0.03
C10-Isoparaffin	0.1	0.1	0.07	0.12	0.12	0.1	0.3	0.1	0.13	0.03	0.04	<0.01
sec-Butylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06
n-Decane	0.38	0.36	0.26	0.35	0.35	0.44	0.64	0.35	0.56	0.75	0.21	0.24
C11-Isoparaffin	0.05	<0.01	<0.01	0.07	0.06	0.03	<0.01	<0.01	<0.01	0.07	<0.01	<0.01
C11-Isoparaffin	<0.01	0.04	0.03	<0.01	<0.01	0.02	0.14	<0.01	0.05	<0.01	<0.01	0.02
Unknowns-C11	NA	NA	NA	NA	NA	NA	0.16	NA	NA	NA	NA	NA
1,2,3-Trimethylbenzene	0.56	0.52	0.47	0.59	0.59	0.56	0.05	0.61	0.61	0.51	0.54	0.52
1-Methyl-3-isopropylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C11-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.19	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl-4-isopropylbenzene	0.04	<0.01	0.02	0.05	0.05	0.04	0.11	0.02	0.03	0.03	0.01	0.02
C11-Isoparaffin	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
C11-Isoparaffin?	0.05	0.05	0.03	0.08	0.06	0.05	0.34	0.03	0.05	<0.01	0.02	0.03
2,3-Dihydroindene	0.25	0.33	0.19	0.27	0.28	0.23	0.27	0.26	0.28	0.18	0.28	0.29
Unknowns-C11	NA	NA	NA	NA	0.02	NA	0.26	NA	NA	NA	NA	NA
sec-Butylcyclohexane	0.08	0.08	0.04	0.06	0.06	0.16	0.08	<0.01	<0.01	0.08	<0.01	<0.01
Unknowns-C11	NA	NA	NA	NA	NA	NA	NA	0.05	NA	NA	0.03	0.04
C11-Isoparaffin	0.02	0.02	0.02	0.03	0.03	0.02	1.88	0.02	0.07	0.05	0.01	0.02
1-Methyl-2-isopropylbenzene	0.02	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.01	<0.01	0.04	0.04
3-Ethylnonane	0.05	0.03	0.04	0.03	0.04	0.08	<0.01	0.07	0.03	0.34	0.03	0.03
C11-Isoparaffin	0.04	0.05	0.02	0.1	0.1	0.09	0.1	<0.01	0.08	0.11	0.01	<0.01
Unknowns-C11	NA	NA	NA	NA	NA	0.05	0.75	NA	NA	NA	NA	0.02
C10-Naphthene	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.16	<0.01	<0.01
C11-Isoparaffin	<0.01	<0.01	0.22	<0.01	<0.01	0.26	0.39	0.29	<0.01	<0.01	<0.01	<0.01
1,3-Diethylbenzene	0.24	0.21	<0.01	0.25	0.25	<0.01	0.51	<0.01	0.3	0.2	0.27	0.22
1-Methyl-3-propylbenzene	0.48	<0.01	0.38	0.49	0.51	0.47	<0.01	0.51	<0.01	0.39	0.33	0.36
1,4-Diethylbenzene	<0.01	0.54	<0.01	0.39	<0.01	<0.01	0.72	<0.01	0.51	<0.01	<0.01	<0.01
1-Methyl-4-propylbenzene	0.36	<0.01	0.29	<0.01	0.4	0.33	0.19	0.41	<0.01	0.27	0.25	0.27
Butylbenzene	<0.01	0.4	<0.01	<0.01	<0.01	<0.01	0.15	<0.01	0.37	<0.01	<0.01	<0.01
3,5-Dimethyl-1-ethylbenzene	0.43	<0.01	0.36	0.45	0.46	0.42	<0.01	0.46	<0.01	0.37	0.33	0.34
Unknowns-C11	NA	NA	NA	NA	NA	NA	0.37	NA	NA	NA	NA	NA
1,2-Diethylbenzene?	<0.01	0.48	0.04	0.07	0.07	0.06	0.34	0.06	0.42	0.02	0.03	0.04
C11-Isoparaffin	0.08	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.09	<0.01	<0.01
C10-Aromatic	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Aromatic	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C10-Aromatic	0.03	0.02	<0.01	0.17	0.03	<0.01	<0.01	0.02	<0.01	<0.01	0.01	0.02
1-Methyl-2-propylbenzene	0.21	0.15	0.12	<0.01	0.17	0.22	0.88	0.17	0.01	0.27	0.11	0.11
C10-Aromatic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.15	<0.01	<0.01	<0.01
5-Methyldecane	0.07	<0.01	0.04	0.07	0.07	0.1	0.62	0.07	<0.01	<0.01	0.05	0.06

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point											
	MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
4-Methyldecane	0.04	0.06	0.02	0.04	0.05	0.02	<0.01	0.04	0.06	0.16	0.04	0.04
2-Methyldecane	0.08	0.03	0.05	0.09	0.09	0.11	0.58	0.08	0.02	<0.01	0.06	0.06
C11-Isoparaffin	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.15	<0.01	<0.01
1,4-Dimethyl-2-ethylbenzene	0.3	0.26	0.24	0.31	0.32	0.32	0.41	0.32	<0.01	0.3	0.28	0.28
1,3-Dimethyl-4-ethylbenzene	0.32	0.28	0.26	0.34	0.36	0.3	0.41	0.36	0.31	0.24	0.3	0.3
C11-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.32	<0.01	<0.01	<0.01
3-Methyldecane	0.09	0.07	0.05	*0.08*	0.09	0.11	0.39	0.09	<0.01	<0.01	0.07	0.07
1,2-Dimethyl-4-ethylbenzene+C1-lndan	0.51	<0.01	0.46	0.59	0.6	0.47	0.59	0.6	0.07	0.59	0.49	0.49
C11-Isoparaffin	<0.01	0.55	<0.01	<0.01	<0.01	<0.01	0.15	<0.01	0.76	0.16	<0.01	<0.01
Unknowns-C11	NA	NA	NA	NA	NA	0.03	0.36	NA	NA	0.01	NA	NA
1,3-Dimethyl-2-ethylbenzene	0.09	0.07	0.05	0.08	0.08	0.09	0.35	0.06	0.05	0.04	0.05	0.05
C11-Isoparaffin	0.03	<0.01	0.01	<0.01	<0.01	0.06	0.65	<0.01	0.01	0.02	<0.01	0.01
C11-Isoparaffin	0.03	0.02	0.02	0.03	0.02	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	<0.01
1-Methyl-4-tert-butylbenzene	0.06	0.02	0.04	0.03	0.02	0.05	0.38	<0.01	0.01	0.03	0.03	0.01
Unknowns-C11	NA	NA	NA	0.08	NA	0.07	0.38	0.11	NA	0.01	NA	NA
1,2-Dimethyl-3-ethylbenzene	0.16	0.04	0.11	*0.15*	0.06	0.17	0.65	0.09	0.01	0.17	0.07	0.11
1-Ethyl-2-isopropylbenzene	<0.01	0.13	<0.01	<0.01	0.16	<0.01	0.17	<0.01	0.17	<0.01	0.1	0.11
n-Undecane	0.41	0.34	0.13	0.22	0.22	0.39	0.52	0.2	*0.42*	0.6	0.15	0.15
Unknowns-C12	NA	NA	NA	NA	NA	NA	0.51	NA	*NA*	NA	NA	NA
1-Ethyl-4-isopropylbenzene	0.03	0.02	<0.01	0.02	0.02	0.04	0.33	<0.01	<0.01	0.01	<0.01	0.01
C12-Isoparaffin	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,2,4,5-Tetramethylbenzene	<0.01	<0.01	<0.01	0.24	0.25	0.19	<0.01	0.23	0.24	<0.01	<0.01	0.18

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	**Sample Point**											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
2-Methylbutylbenzene	0.21	0.17	<0.01	<0.01	<0.01	<0.01	0.41	<0.01	<0.01	0.14	0.24	<0.01
1,2,3,5-Tetramethylbenzene	0.3	0.24	0.41	0.37	0.38	0.27	0.46	0.34	0.4	0.21	0.27	0.29
C11-Aromatic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
C12-Isoparaffin	<0.01	0.04	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C11-Aromatic	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	0.66	<0.01	<0.01	0.11	<0.01	<0.01
C11-Aromatic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
C11-Aromatic	<0.01	<0.01	<0.01	0.07	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04
1-tert-Butyl-2-methylbenzene	<0.01	0.05	<0.01	<0.01	<0.01	0.12	<0.01	<0.01	0.04	<0.01	0.04	<0.01
C11-Aromatic	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	1	<0.01	<0.01	0.16	<0.01	<0.01
Unknowns-C12	NA	NA	NA	NA	NA	0.02	0.29	NA	NA	0.04	NA	NA
Unknowns-C12	0.01	NA	NA	NA	NA	NA	0.35	NA	NA	0.05	NA	NA
1-Ethyl-2-propylbenzene	0.28	0.22	0.33	0.3	0.32	0.27	0.18	0.6	0.35	0.23	0.26	0.26
Unknowns-C12	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA
C11-Aromatic	0.1	0.08	0.04	0.09	0.1	0.12	0.54	0.05	0.1	0.13	0.06	0.06
C11-Aromatic	0.1	0.08	0.06	0.11	0.12	0.1	0.51	0.08	0.12	0.09	0.08	0.08
C11-Aromatic	0.09	0.07	0.04	*0.07*	0.07	0.13	0.91	0.05	0.08	0.15	0.04	0.04
1-Methyl-3-butylbenzene	0.21	0.16	0.15	0.23	0.24	0.19	0.64	0.21	0.24	0.16	0.23	0.24
1,2,3,4-Tetramethylbenzene+C11-Aromatic	0.2	0.15	0.13	0.21	0.22	0.19	0.62	0.19	0.22	0.18	0.16	0.16
Pentylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3	<0.01	<0.01	<0.01	<0.01	<0.01
trans-1-Methyl-2-(4-methylpentyl)	<0.01	0.09	0.06	0.13	0.13	0.13	0.35	0.08	0.14	0.14	0.06	<0.01
C11-Aromatic	0.11	<0.01	<0.01	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.12
C11-Aromatic	0.12	0.09	0.07	0.08	0.13	0.13	0.54	0.09	0.13	0.13	0.08	0.08
C11-Aromatic	0.1	NA	0.04	<0.01	<0.01	<0.01	1.18	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C12	NA	0.04	NA	NA	NA	0.19	NA	NA	NA	0.23	NA	0.06
C12-Isoparaffin	0.13	0.09	<0.01	<0.01	0.08	0.08	<0.01	0.07	0.13	<0.01	0.07	0.08

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point										
	MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
1,2,3,4-Tetrahydronaphthalene	0.09	0.07	0.07	0.11	0.12	0.09	0.61	0.13	0.11	0.1	0.06	0.02
1-tert-Butyl-3,5-dimethylbenzene	0.05	0.1	0.07	0.13	0.14	0.18	0.87	<0.01	0.05	0.2	0.02	0.1
Naphthalene	0.14	0.17	0.1	0.27	0.29	0.22	0.64	0.11	0.15	0.19	0.09	0.25
C12-lsoparaffin?	0.23	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.27	0.31	0.07	0.24	<0.01
C11-Aromatic	<0.01	0.05	<0.01	0.08	0.08	0.07	0.35	<0.01	<0.01	0.07	0.04	0.05
C11-Aromatic	0.07	0.06	0.01	0.11	0.11	0.1	0.55	0.06	0.03	0.09	0.08	0.1
C12-Isoparaffin	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	0.1	<0.01	<0.01	<0.01
C12-Isoparaffin	<0.01	0.04	0.01	0.07	0.07	0.06	0.39	<0.01	<0.01	<0.01	0.05	0.06
C11-Aromatic	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.06	0.06	<0.01	<0.01
Unknowns-C12	NA	0.14	NA	NA	NA	0.06	0.51	NA	NA	NA	NA	NA
C12-lsoparaffin	0.04	0.03	0.03	0.09	0.09	0.07	0.51	<0.01	<0.01	0.06	0.05	0.07
1,3-Dipropylbenzene	0.19	0.03	0.12	0.2	0.21	0.24	1.26	0.07	0.09	0.22	0.14	0.16
Unknowns-C12	0.04	0.02	NA	0.03	0.03	0.09	1.14	NA	NA	0.14	NA	0.01
n-Dodecane	0.36	0.27	0.1	0.18	0.19	0.36	1.08	0.19	0.22	0.6	0.11	0.12
C12-lsoparaffin?	0.02	0.01	<0.01	0.02	0.02	0.04	0.44	0.16	0.31	0.08	<0.01	<0.01
C11-Aromatic?	0.02	0.01	<0.01	<0.01	<0.01	0.04	0.33	<0.01	<0.01	0.01	<0.01	0.02
C11-Aromatic	0.03	0.02	<0.01	0.05	0.05	0.04	0.34	<0.01	<0.01	0.01	0.02	0.02
Unknowns-C13	0.01	NA	NA	NA	NA	0.03	0.3	NA	NA	NA	NA	0.04
1,3,5-Triethylbenzene	0.14	0.1	0.05	0.09	0.09	0.27	2.16	<0.01	0.02	0.31	0.05	0.06
C11-Aromatic?	0.04	0.02	0.02	0.04	0.04	0.06	0.56	0.06	0.1	0.07	0.03	<0.01
C11-Aromatic	0.05	0.03	0.03	0.06	0.06	0.07	0.48	0.03	0.04	0.07	0.04	0.05
1-tert-Butyl-4-ethylbenzene	0.02	0.01	0.01	0.03	0.03	0.04	0.33	0.05	0.06	0.04	0.02	0.02
Unknowns-C13	0.1	0.06	0.03	NA	0.07	0.17	0.66	0.02	0.03	0.09	0.03	0.04
1,2,4-Triethylbenzene	0.13	0.08	0.05	0.27	0.11	0.19	1.44	0.04	0.07	0.2	0.08	0.1
Unknowns-C13	0.05	0.03	0.04	NA	0.02	0.03	0.73	0.09	0.11	0.09	0.06	0.04
Unknowns-C13	0.03	0.02	NA	NA	0.05	0.09	0.36	NA	0.02	0.04	NA	0.02
Unknowns-C13	NA	NA	NA	NA	0.02	0.07	0.62	NA	0.05	0.1	NA	NA

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	Sample Point										
	MP-47C-G-0106-007	MP-47C-G-0106-008	MP-79C-G-01 06-0 13	MP-38C-G-0106-019	MP-39C-G-0106-020	MP-29D-G-0106-024	MP-29C-G-0106-025	MP-60C-G-0106-033	MP-46C-G-0106-037	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
1-Methyl-4-pentylbenzene	0.08	0.05	0.02	0.07	0.07	0.14	0.62	0.03	0.03	0.15	0.05	0.08
Unknowns-C13	0.05	0.03	0.02	NA	0.02	0.09	1.31	0.05	0.08	0.09	0.01	0.03
Unknowns-C13	0.03	0.02	NA	NA	0.04	0.05	0.91	0.02	0.04	0.12	0.01	0.03
Unknowns-C13	0.04	0.02	NA	NA	0.04	0.09	0.66	NA	0.03	0.05	0.01	0.02
Unknowns-C13	NA	NA	NA	NA	0.02	NA	NA	NA	NA	NA	NA	NA
Hexylbenzene	0.1	0.06	0.04	0.19	0.08	0.19	1.63	0.01	0.03	0.21	0.05	0.06
Unknowns-C13	0.02	NA	0.05	0.02	0.02	0.05	0.56	0.22	0.08	0.11	NA	0.01
2-Methylnaphthalene	0.21	0.09	0.13	0.2	0.32	0.25	NA	0.05	0.02	0.24	0.29	0.23
Unknowns-C13	0.06	0.03	NA	0.04	0.1	0.11	1.53	0.01	0.21	0.06	0.02	0.05
Unknowns-C13	0.21	0.14	NA	0.09	0.18	0.2	1.01	0.06	0.01	0.13	0.04	0.14
Unknowns-C13	0.11	0.03	NA	NA	NA	0.16	0.55	NA	0.12	0.23	0.11	NA
Unknowns-C13	NA	NA	NA	NA	NA	NA	0.32	NA	NA	0.17	NA	NA
Unknowns-C13	NA	NA	NA	NA	NA	NA	1.19	NA	NA	NA	NA	NA
n-Tridecane	0.02	0.06	0.06	0.07	0.04	0.06	0.67	<0.01	<0.01	0.07	<0.01	<0.01
1-Methylnaphthalene	0.02	0.01	<0.01	0.03	0.05	0.04	0.42	0.12	0.14	0.05	0.02	0.02
Unknowns-C14	0.04	NA	NA	0.01	0.01	0.09	0.79	NA	0.02	0.1	NA	0.01
Unknowns-C14	0.01	NA	NA	0.02	0.02	0.04	0.43	NA	0.02	0.04	NA	0.01
Unknowns-C14	0.03	NA	NA	0.01	0.01	0.02	0.24	NA	0.02	0.02	NA	0.01
Unknowns-C14	0.01	NA	NA	NA	NA	0.02	0.24	NA	0.02	0.1	NA	NA
Unknowns-C14	0.04	NA	NA	NA	NA	0.07	0.74	NA	0.01	0.03	NA	NA
Unknowns-C14	0.01	NA	NA	NA	NA	0.02	0.27	NA	0.02	0.03	NA	NA
Unknowns-C14	0.02	NA	NA	NA	NA	0.03	0.34	NA	NA	0.13	NA	NA
Unknowns-C14	0.02	NA	NA	NA	NA	0.1	0.96	NA	NA	0.05	NA	NA
Unknowns-C14	NA	NA	NA	NA	NA	0.04	0.4	NA	NA	0.07	NA	NA
Unknowns-C14	NA	NA	NA	NA	NA	0.06	0.66	NA	NA	NA	NA	NA
Unknowns-C14	NA	NA	NA	NA	NA	0.05	0.43	NA	NA	NA	NA	NA
trans-7-Decene	0.02	<0.01	<0.01	<0.01	<0.01	0.05	0.41	<0.01	0.01	0.07	<0.01	0.01
Unknowns-C14	NA	NA	NA	NA	NA	0.03	0.38	NA	0.01	0.06	NA	NA
2,6-Dimethylnaphthalene	0.01	<0.01	<0.01	<0.01	<0.01	0.07	0.39	<0.01	0.01	0.03	<0.01	<0.01
2,7-Dimethylnaphthalene	0.03	0.02	<0.01	<0.01	<0.01	<0.01	0.71	<0.01	0.01	0.08	<0.01	<0.01

Table 1(b)
Concentrations of Various Chemicals in LNAPL, PIONAOX Analysis (Volume %)
Apex Oil, Hartford, Illinois

Component	**Sample Point**											
	MP-47C-G-0106-007	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Unknowns-C14	0.03	NA	NA	NA	0.06	0.02	0.26	NA	0.03	0.02	NA	0.03
Unknowns-C14	NA	NA	NA	NA	NA	0.07	0.72	NA	NA	0.08	NA	NA
1,3-Dimethylnaphthalene	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.03
1,6-Dimethylnaphthalene	0.05	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01
Unknowns-C14	NA	0.05	NA	NA	NA	0.09	NA	NA	0.02	0.06	NA	NA
n-Tetradecane	0.11	0.06	<0.01	0.03	0.02	0.12	1.14	<0.01	0.03	0.13	0.02	0.01
1,5-Dimethylnaphthalene	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.31	<0.01	<0.01	<0.01	<0.01	<0.01
1,4-Dimethylnaphthalene	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Unknowns-C15	0.01	0.02	NA	NA	0.02	0.08	0.87	<0.01	0.02	0.09	0.04	0.03
Acenaphthalene	0.02	0.01	<0.01	<0.01	<0.01	0.06	0.55	NA	0.01	0.07	<0.01	0.01
Unknowns-C15	0.04	0.02	NA	NA	0.02	0.03	0.3	NA	NA	0.03	NA	NA
Unknowns-C15	NA	NA	NA	NA	0.01	0.04	0.58	NA	NA	0.05	NA	NA
1,2-Dimethylnaphthalene	0.02	<0.01	<0.01	<0.01	<0.01	0.03	0.17	0.01	<0.01	0.04	<0.01	0.01
Unknowns-C15	0.01	0.02	NA	NA	NA	0.04	0.13	NA	NA	0.05	NA	NA
Unknowns-C15	0.01	NA	NA	NA	NA	0.03	0.39	NA	NA	0.03	NA	NA
Unknowns-C15	0.03	NA	NA	NA	NA	0.07	0.31	NA	NA	0.08	NA	NA
Unknowns-C15	0.01	NA	NA	NA	NA	0.03	1.01	NA	NA	0.03	NA	NA
Unknowns-C15	0.01	NA	NA	NA	NA	0.01	0.19	NA	NA	0.01	NA	NA
Unknowns-C15	NA	NA	NA	NA	NA	0.02	0.25	NA	NA	0.01	NA	NA
Unknowns-C15	NA	NA	NA	NA	NA	NA	0.33	NA	NA	0.03	NA	NA
n-Pentadecane	0.08	0.04	<0.01	<0.01	<0.01	0.06	0.42	<0.01	0.01	0.04	<0.01	<0.01
C15+(Balance)	NA	NA	NA	NA	NA	NA	3.59	NA	NA	NA	NA	NA
Total	**99.55**	**99.79**	**97.31**	**99.82**	**100.21**	**99.26**	**99.96**	**100.04**	**99.88**	**98.95**	**100.02**	**99.87**

Notes:

Detection Limit 0.01 <: Not detect values

NA: Not available

The identification of components is based on relative retention time data. Identification in some cases is speculative.

Data obtained from Maxxam Analytics Laboratory reports (January 2006)

Table 1(c)
Concentration of Selected Constituents in LNAPL (Weight %), January 2006
Apex Oil, Hartford, Illinois

Component	**Gasoline Check Standard**	**MP-47C-G-0106-007**	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)		46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Screening Interval (ft bgs)		23.8 - 38.5		35.1 - 37.1	24 - 38.7	29 - 43.7	31.5 - 41.2	21.6 - 28.3	22 - 36.7	26.8 - 41.5		Unknown	
Stratum		Main		Main	Main	Main	Main	Rand	Main	Main		Unknown	
n-Hexane	3.4	3.06	3.24	3.71	3.31	2.91	3.59	0.08	3.11	2.19	3.31	2.09	2.07
Benzene	0.93	1.48	1.57	1.08	1.47	1.25	0.76	0.05	1.33	0.91	0.99	1.27	1.25
Methylcyclohexane	0.49	1.12	1.19	1.41	1.29	1.26	1.54	0.54	1.16	<0.01	1.46	0.69	0.67
Toluene	7.06	4.99	5.21	4.17	4.48	4.4	0.83	0.11	4.93	4.45	0.79	6.87	6.73
m-Xylene	5.27	3.42	3.6	3.08	3.44	3.52	3.8	0.07	4.92	4.05	3.15	3.65	3.68
p-Xylene	2.06	1.42	1.59	1.28	1.42	1.41	2.04	0.04	0.41	2.17	1.82	1.53	1.51
o-Xylene	2.72	1.88	1.96	1.66	1.9	1.94	2.2	0.13	1.88	2.43	0.29	2.07	2.08
1,2,4-Trimethylbenzene	3.94	2.7	2.65	2.32	2.77	2.83	4.44	0.26	2.78	4.57	2.6	2.68	2.71
1,3,5-Trimethylbenzene	1.45	1	1	0.79	1.03	1.04	1.36	0.95	1.02	1.42	1.14	0.85	0.9
Isopentane	8.03	5.68	5.91	7.97	4.94	5.15	3.72	0.71	5.45	2.41	3.78	9.11	8.96
n-Butane	2.19	1.43	1.39	3.06	0.91	1.53	0.34	0.11	1.31	0.45	0.49	8	7.8
1,2-Butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total	**37.54**	**28.18**	**29.31**	**30.53**	**26.96**	**27.24**	**24.62**	**3.05**	**28.3**	**25.05**	**19.82**	**38.81**	**38.36**

Notes:

<: Below detection limit

Detection Limit: 0.01%

ft bgs: Feet below ground surface

Data obtained from Maxxam Analytics Laboratory reports (January 2006)

Table 1(d)
Concentration of Selected Constituents in LNAPL (Volume %), January 2006
Apex Oil, Hartford, Illinois

Component	**MP-47C-G-0106-007**	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Screening Interval (ft bgs)	23.8 - 38.5		35.1 - 37.1	24 - 38.7	29 - 43.7	31.5 - 41.2	21.6 - 28.3	22 - 36.7	26.8 - 41.5		Unknown	
Stratum	Main		Main	Main	Main	Main	Rand	Main	Main		Unknown	
n-Hexane	3.43	3.59	3.89	3.58	3.13	4.06	0.1	3.49	2.5	3.67	2.28	2.26
Benzene	1.25	1.31	0.89	1.25	1.05	0.65	0.05	1.12	0.78	0.82	1.04	1.02
Methylcyclohexane	1.08	1.13	1.33	1.25	1.21	1.49	0.56	1.12	<0.01	0.42	0.64	0.63
Toluene	3.99	4.24	3.82	3.62	3.65	0.72	0.1	4.06	3.64	0.67	5.51	5.43
m-Xylene	2.93	3.05	2.58	2.97	3.01	3.28	0.08	4.21	3.53	2.67	3.04	3.07
p-Xylene	1.22	1.62	1.07	1.23	1.21	1.77	0.04	0.35	1.9	1.55	1.28	1.26
o-Xylene	1.58	1.63	1.36	1.61	1.63	1.87	0.12	1.58	2.08	0.24	1.69	1.7
1,2,4-Trimethylbenzene	2.28	2.21	1.91	2.36	2.39	3.78	0.28	2.35	3.93	2.61	2.2	2.22
1,3,5-Trimethylbenzene	0.86	0.85	0.66	0.89	0.89	1.17	0.87	0.87	1.24	0.97	0.7	0.75
Isopentane	6.77	6.97	9.29	5.94	6.14	4.47	0.9	6.5	2.87	4.47	10.55	10.39
n-Butane	1.82	1.76	3.82	1.17	1.95	0.44	0.14	1.67	0.58	0.62	9.92	9.69
1,2-Butadiene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total	**27.21**	**28.36**	**30.62**	**25.87**	**26.26**	**23.7**	**3.24**	**27.32**	**23.05**	**18.71**	**38.85**	**38.42**

Notes:

<: Below detection limit

Detection Limit: 0.01%

ft bgs: Feet below ground surface

Data obtained from Maxxam Analytics Laboratory reports (January 2006)

Table 1(e)
Concentration of Selected Constituents in LNAPL (Mole %), January 2006
Apex Oil, Hartford, Illinois

Component	**MP-47C-G-0106-007**	**MP-47C-G-0106-008**	**MP-79C-G-01 06-0 13**	**MP-38C-G-0106-019**	**MP-39C-G-0106-020**	**MP-29D-G-0106-024**	**MP-29C-G-0106-025**	**MP-60C-G-0106-033**	**MP-46C-G-0106-037**	**MP-46C-G-016-044**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Screening Interval	23.8 - 38.5		35.1 - 37.1	24 - 38.7	29 - 43.7	31.5 - 41.2	21.6 - 28.3	22 - 36.7	26.8 - 41.5		Unknown	
Stratum	Main		Main	Main	Main	Main	Rand	Main	Main		Unknown	
n-Hexane	3.73	3.95	4.52	4.03	3.55	4.37	0.10	3.79	2.67	4.03	2.55	2.52
Benzene	1.99	2.11	1.45	1.98	1.68	1.02	0.07	1.79	1.22	1.33	1.71	1.68
Methylcyclohexane	1.20	1.27	1.51	1.38	1.35	1.65	0.58	1.24	0.01	1.56	0.74	0.72
Toluene	5.69	5.94	4.75	5.11	5.01	0.95	0.13	5.62	5.07	0.90	7.83	7.67
m-Xylene	3.38	3.56	3.05	3.40	3.48	3.76	0.07	4.87	4.01	3.12	3.61	3.64
p-Xylene	1.40	1.57	1.27	1.40	1.39	2.02	0.04	0.41	2.15	1.80	1.51	1.49
o-Xylene	1.86	1.94	1.64	1.88	1.92	2.18	0.13	1.86	2.40	0.29	2.05	2.06
1,2,4-Trimethylbenzene	2.36	2.31	2.03	2.42	2.47	3.88	0.23	2.43	3.99	2.27	2.34	2.37
1,3,5-Trimethylbenzene	0.87	0.87	0.69	0.90	0.91	1.19	0.83	0.89	1.24	1.00	0.74	0.79
Isopentane	8.27	8.60	11.60	7.19	7.49	5.41	1.03	7.93	3.51	5.50	13.26	13.04
n-Butane	2.58	2.51	5.53	1.64	2.76	0.61	0.20	2.37	0.81	0.89	14.45	14.09

Notes:
Mole % calculated using weight % of each chemical and assuming an average LNAPL molecular weight of 105 g/mole

Table 1(f)
Concentrations of Oxygenates in LNAPL (Weight %), January 2006
Apex Oil, Hartford, Illinois

Component	MP-47C-G-0106-	MP-47C-G-0106-	MP-79C-G-01 06-0	MP-38C-G-0106-	MP-39C-G-0106-	MP-29D-G-0106-	MP-29C-G-0106-	MP-60C-G-0106-	MP-46C-G-0106-	MP-46C-G-016-044	RSI-G-0106-045	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Alcohols												
Methanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isopropanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
tert-Butanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
n-Propanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Butanol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutanol	2.09	<0.01	1.48	2.13	0.04	1.47	0.22	2.59	<0.01	<0.01	1.01	0.58
n-Butanol	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Alcohols	**2.09**	**0**	**1.48**	**2.13**	**0.06**	**1.47**	**0.22**	**2.59**	**0**	**0**	**1.01**	**0.58**
Ethers												
Methyl-tert-butylether (MTBE)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	0.04	<0.01	<0.01	<0.01
Methyl-sec-butylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Diisopropylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethyl-tert-butylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
tert-Amyl-methylether	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total ethers	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.09**	**0.04**	**0**	**0**	**0**
Total Oxygenates	**2.09**	**0**	**1.48**	**2.13**	**0.06**	**1.47**	**0.22**	**2.68**	**0.04**	**0**	**1.01**	**0.58**

Table 1(g)
Summary of PIONAX Analysis of LNAPL (Weight %)
Apex Oil, Hartford, IL

Group Type	**MP-47C-G-0106-007**	**MP-47C-G-0106-008**	**MP-79C-G-**	**MP-38C-G-**	**MP-39C-G-**	**MP-29D-G-**	**MP-29C-G-**	**MP-60C-G-**	**MP-46C-G-**	**MP-46C-G-**	**RSI-G-0106-045**	
Sample ID (A604016)	46239	46242	46243	46244	46245	46246	46247	46248	46249	46250	46251	46251Dup
Screening Interval	23.8 - 38.5		35.1 - 37.1	24 - 38.7	29 - 43.7	31.5 - 41.2	21.6 - 28.3	22 - 36.7	26.8 - 41.5		Unknown	
Stratum	Main		Main	Main	Main	Main	Rand	Main	Main		Unknown	
Paraffins	12.47	11.9	18.7	14.64	11.91	12.68	2.15	11.9	9.89	13.61	16.84	17.19
isoParaffins	34.24	35.74	31.76	30.76	38.09	31.23	18.63	36.46	40.28	37.62	32.59	32.61
Olefins	9.73	12.59	13.6	11.31	9.24	9.15	2.83	9.28	9.18	9.49	11.21	10.26
Naphthenes	8.3	10.03	9.15	9.82	8.63	10.94	13.06	7.99	5.16	7.72	6.29	6.54
Aromatics	30.6	28.61	24.51	30.92	30.95	30.62	30.94	30.33	33.66	24.32	31.13	31.59
Oxegenates	2.1	<0.01	1.48	2.13	0.04	1.47	0.22	2.68	0.04	0	1.01	0.58
Total	**97**	**99**	**99**	**100**	**99**	**96**	**68**	**99**	**98**	**93**	**99**	**99**

Notes:

Data obtained from Maxxam Analytics Laboratory reports (January 2006)

Table 2(a)

Detected Chemical Concentrations in LNAPL (µg/kg)

Apex Oil, Hartford, IL

Chemical of Conern	MP-39C*	HMW-18	Ratio
SW8015B Gasoline Range Organics			
GRO	800,000,000	880,000,000	0.91
SW8015B Semi-volatile Hydrocarbons			
DRO	85,000,000	110,000,000	0.77
SW8270C Semivolatile Organics			
2-Methylnaphthalene	1,900,000	2,500,000	0.76
Naphthalene	2,400,000	3,000,000	0.80
SW8260B Volatile Organics			
1,2,4-Trimethylbenzene	26,000,000	35,000,000	0.74
1,3,5-Trimethylbenzene	8,600,000	12,000,000	0.72
4-Isoprpyltoluene	34,000	38,000	0.89
Benzene	10,000,000	7,200,000	1.39
Ethylbenzene	16,000,000	19,000,000	0.84
Isopropylbenzene	200,000	190,000	1.05
Naphthalene	5,700,000	4,800,000	1.19
n-Butylbenzene	200,000	240,000 J	0.83
n-Propylbenzene	5,600,000	6,900,000	0.81
sec-Butylbenzene	79,000	81,000	0.98
Styrene	11,000	7,100	1.55
Toluene	45,000,000	36,000,000	1.25
m,p-Xylene	53,000,000	71,000,000	0.75
o-Xylene	20,000,000	26,000,000	0.77
Xylenes,Total	73,000,000	97,000,000	0.75
Lead Analysis			
Lead Content ICP/AES	205,000	238,200	0.86
Lead (calculated as Tetraethyl Lead, 64.2% Pb)	319,300	371,000	0.86
Organic Lead (Tetraethyl Lead) GC/MS	294,300	287,800	1.02

Notes:

Oxygenates were analyzed by ASTM D 6733M using Chromatography and none of the compounds were detected.

Detailed Hydrocarbon Analysis (PIONAOX) data is presented in Table 2(b), 2(c), and 2(d)

J: Estimated value between MDL and PQL

MDL: Method detection limit

PQL: Practical quantitation limit

*: Located in the alley behind 119 West Date

Data obtained from SPL Laboratory reports (November 2009)

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum)			HMW-18 (Main Stratum)		
	(Screened at 29 - 43.7 ft bgs)			(Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
methane	0	0	0	0.01	0.027	0.061
propane	0.005	0.007	0.011	0.007	0.011	0.017
i-butane	0.272	0.356	0.468	0.207	0.27	0.359
butene-1	0.059	0.072	0.105	0.033	0.041	0.06
n-butane	1.84	2.313	3.163	1.324	1.663	2.295
t-butene-2	0.12	0.144	0.214	0.07	0.084	0.126
2,2-dimethylpropane	0.039	0.048	0.054	0.03	0.037	0.042
c-butene-2	0.111	0.13	0.198	0.06	0.07	0.107
3-methylbutene-1	0.051	0.059	0.073	0.041	0.048	0.059
i-pentane	5.899	6.929	8.169	5.313	6.232	7.417
butyne-2	0.165	0.174	0.304	0.157	0.166	0.293
2-methylbutene-1	0.374	0.418	0.532	0.325	0.363	0.466
n-pentane	3.726	4.33	5.16	3.57	4.144	4.985
t-pentene-2	0.446	0.501	0.636	0.414	0.464	0.595
3,3-dimethylbutene-1	0.265	0.297	0.378	0.245	0.274	0.352
c-pentene-2	0.847	0.94	1.206	0.77	0.853	1.105
2,2-dimethylbutane	0.272	0.305	0.315	0.277	0.311	0.324
cyclopentene	0.09	0.085	0.132	0.077	0.073	0.115
4-methylpentene-1	0.046	0.05	0.054	0.049	0.053	0.058
3-methylpentene-1	0.061	0.067	0.073	0.065	0.071	0.078
cyclopentane	0.322	0.315	0.459	0.33	0.322	0.475
2,3-dimethylbutane	1.091	1.2	1.265	1.178	1.294	1.377
C6-Iso-Paraffin	0.042	0.046	0.049	0.045	0.049	0.052
2-methylpentane	3.603	4.015	4.177	3.863	4.299	4.516
3-methylpentane	2.347	2.571	2.721	2.537	2.775	2.965
2-methylpentene-1	0.216	0.229	0.256	0.229	0.243	0.274
hexene-1	0.102	0.109	0.121	0.107	0.115	0.128
n-hexane	3.02	3.333	3.501	3.201	3.528	3.742
t-hexene-3	0.121	0.129	0.143	0.127	0.135	0.151
c-hexene-3	0.048	0.051	0.057	0.05	0.053	0.059
t-hexene-2	0.25	0.266	0.297	0.259	0.276	0.31
2-methylpentene-2	0.357	0.375	0.423	0.375	0.394	0.448
3-methyl-c-pentene-2	0.073	0.076	0.087	0.076	0.08	0.091
3-methylcyclopentene	0.228	0.218	0.277	0.239	0.228	0.293
O13	0.037	0.039	0.044	0.038	0.04	0.045
c-hexene-2	0.14	0.148	0.167	0.146	0.153	0.175
3,3-dimethylpentene-1	0.349	0.362	0.355	0.371	0.384	0.38
2,2-dimethylpentane	0.13	0.14	0.129	0.141	0.152	0.141
methylcyclopentane	1.678	1.631	1.992	1.835	1.782	2.197
2,4-dimethylpentane	1.416	1.532	1.412	1.619	1.749	1.627
cyclic diolefin or triolefin-[2]	0.005	0.005	0.006	0.006	0.006	0.007
2,2,3-trimethylbutane	0.044	0.046	0.044	0.047	0.05	0.048
C7-Iso-Paraffin	0.007	0.008	0.007	0.008	0.008	0.008
4,4-dimethyl-c-pentene-2	0.01	0.01	0.01	0.011	0.011	0.011
1-methylcyclopentene	0.044	0.041	0.053	0.045	0.042	0.056
C7-Iso-Paraffin	0.011	0.011	0.014	0.011	0.011	0.014
C7-Iso-Paraffin	0.002	0.002	0.002	0.282	0.263	0.346

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum)			HMW-18 (Main Stratum)		
	(Screened at 29 - 43.7 ft bgs)			(Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
benzene	1.251	1.036	1.601	0.599	0.495	0.772
2-methyl-c-hexene-3	0.02	0.021	0.02	0.022	0.023	0.023
5-methylhexene-1	0.013	0.013	0.013	0.014	0.014	0.014
3,3-dimethylpentane	0.188	0.197	0.187	0.202	0.212	0.203
2-methyl-t-hexene-3	0.015	0.015	0.015	0.017	0.017	0.017
2-ethyl-3-methylbutene-1	0.686	0.7	0.698	0.738	0.752	0.757
4-methylhexene-1	0.047	0.049	0.048	0.05	0.052	0.052
C7-Iso-Paraffin	0.01	0.01	0.01	0.012	0.012	0.012
4-methyl-t/c-hexene-2	0.006	0.007	0.007	0.007	0.007	0.007
C7-Iso-Paraffin	0.038	0.039	0.038	0.042	0.043	0.043
C7-Iso-Paraffin	0.105	0.109	0.107	0.113	0.117	0.116
2-methylhexane	1.832	1.965	1.827	1.994	2.136	2.005
2,3-dimethylpentane	2.843	2.977	2.835	3.292	3.442	3.31
1,1-dimethylcyclopentane	0.112	0.108	0.114	0.124	0.12	0.128
1,6-heptadiene	0.04	0.039	0.041	0.043	0.042	0.045
3-methylhexane	1.972	2.088	1.966	2.157	2.281	2.168
C7-Iso-Paraffin	0.049	0.052	0.049	0.054	0.057	0.054
1c,3-dimethylcyclopentane	0.419	0.409	0.426	0.464	0.453	0.476
1t,3-dimethylcyclopentane	0.375	0.365	0.382	0.415	0.402	0.425
1t,2-dimethylcyclopentane	0.242	0.235	0.247	0.263	0.254	0.269
3-ethylpentane	0.473	0.493	0.472	0.513	0.534	0.516
2,2,4-trimethylpentane	3.751	3.946	3.281	4.271	4.487	3.767
O25	0.002	0.002	0.002	0	0	0
3-methyl-c-hexene-3	0.063	0.064	0.064	0.069	0.07	0.071
t-heptene-3	0.209	0.217	0.213	0.219	0.227	0.225
n-heptane	1.821	1.938	1.816	1.924	2.045	1.934
3-methyl-c-hexene-2	0.26	0.266	0.265	0.275	0.281	0.282
3-methyl-t-hexene-3	0.098	0.103	0.1	0.106	0.111	0.109
3-ethylpentene-2	0.093	0.093	0.094	0.096	0.097	0.099
C8-Iso-Paraffin	0.06	0.06	0.061	0.064	0.065	0.066
2,3-dimethylpentene-2	0.003	0.003	0.003	0.004	0.004	0.004
3-methyl-t-hexene-2	0.233	0.236	0.237	0.25	0.253	0.256
O26	0.229	0.232	0.233	0.241	0.243	0.247
1c,2-dimethylcyclopentane	0.002	0.002	0.002	0	0	0
O27	0.038	0.038	0.039	0.044	0.044	0.045
2,2-dimethylhexane	0.174	0.182	0.152	0.197	0.206	0.174
methylcyclohexane	1.081	1.023	1.1	1.172	1.107	1.203
1,1,3-trimethylcyclopentane	0.171	0.166	0.152	0.185	0.179	0.166
ethylcyclopentane	0.013	0.012	0.013	0.014	0.013	0.014
2,4-dimethylhexane	0.015	0.015	0.013	0.015	0.016	0.014
O33	0.22	0.218	0.224	0.243	0.241	0.249
1c,2t,4-trimethylcyclopentane	0.446	0.425	0.397	0.495	0.472	0.445
O34	0.105	0.104	0.107	0.113	0.112	0.116
C8-Iso-Paraffin	0.668	0.664	0.68	0.738	0.733	0.757
3,3-dimethylhexane	0.021	0.021	0.018	0.023	0.024	0.02
1t,2c,3-trimethylcyclopentane	0.185	0.174	0.164	0.198	0.187	0.178
2,3,4-trimethylpentane	0.065	0.066	0.057	0.072	0.072	0.063

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum)			HMW-18 (Main Stratum)		
	(Screened at 29 - 43.7 ft bgs)			(Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
O39	0.148	0.147	0.132	0.149	0.148	0.134
I1	0.126	0.127	0.11	0.134	0.135	0.118
C8-Iso-Paraffin	0.037	0.037	0.032	0.037	0.038	0.033
2,3,3-trimethylpentane	1.431	1.434	1.252	1.617	1.618	1.426
O41	0.085	0.085	0.076	0.089	0.088	0.08
toluene	4.954	4.158	5.372	3.604	3.021	3.94
2,3-dimethylhexane	0.066	0.068	0.058	0.063	0.064	0.055
C8-Iso-Paraffin	0.022	0.022	0.019	0.024	0.025	0.021
C8-Iso-Paraffin	0.057	0.058	0.05	0.058	0.059	0.051
O44	0.008	0.008	0.007	0.009	0.009	0.008
1,1,2-trimethylcyclopentane	0.559	0.526	0.498	0.618	0.581	0.554
*2-ethylhexene-1	0.242	0.23	0.215	0.248	0.236	0.223
4-methylheptane	0.074	0.076	0.065	0.078	0.08	0.069
2-methylheptane	0.944	0.985	0.826	1.01	1.052	0.891
1c,2c,4-trimethylcyclopentane	0.356	0.34	0.317	0.384	0.366	0.345
1c,3-dimethylcyclohexane	0.081	0.077	0.072	0.09	0.086	0.081
C8-Iso-Paraffin	0.078	0.075	0.07	0.087	0.083	0.078
1c,2t,3-trimethylcyclopentane	0.151	0.142	0.134	0.16	0.151	0.143
1t,4-dimethylcyclohexane	0.886	0.846	0.789	0.958	0.913	0.86
1,1-dimethylcyclohexane	0.417	0.388	0.371	0.451	0.419	0.404
1,3-octadiene	0.067	0.063	0.06	0.072	0.069	0.066
2,2,5-trimethylhexane	0.126	0.129	0.098	0.135	0.139	0.106
C8-Iso-Paraffin	0.014	0.014	0.011	0.014	0.015	0.011
C8-Iso-Paraffin	0.071	0.073	0.056	0.073	0.075	0.057
3c-ethylmethylcyclopentane	0.039	0.037	0.035	0.042	0.04	0.038
C8-Iso-Paraffin	0.274	0.26	0.244	0.291	0.275	0.261
3t-ethylmethylcyclopentane	0.157	0.149	0.14	0.17	0.161	0.152
2t-ethylmethylcyclopentane	0.121	0.114	0.108	0.129	0.122	0.116
1,1-methylethylcyclopentane	0.113	0.106	0.101	0.123	0.115	0.111
2,2,4-trimethylhexane	0.071	0.07	0.055	0.075	0.074	0.059
t-octene-4	0.076	0.077	0.068	0.077	0.077	0.069
1t,2-dimethylcyclohexane	0.147	0.138	0.131	0.16	0.15	0.144
3,5,5-trimethylhexene-1	0.006	0.006	0.004	0.007	0.007	0.005
1t,3-dimethylcyclohexane	0.149	0.14	0.133	0.157	0.147	0.141
1c,2c,3-trimethylcyclopentane	0.015	0.014	0.014	0.016	0.015	0.014
n-octane	0.934	0.967	0.817	0.979	1.012	0.863
1c,4-dimethylcyclohexane	0.218	0.203	0.194	0.235	0.218	0.211
3,3-dimethylheptene-1	0.01	0.01	0.008	0.01	0.01	0.008
t-octene-2	0.039	0.039	0.035	0.038	0.038	0.034
C9-Iso-Paraffin	0.016	0.017	0.015	0.02	0.02	0.018
O49	0.118	0.119	0.105	0.123	0.124	0.11
C9-Iso-Paraffin	0.064	0.065	0.057	0.066	0.066	0.059
i-propylcyclopentane	0.023	0.022	0.021	0.026	0.025	0.024
I2	0.017	0.017	0.013	0.016	0.016	0.013
O50	0.012	0.012	0.009	0.014	0.014	0.011
C9-Iso-Paraffin	0.033	0.034	0.026	0.032	0.033	0.026
c-octene-2	0.03	0.03	0.024	0.033	0.033	0.026

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum)			HMW-18 (Main Stratum)		
	(Screened at 29 - 43.7 ft bgs)			(Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
N1	0.019	0.017	0.017	0.021	0.019	0.018
C9-Iso-Paraffin	0.024	0.022	0.021	0.025	0.023	0.023
2,3,4-trimethylhexane	0.066	0.065	0.051	0.07	0.069	0.055
2,2,3,4-tetramethylpentane	0.057	0.056	0.044	0.062	0.061	0.049
N2	0.052	0.049	0.047	0.056	0.052	0.05
O52	0.036	0.036	0.028	0.036	0.036	0.029
N3	0.163	0.152	0.145	0.173	0.161	0.155
1c,2-dimethylcyclohexane	0.011	0.01	0.01	0.013	0.012	0.012
C9-Iso-Paraffin	0.008	0.007	0.007	0.009	0.008	0.008
C9-Iso-Paraffin	0.019	0.017	0.017	0.021	0.019	0.019
2,2-dimethylheptane	0.214	0.219	0.167	0.23	0.236	0.181
N4	0.128	0.12	0.114	0.137	0.128	0.123
1,1,4-trimethylcyclohexane	0.037	0.034	0.029	0.039	0.037	0.031
C9-Iso-Paraffin	0.036	0.034	0.029	0.04	0.037	0.032
2,2,3-trimethylhexane	0.087	0.088	0.068	0.09	0.091	0.07
2,4-dimethylheptane	0.012	0.012	0.009	0.011	0.011	0.008
C9-Iso-Paraffin	0.296	0.301	0.23	0.31	0.315	0.243
4,4-dimethylheptane	0.075	0.076	0.058	0.079	0.08	0.062
ethylcyclohexane	0.029	0.027	0.026	0.029	0.027	0.026
3,5-dimethylheptane	0.035	0.035	0.027	0.026	0.026	0.02
3,3-&3,5-dimethylheptane	0.035	0.035	0.027	0	0	0
C9-Iso-Paraffin	0.02	0.02	0.016	0	0	0
2,6-dimethylheptane	0.034	0.035	0.026	0	0	0
ethylbenzene	1.32	1.108	1.242	1.288	1.079	1.222
N8	0.037	0.034	0.033	0.037	0.035	0.034
I3	0.028	0.028	0.022	0	0	0
N7	0.016	0.015	0.014	0	0	0
m-xylene	3.616	3.855	2.862	3.759	4.002	2.999
p-xylene	1.503	1.602	1.19	1.577	1.679	1.258
N13	0.155	0.144	0.122	0.157	0.147	0.126
1,3-dimethylbenzene	0.05	0.042	0.047	0	0	0
1,4-dimethylbenzene	0.043	0.037	0.041	0	0	0
3,4-dimethylheptane	0.064	0.064	0.05	0.059	0.059	0.047
N14	0.013	0.012	0.01	0	0	0
I5	0.301	0.3	0.234	0.313	0.312	0.246
C9-Iso-Paraffin	0.364	0.362	0.283	0.378	0.376	0.297
4-ethylheptane	0.033	0.033	0.025	0.031	0.031	0.024
4-methyloctane	0.01	0.011	0.008	0	0	0
1c,2t,3c-trimethylcyclohexane	0.092	0.088	0.073	0.087	0.084	0.07
3-methyloctane	0.411	0.415	0.32	0.417	0.421	0.328
C9-Iso-Paraffin	0.013	0.014	0.011	0	0	0
1c,2t,4c-trimethylcyclohexane	0.028	0.026	0.022	0	0	0
o-xylene	1.97	1.891	1.535	1.998	1.916	1.57
1,2-dimethylbenzene	0.032	0.027	0.031	0	0	0
I6	0.103	0.103	0.08	0.073	0.073	0.058
N18	0.068	0.064	0.054	0.074	0.069	0.059
N19	0.127	0.118	0.101	0.128	0.119	0.102

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum)			HMW-18 (Main Stratum)		
	(Screened at 29 - 43.7 ft bgs)			(Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
N20	0.066	0.062	0.052	0.065	0.061	0.052
I8	0.149	0.149	0.116	0.154	0.153	0.121
i-butylcyclopentane	0.028	0.026	0.022	0.02	0.018	0.016
C9-Iso-Paraffin	0.032	0.029	0.025	0	0	0
nonene-1	0.012	0.011	0.01	0	0	0
N21	0.014	0.013	0.011	0	0	0
N22	0.049	0.045	0.038	0.033	0.031	0.027
N23	0.037	0.034	0.029	0.021	0.02	0.017
t-nonene-3	0.021	0.021	0.017	0	0	0
C9-Iso-Paraffin	0.03	0.03	0.024	0	0	0
C9-Iso-Paraffin	0.014	0.014	0.011	0	0	0
I10	0.095	0.095	0.074	0.077	0.077	0.06
n-nonane	0.457	0.463	0.356	0.448	0.453	0.351
3,7-dimethyloctene-1	0.017	0.018	0.012	0.007	0.007	0.005
1,1-methylethylcyclohexane	0.058	0.052	0.046	0.038	0.034	0.03
N24	0.017	0.015	0.013	0	0	0
N25	0.023	0.021	0.018	0	0	0
t-2,2,5,5-tetramethylhexene-3	0.028	0.029	0.02	0.015	0.016	0.011
3,3,5-Trimethylheptane	0.127	0.107	0.106	0.12	0.101	0.1
N27	0.02	0.018	0.016	0	0	0
I11	0.062	0.062	0.044	0	0	0
t-nonene-2	0.02	0.021	0.016	0	0	0
i-propylcyclohexane	0.017	0.016	0.014	0	0	0
I12	0.015	0.015	0.01	0.083	0.083	0.059
C10-Iso-Paraffin	0.099	0.099	0.07	0	0	0
2,4-dimethyloctane	0.108	0.108	0.076	0.096	0.096	0.068
N28	0.047	0.043	0.037	0.025	0.023	0.02
N29	0.015	0.013	0.012	0	0	0
C10-Iso-Paraffin	0.035	0.032	0.028	0	0	0
2,6-dimethyloctane	0.042	0.042	0.029	0	0	0
2,5-dimethyloctane	0.135	0.135	0.095	0.182	0.181	0.129
C10-Iso-Paraffin	0.023	0.023	0.016	0.015	0.015	0.011
C10-Iso-Paraffin	0.105	0.104	0.074	0.098	0.097	0.069
N30	0.051	0.046	0.036	0.048	0.044	0.035
3,3-dimethyloctane	0.019	0.019	0.013	0.172	0.169	0.122
C10-Iso-Paraffin	0.166	0.164	0.117	0	0	0
n-propylbenzene	0.555	0.468	0.461	0.527	0.444	0.442
C10-Iso-Paraffin	0.037	0.031	0.03	0	0	0
3,6-dimethyloctane	0.04	0.04	0.028	0.063	0.062	0.044
3-methyl-5-ethylheptane	0.063	0.064	0.045	0.039	0.04	0.028
N32	0.05	0.045	0.035	0.031	0.028	0.022
1,3-methylethylbenzene	1.746	1.47	1.452	1.819	1.529	1.524
1,4-methylethylbenzene	0.775	0.655	0.644	0.817	0.69	0.685
N33	0.018	0.016	0.013	0.016	0.015	0.012
C10-Iso-Paraffin	0.019	0.017	0.013	0.018	0.016	0.013
1,3,5-trimethylbenzene	0.938	0.789	0.78	0.993	0.834	0.832
I15	0.069	0.068	0.049	0.068	0.067	0.048

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum)			HMW-18 (Main Stratum)		
	(Screened at 29 - 43.7 ft bgs)			(Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
N34	0.024	0.021	0.017	0.018	0.017	0.013
C10-Iso-Paraffin	0.051	0.047	0.037	0.045	0.041	0.032
5-methylnonane	0.081	0.081	0.057	0.074	0.073	0.052
1,2-methylethylbenzene	0.934	0.772	0.776	0.983	0.811	0.823
2-methylnonane	0.189	0.189	0.133	0.181	0.181	0.128
C10-Iso-Paraffin	0.024	0.024	0.017	0.016	0.016	0.012
3-ethyloctane	0.047	0.046	0.033	0.035	0.035	0.025
N35	0.017	0.015	0.012	0	0	0
3-methylnonane	0.223	0.221	0.156	0.189	0.188	0.134
N36	0.013	0.011	0.009	0	0	0
I18	0.009	0.009	0.006	0	0	0
I19	0.085	0.084	0.06	0.075	0.073	0.053
1,2,4-trimethylbenzene	2.722	2.262	2.263	2.898	2.405	2.429
i-butylcyclohexane	0.043	0.039	0.03	0.041	0.037	0.029
I20	0.02	0.02	0.014	0	0	0
I21	0.06	0.059	0.042	0.076	0.074	0.054
I22	0.032	0.031	0.022	0.031	0.03	0.022
I23	0.021	0.021	0.015	0.019	0.019	0.014
N37	0.034	0.031	0.024	0.032	0.029	0.023
1t-methyl-2-n-propylcyclohexane	0.044	0.04	0.031	0	0	0
i-butylbenzene	0.041	0.035	0.031	0.015	0.012	0.011
C10-Iso-Paraffin	0.085	0.073	0.063	0.061	0.052	0.045
sec-butylbenzene	0.112	0.095	0.083	0.084	0.071	0.063
n-decane	0.258	0.257	0.181	0.251	0.25	0.178
N38	0.035	0.032	0.025	0.037	0.034	0.027
1,2,3-trimethylbenzene	0.577	0.47	0.48	0.618	0.502	0.518
1,3-methyl-i-propylbenzene	0.107	0.091	0.08	0.112	0.095	0.084
1,4-methyl-i-propylbenzene	0.043	0.036	0.032	0.037	0.031	0.028
I27	0.018	0.018	0.012	0	0	0
I29	0.027	0.026	0.017	0	0	0
2-3-dihydroindene	0.314	0.237	0.265	0.356	0.268	0.303
C11-Iso-Paraffin	0.007	0.005	0.006	0	0	0
sec-butylcyclohexane	0.016	0.015	0.012	0.022	0.019	0.016
I30	0.039	0.038	0.025	0.041	0.04	0.027
C11-Iso-Paraffin	0.019	0.018	0.012	0.02	0.019	0.013
1,2-methyl-i-propylbenzene	0.053	0.044	0.039	0.057	0.047	0.043
3-ethylnonane	0.037	0.036	0.024	0.034	0.033	0.022
I31	0.075	0.073	0.048	0.075	0.074	0.048
I32	0.015	0.014	0.01	0	0	0
1,3-diethylbenzene	0.279	0.235	0.208	0.31	0.261	0.233
1,3-methyl-n-propylbenzene	0.551	0.466	0.41	0	0.579	0.489
I33	0.034	0.034	0.022	0	0	0
1,4-diethylbenzene	0	0	0	0.031	0.026	0.023
C11-Iso-Paraffin	0.329	0.324	0.21	0.327	0.276	0.246
1,4-methyl-n-propylbenzene	0.172	0.146	0.128	0.177	0.149	0.132
1,3-dimethyl-5-ethylbenzene	0.511	0.422	0.38	0.542	0.448	0.407
1,2-diethylbenzene	0.044	0.036	0.033	0.04	0.033	0.03

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum)			HMW-18 (Main Stratum)		
	(Screened at 29 - 43.7 ft bgs)			(Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
C11-Iso-Paraffin	0.033	0.028	0.025	0.013	0.011	0.01
1,2-methyl-n-propylbenzene	0.206	0.171	0.153	0.223	0.186	0.167
I35	0.016	0.016	0.01	0.019	0.018	0.012
I37	0.112	0.11	0.072	0.116	0.114	0.075
C11-Iso-Paraffin	0.012	0.012	0.008	0	0	0
I38	0.064	0.063	0.041	0.074	0.073	0.048
1,4,dimethyl-2-ethylbenzene	0.329	0.273	0.245	0.351	0.291	0.263
A3	0.43	0.364	0.32	0.459	0.388	0.344
I39	0.042	0.041	0.027	0.039	0.038	0.025
C11-Iso-Paraffin	0.004	0.003	0.002	0	0	0
1,2-dimethyl-4-ethylbenzene	0.751	0.625	0.559	0.802	0.666	0.602
I41	0.007	0.007	0.004	0	0	0
1,3-dimethyl-2-ethylbenzene	0.057	0.046	0.042	0.037	0.031	0.028
I42	0.025	0.024	0.016	0	0	0
C11-Iso-Paraffin	0.016	0.015	0.01	0.068	0.055	0.051
I43	0.014	0.014	0.009	0	0	0
C11-Iso-Paraffin	0.008	0.008	0.005	0	0	0
C11-Iso-Paraffin	0.013	0.011	0.008	0	0	0
1,3-di-n-propylbenzene	0.077	0.063	0.047	0	0	0
C11-Iso-Paraffin	0.184	0.158	0.124	0.012	0.01	0.008
1,4-methyl-t-butylbenzene	0.007	0.005	0.005	0.184	0.157	0.125
1,2-dimethyl-3-ethylbenzene	0.031	0.026	0.021	0	0	0
1,2-ethyl-i-propylbenzene	0.026	0.021	0.018	0.013	0.011	0.009
n-undecane	0.156	0.153	0.1	0.147	0.144	0.095
1,2,4,5-tetramethylbenzene	0.337	0.277	0.251	0.344	0.282	0.258
1,2-methyl-n-butylbenzene	0.424	0.347	0.286	0.453	0.37	0.308
1,2,3,5-tetramethylbenzene	0.009	0.007	0.007	0.023	0.019	0.017
C12-Iso-Paraffin	0.019	0.015	0.014	0	0	0
1,2-methyl-t-butylbenzene	0.034	0.027	0.023	0.027	0.022	0.019
C12-Iso-Paraffin	0.013	0.011	0.009	0.027	0.022	0.018
C12-Iso-Paraffin	0.045	0.037	0.03	0	0	0
5-methylindan	0.354	0.289	0.267	0.387	0.316	0.295
I44	0.156	0.15	0.091	0.157	0.152	0.093
4-methylindan	0.15	0.123	0.114	0.163	0.133	0.124
1,2-ethyl-n-propylbenzene	0.334	0.273	0.225	0.361	0.295	0.246
C12-Iso-Paraffin	0.024	0.02	0.016	0	0	0
1,3-methyl-n-butylbenzene	0.128	0.105	0.087	0.156	0.127	0.106
1,3-di-i-propylbenzene	0.116	0.095	0.072	0.121	0.099	0.075
s-pentylbenzene	0.011	0.009	0.008	0	0	0
C12-Iso-Paraffin	0.081	0.066	0.054	0.082	0.067	0.051
n-pentylbenzene	0.059	0.049	0.04	0.062	0.051	0.042
C12-Iso-Paraffin	0.064	0.052	0.043	0.07	0.063	0.042
1t-M-2-(4-MP)cyclopentane	0.062	0.057	0.037	0.072	0.065	0.043
1,2-di-i-propylbenzene	0.056	0.046	0.035	0.063	0.052	0.039
1,4-di-i-propylbenzene	0.135	0.11	0.083	0.152	0.124	0.095
tetrahydronaphthalene	0.028	0.021	0.021	0.039	0.029	0.029
C12-Iso-Paraffin	0.1	0.075	0.076	0.113	0.084	0.086

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum)			HMW-18 (Main Stratum)		
	(Screened at 29 - 43.7 ft bgs)			(Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
C12-Iso-Paraffin	0.408	0.306	0.308	0.459	0.344	0.35
naphthalene	0.003	0.002	0.003	0	0	0
1-t-butyl-3,5-dimethylbenzene	0.025	0.021	0.016	0.037	0.03	0.023
C12-Iso-Paraffin	0.039	0.032	0.024	0.046	0.038	0.029
1,4-ethyl-t-butylbenzene	0.045	0.037	0.028	0.048	0.039	0.03
C12-Iso-Paraffin	0.126	0.103	0.078	0.139	0.113	0.086
C12-Iso-Paraffin	0.058	0.047	0.035	0	0	0
I45	0.003	0.003	0.002	0.067	0.064	0.039
I46	0.076	0.074	0.045	0.084	0.081	0.05
I47	0.064	0.062	0.038	0.073	0.071	0.043
C12-Iso-Paraffin	0.103	0.099	0.06	0.112	0.108	0.066
I48	0.063	0.061	0.037	0.07	0.067	0.041
A5	0.008	0.006	0.005	0	0	0
A6	0.007	0.006	0.005	0.06	0.049	0.038
C12-Iso-Paraffin	0.055	0.045	0.034	0.115	0.094	0.072
C12-Iso-Paraffin	0.107	0.088	0.066	0	0	0
n-dodecane	0.014	0.013	0.008	0.016	0.015	0.009
C13-Iso-Paraffin	0.02	0.02	0.012	0.013	0.013	0.008
C13-Iso-Paraffin	0.013	0.012	0.008	0	0	0
1,3,5-triethylbenzene	0.078	0.064	0.048	0.071	0.058	0.044
C13-Iso-Paraffin	0.039	0.032	0.024	0.043	0.035	0.026
C13-Iso-Paraffin	0.034	0.028	0.021	0.036	0.03	0.023
C13-Iso-Paraffin	0.023	0.019	0.014	0.02	0.017	0.013
C13-Iso-Paraffin	0.024	0.02	0.015	0.017	0.014	0.011
C13-Iso-Paraffin	0.035	0.029	0.022	0	0	0
C13-Iso-Paraffin	0.01	0.008	0.006	0	0	0
C13-Iso-Paraffin	0.038	0.031	0.023	0	0	0
1,2,4-triethylbenzene	0.006	0.005	0.004	0.034	0.028	0.021
C13-Iso-Paraffin	0.088	0.072	0.054	0.103	0.084	0.064
C13-Iso-Paraffin	0.028	0.023	0.017	0.029	0.023	0.018
C13-Iso-Paraffin	0.019	0.016	0.012	0.02	0.017	0.013
C13-Iso-Paraffin	0.013	0.01	0.008	0.013	0.011	0.008
C13-Iso-Paraffin	0.043	0.035	0.027	0.045	0.037	0.028
C13-Iso-Paraffin	0.064	0.052	0.039	0.071	0.058	0.044
n-hexylbenzene	0.043	0.035	0.027	0.047	0.038	0.029
C13-Iso-Paraffin	0.021	0.018	0.013	0.019	0.016	0.012
C13-Iso-Paraffin	0.019	0.016	0.012	0.027	0.022	0.017
C13-Iso-Paraffin	0.022	0.018	0.014	0.008	0.007	0.005
C13-Iso-Paraffin	0.016	0.013	0.01	0	0	0
C13-Iso-Paraffin	0.007	0.006	0.004	0	0	0
C13-Iso-Paraffin	0.015	0.013	0.009	0	0	0
I50	0.08	0.077	0.043	0.078	0.075	0.043
1,2,3,4,5-pentamethylbenzene	0.009	0.006	0.006	0	0	0
2-methylnaphthalene	0.017	0.012	0.012	0.021	0.015	0.015
C13-Iso-Paraffin	0.285	0.204	0.199	0.323	0.23	0.227
1-methylnaphthalene	0.006	0.005	0.004	0	0	0
C13-Iso-Paraffin	0.019	0.014	0.013	0.008	0.006	0.005

Table 2(b)
Detailed Hydrocarbon Analysis of LNAPL
Apex Oil, Hartford, IL

Component	MP-39C (Main Stratum) (Screened at 29 - 43.7 ft bgs)			HMW-18 (Main Stratum) (Screened at 27.68 - 42.98 ft bgs)		
	Weight %	Volume %	Mole %	Weight %	Volume %	Mole %
C13-Iso-Paraffin	0.021	0.015	0.014	0.138	0.099	0.097
C13-Iso-Paraffin	0.021	0.015	0.015	0	0	0
C13-Iso-Paraffin	0.006	0.004	0.004	0	0	0
C13-Iso-Paraffin	0.125	0.089	0.087	0	0	0
C13-Iso-Paraffin	0.051	0.037	0.036	0	0	0
n-tridecane	0.007	0.007	0.004	0.059	0.057	0.032
C14-Iso-Paraffin	0.006	0.005	0.003	0.006	0.005	0.003
C14-Iso-Paraffin	0.013	0.012	0.007	0.011	0.01	0.006
C14-Iso-Paraffin	0.024	0.023	0.013	0.016	0.016	0.009
C14-Iso-Paraffin	0.002	0.002	0.001	0.019	0.018	0.01
C14-Iso-Paraffin	0.013	0.012	0.007	0.009	0.009	0.005
C14-Iso-Paraffin	0.003	0.003	0.002	0	0	0
C14-Iso-Paraffin	0.004	0.004	0.002	0	0	0
C14-Iso-Paraffin	0.015	0.014	0.008	0	0	0
C14-Iso-Paraffin	0.016	0.015	0.009	0	0	0
C14	0.013	0.012	0.006	0	0	0
C15-Iso-Paraffin	0.03	0.029	0.015	0.032	0.031	0.016
C15-Iso-Paraffin	0.016	0.015	0.008	0.019	0.018	0.01
C15-Iso-Paraffin	0.007	0.007	0.003	0	0	0
C15-Iso-Paraffin	0.003	0.003	0.001	0	0	0
C15-Iso-Paraffin	0.004	0.004	0.002	0	0	0
C15-Iso-Paraffin	0.004	0.004	0.002	0	0	0
C15	0.007	0.005	0.004	0	0	0
C16-Iso-Paraffin	0.07	0.05	0.034	0	0	0
C16-Iso-Paraffin	0.005	0.004	0.002	0	0	0
C16	0.003	0.003	0.001	0	0	0
C17-Iso-Paraffin	0.014	0.014	0.006	0	0	0
C17	0.003	0.002	0.001	0	0	0
C18-Iso-Paraffin	0.003	0.003	0.001	0	0	0
C18	0.006	0.005	0.002	0	0	0
C19-Iso-Paraffin	0.005	0.004	0.002	0	0	0
C19	0.005	0.005	0.002	0	0	0
C20-Iso-Paraffin	0.009	0.009	0.003	0	0	0
C20	0.004	0.004	0.002	0	0	0
C21-Iso-Paraffin	0.002	0.002	0.001	0	0	0
C21	0.003	0.003	0.001	0	0	0
C22-Iso-Paraffin	0.002	0.002	0.001	0	0	0
C22	0.002	0.002	0.001	0	0	0
C24	0.005	0.004	0.001	0	0	0
C25	0.003	0.003	0.001	0	0	0

Notes:
Average Molecular Weight of LNAPL at MP-39C: 99.9175
Average Molecular Weight of LNAPL at HMW-18: 100.7325
Data obtained from SPL Laboratory reports (November 2009)

Table 2(c)
Selected Chemicals of Concern Fractions in LNAPL
Apex Oil, Hartford, IL

Component	**CAS No.**	**MP-39C (Main Stratum)**			**HMW-18 (Main Stratum)**		
		(Screened at 29 - 43.7 ft bgs)			**(Screened at 27.68 - 42.98 ft bgs)**		
		Weight %	**Volume %**	**Mole %**	**Weight %**	**Volume %**	**Mole %**
n-Hexane	110-54-3	3.02	3.33	3.50	3.20	3.53	3.74
Benzene	71-43-2	1.25	1.04	1.60	0.60	0.50	0.77
Methylcyclohexane	108-87-2	1.08	1.02	1.10	1.17	1.11	1.20
Toluene	108-88-3	4.95	4.16	5.37	3.60	3.02	3.94
m-Xylene	108-38-3	3.62	3.86	2.86	3.76	4.00	3.00
p-Xylene	106-42-3	1.50	1.60	1.19	1.58	1.68	1.26
o-Xylene	95-47-6	1.97	1.89	1.54	2.00	1.92	1.57
1,2,4-Trimethylbenzene	95-63-6	2.72	2.26	2.26	2.90	2.41	2.43
1,3,5-Trimethylbenzene	108-67-8	0.94	0.79	0.78	0.99	0.83	0.83
Isopentane	78-78-4	5.90	6.93	8.17	5.31	6.23	7.42
n-Butane	106-97-8	1.84	2.31	3.16	1.32	1.66	2.30
Total		**28.79**	**29.19**	**31.54**	**26.44**	**26.88**	**28.46**

Notes:
Average Molecular Weight of LNAPL at MP-39C: 99.9175
Average Molecular Weight of LNAPL at HMW-18: 100.7325
Data obtained from SPL Laboratory reports (November 2009)

Table 2(d)
Summary of PIONAX Analysis of LNAPL
Apex Oil, Hartford, IL

Group Type	MP-39C			HMW-18		
	Weight %	**Volume %**	**Mole %**	**Weight %**	**Volume %**	**Mole %**
Paraffins	12.3	13.8	15.1	11.9	13.4	14.6
isoParaffins	39.7	41.8	39.8	40.8	42.9	41.4
Olefins	8.0	8.4	9.5	7.9	8.2	9.3
Naphthenes	10.2	9.7	9.9	10.7	10.2	10.5
Aromatics	29.8	26.2	25.7	28.7	25.3	24.3
Oxegenates	0.0	0.0	0.0	0.0	0.0	0.0
Total	**100**	**100**	**100**	**100**	**100**	**100**

Notes:
Data obtained from SPL Laboratory reports (November 2009)

Table 3
Summary of Weight % of LNAPL
Apex Oil, Hartford, IL

Component	January 2006 LNAPL, 12 Samples			November 2009 LNAPL, 2 Samples		
	Minimum	Average	Maximum	Minimum	Average	Maximum
n-Hexane	0.08	2.78	3.71	3.02	3.11	3.20
Benzene	0.05	1.10	1.57	0.60	0.93	1.25
Methylcyclohexane	0.54	1.17	1.54	1.08	1.13	1.17
Toluene	0.11	3.74	6.80	3.60	4.28	4.95
m-Xylene	0.07	3.34	4.92	3.62	3.69	3.76
p-Xylene	0.04	1.37	2.17	1.50	1.54	1.58
o-Xylene	0.13	1.67	2.43	1.97	1.98	2.00
1,2,4-Trimethylbenzene	0.26	2.78	4.57	2.72	2.81	2.90
1,3,5-Trimethylbenzene	0.79	1.06	1.42	0.94	0.97	0.99
Isopentane	0.71	4.98	9.04	5.31	5.61	5.90
n-Butane	0.11	1.72	7.90	1.32	1.58	1.84

Table 4
Detected Chemical Concentrations in Soil (µg/kg)
Apex Oil, Hartford, IL

Chemical of Conern	HGP7	HGP8	Ratio
	30 - 31 ft	30 - 32 ft	
SW8015B Gasoline Range Organics			
GRO	5,500,000	810,000	6.79
SW8015B Semi-volatile Hydrocarbons			
DRO	1,000,000	210,000	4.76
SW8270C Semivolatile Organics			
2-Methylnaphthalene	15,000	1,500	10.00
Naphthalene	18,000	1,600	11.25
SW8260B Volatile Organics			
1,2,4-Trimethylbenzene	250,000	54,000	4.63
1,2-Dichloroethane	<250	35	NA
1,3,5-Trimethylbenzene	77,000	16,000	4.81
4-Isoprpyltoluene	3,500	110	31.82
Benzene	38,000	8,600	4.42
Ethylbenzene	110,000	30,000	3.67
Isopropylbenzene	12,000 J	2,700	4.44
Naphthalene	47,000	6,200	7.58
n-Butylbenzene	18,000 J	4,000	4.50
n-Propylbenzene	46,000	11,000	4.18
sec-Butylbenzene	7,700	1,400 J	5.50
Styrene	270	<5	NA
tert-Butylbenzene	<250	100	NA
Toluene	270,000	60,000	4.50
m,p-Xylene	420,000	96,000	4.38
o-Xylene	160,000	35,000	4.57
Xylenes,Total	580,000	131,000	4.43
Cyclohexane	38,000	9,000	4.22
Hexane	190,000	47,000	4.04
Methylcyclohexane	110,000	20,000	5.50

Notes:

<: Below detection limit

J: Estimated value between MDL and PQL

MDL: Method detection limit

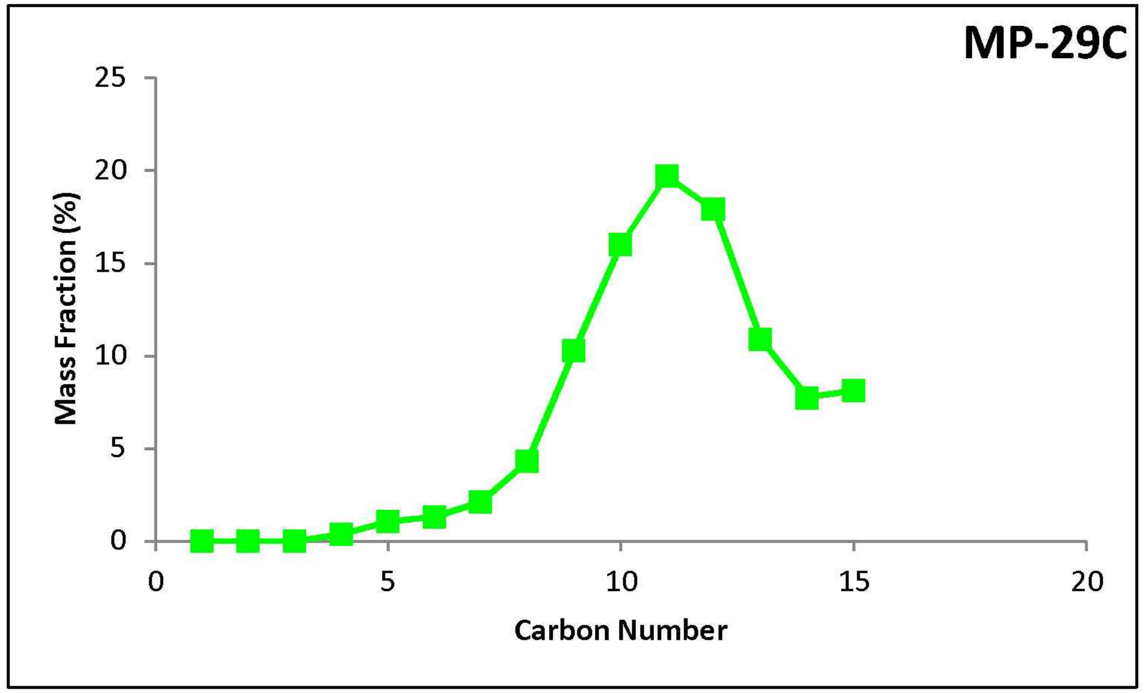
PQL: Practical quantitation limit

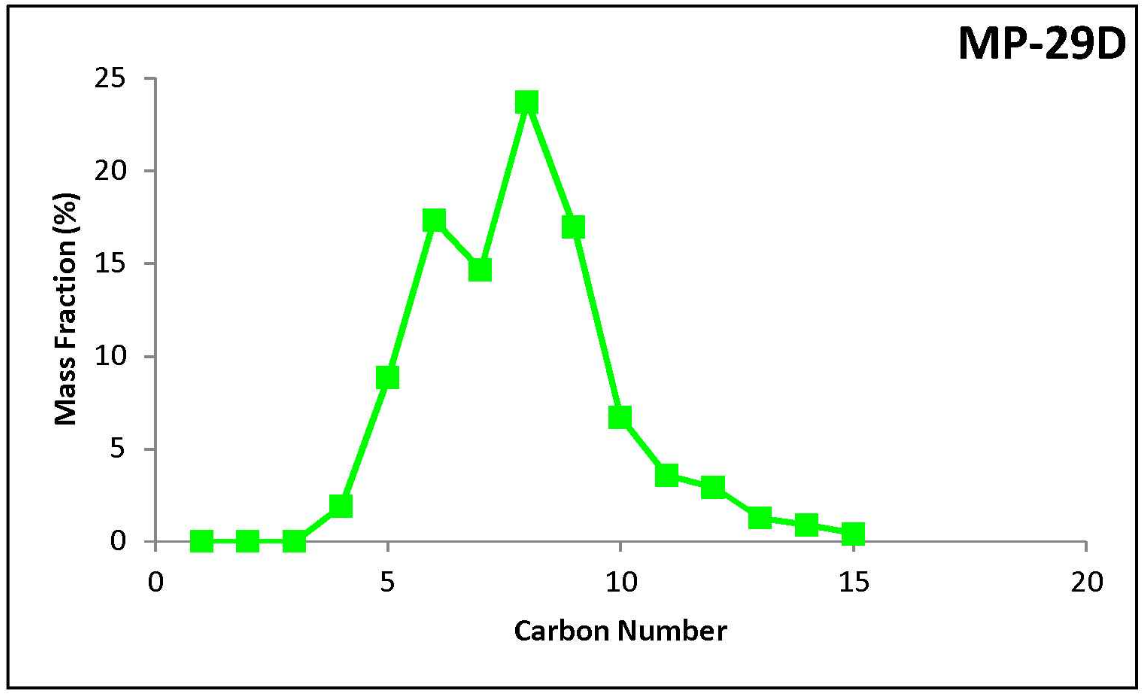
NA: Particular chemical is not detected in one of the soil borings

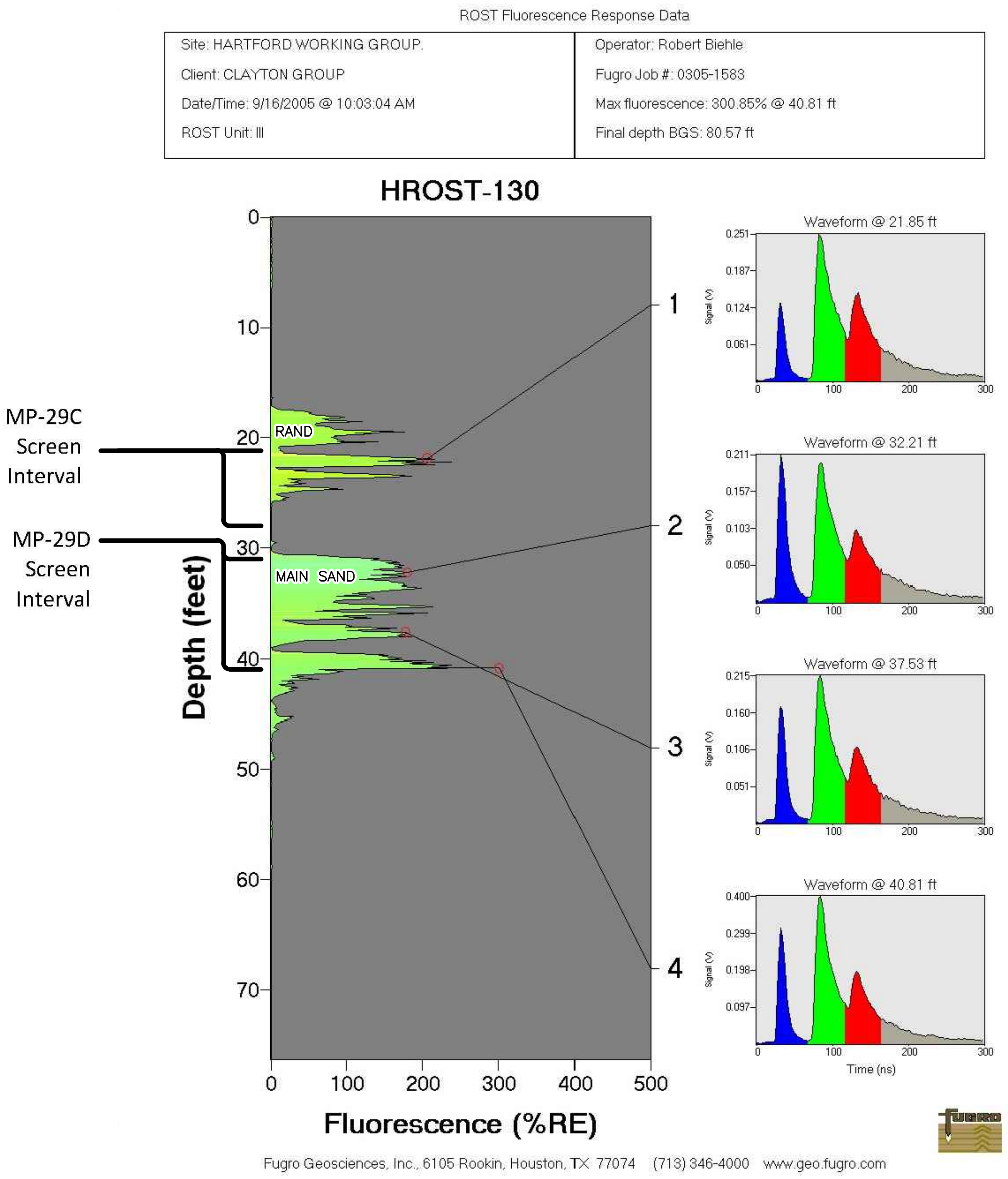
Data obtained from SPL Laboratory reports (November 2009)

APPENDIX D

LNAPL CHEMISTRY COMPARED TO LASER INDUCED FLUORESENCE RESULTS







ROST Fluorescence Response Data

Site: HARTFORD WORKING GROUP.	Operator: Robert Biehle
Client: CLAYTON GROUP	Fugro Job #: 0305-1583
Date/Time: 9/16/2005 @ 10:03:04 AM	Max fluorescence: 300.85% @ 40.81 ft
ROST Unit: III	Final depth BGS: 80.57 ft

Fugro Geosciences, Inc., 6105 Rookin, Houston, TX 77074 (713) 346-4000 www.geo.fugro.com

ROST Hydrocarbon Type

🟩 Mid–Range LNAPL

Note:
LIF type for HROST–130 not reported in Clayton (2005) report. Therefore, the types reported here are based on other similar waveforms reported by Clayton (2005).

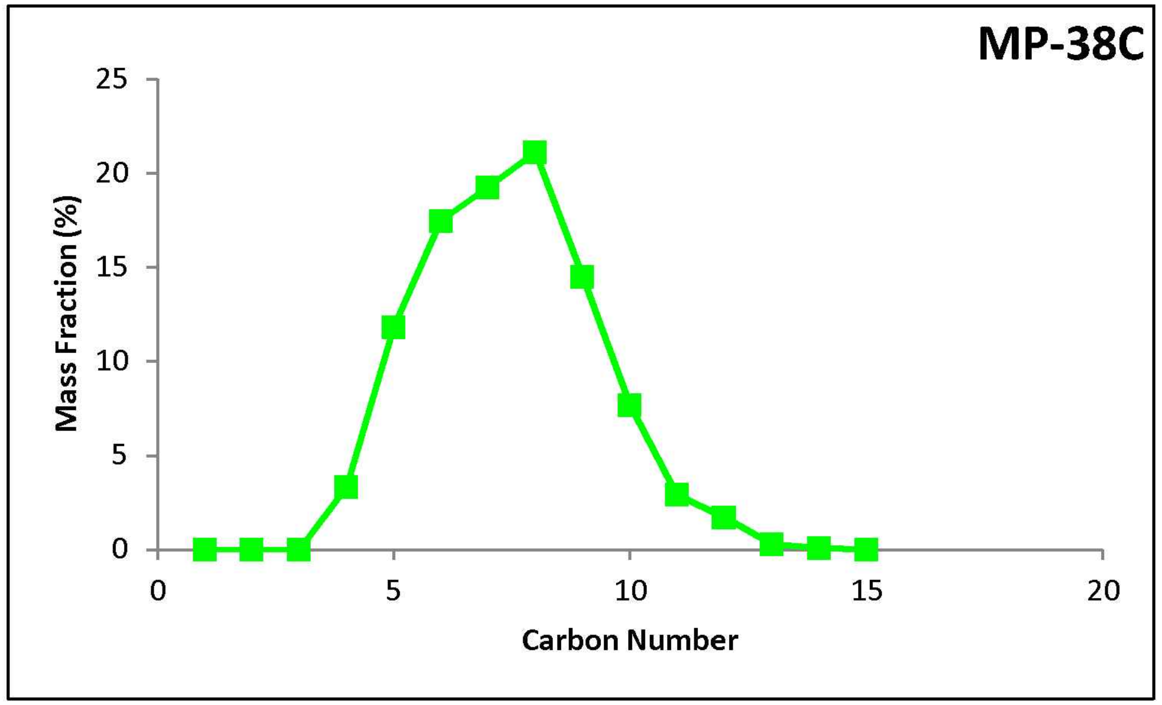
Trihydro
CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

FIGURE D-1

LNAPL CHEMISTRY FOR MP-029C COMPARED TO FLUORESCENCE RESPONSE IN HROST-130

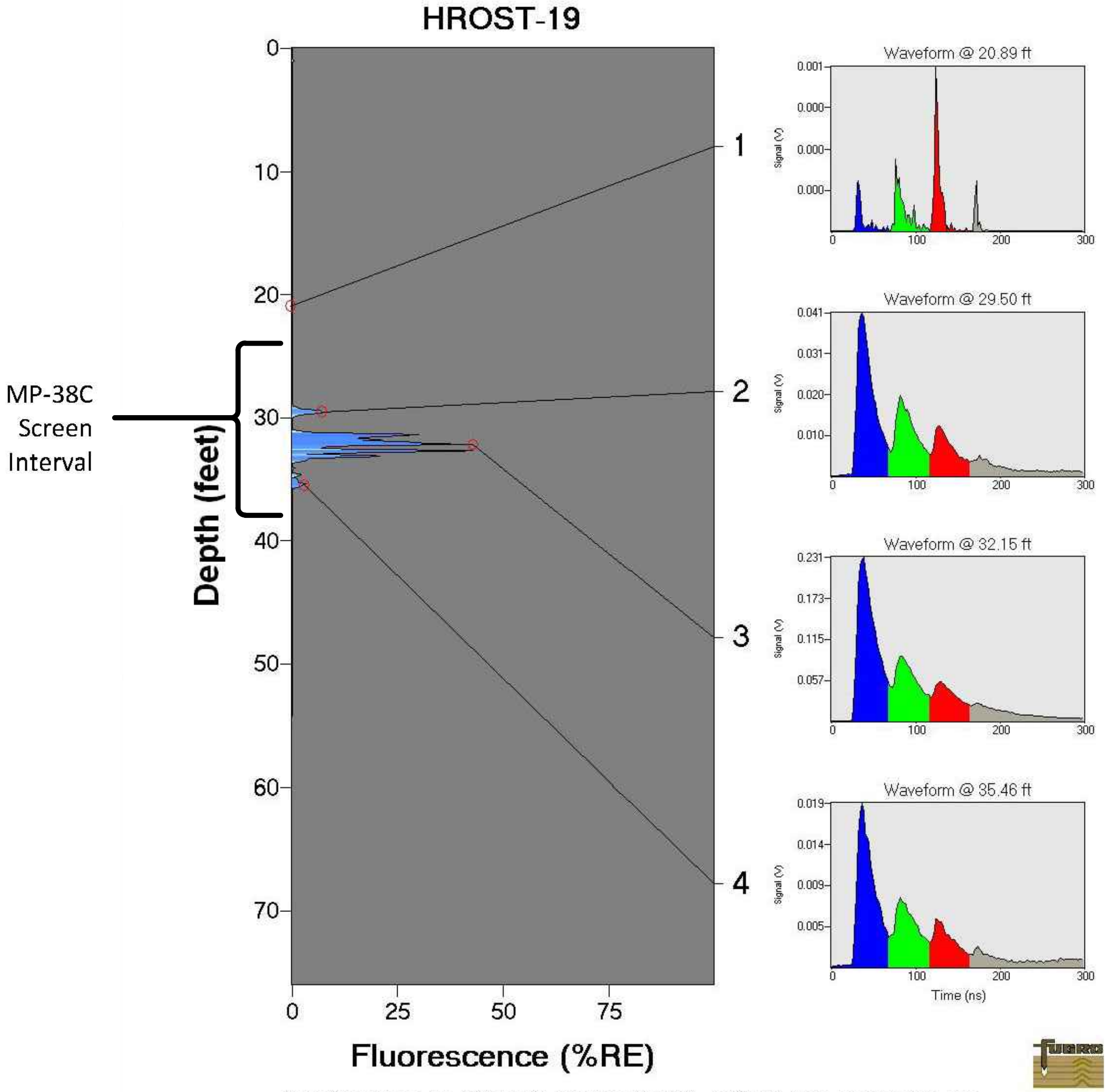
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: KJW	Checked By: PM	Scale: NO SCALE	Date: 1/27/14	File: 24S_CARBONDIST20130919



ROST Fluorescence Response Data

Site: Village of Hartford	Operator: ddeleon
Client: Clayton Group Services	Fugro Job #: 0303-0921
Date/Time: 2/16/2004 @ 12:48:47 PM	Max fluorescence: 43.20% @ 32.15 ft
ROST Unit: 1	Final depth BGS: 54.32 ft



Fugro Geosciences, Inc., 6105 Rookin, Houston, TX 77074 (713) 346-4000 www.geo.fugro.com

ROST Hydrocarbon Type

🟦 Light–Range LNAPL

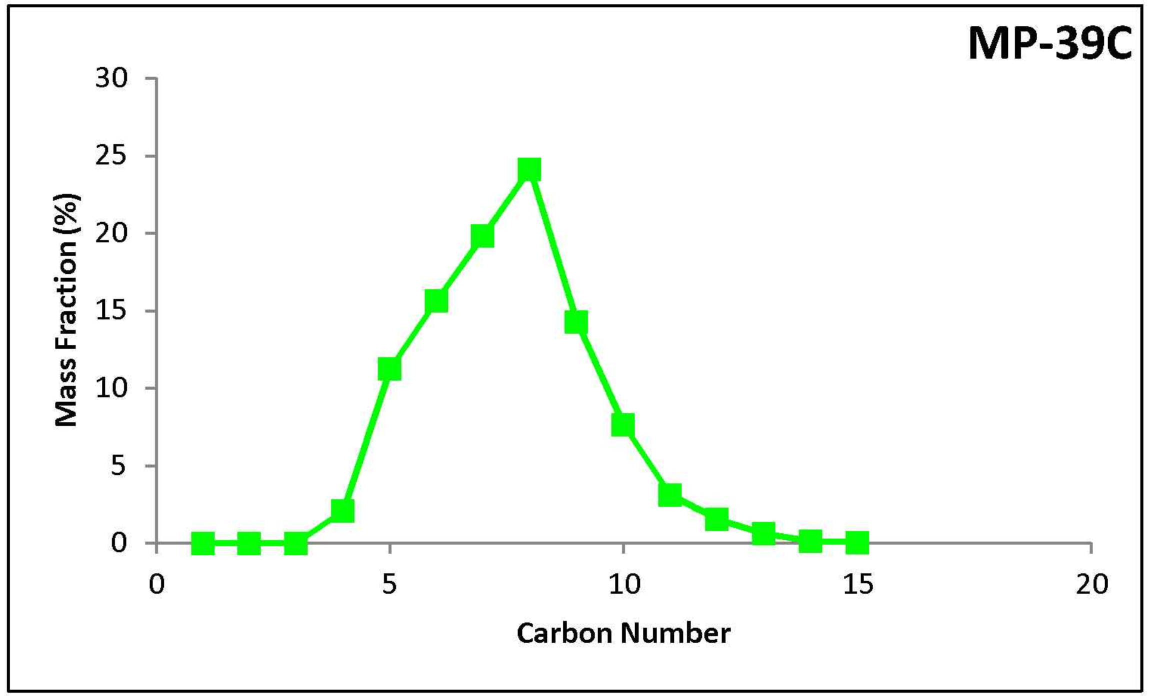
Trihydro
CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

FIGURE D-2

LNAPL CHEMISTRY FOR MP-038C COMPARED TO FLUORESCENCE RESPONSE IN HROST-019

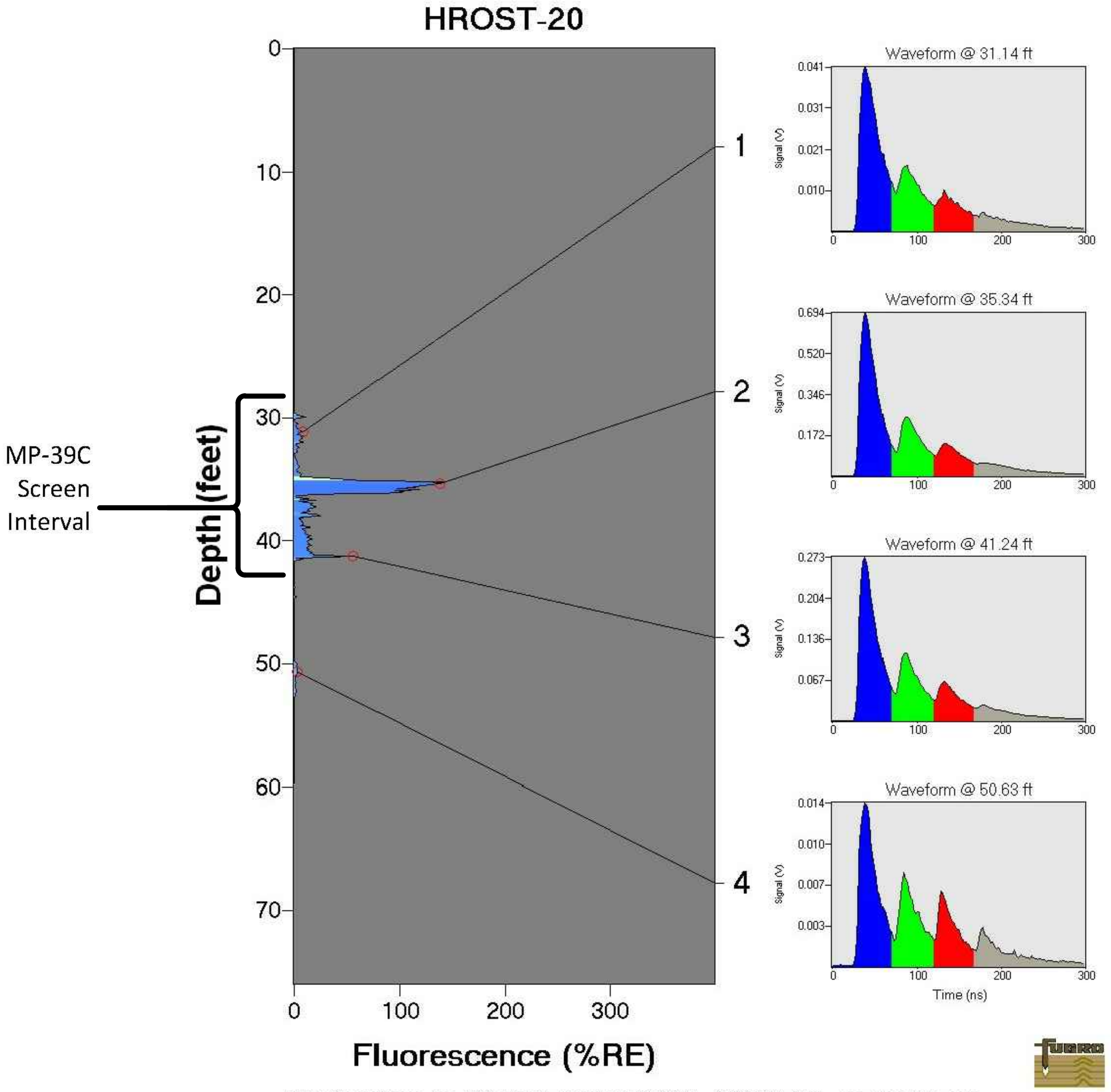
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: KJW	Checked By: PM	Scale: NO SCALE	Date: 1/27/14	File: 24S_CARBONDIST20130919



ROST Fluorescence Response Data

Site: Village of Hartford	Operator: ddeleon
Client: Clayton Group Services	Fugro Job #: 0303-0921
Date/Time: 2/21/2004 @ 7:08:02 AM	Max fluorescence: 144.35% @ 35.19 ft
ROST Unit: 1	Final depth BGS: 59.80 ft



Fugro Geosciences, Inc., 6105 Rookin, Houston, TX 77074 (713) 346-4000 www.geo.fugro.com

ROST Hydrocarbon Type

🟦 Light–Range LNAPL

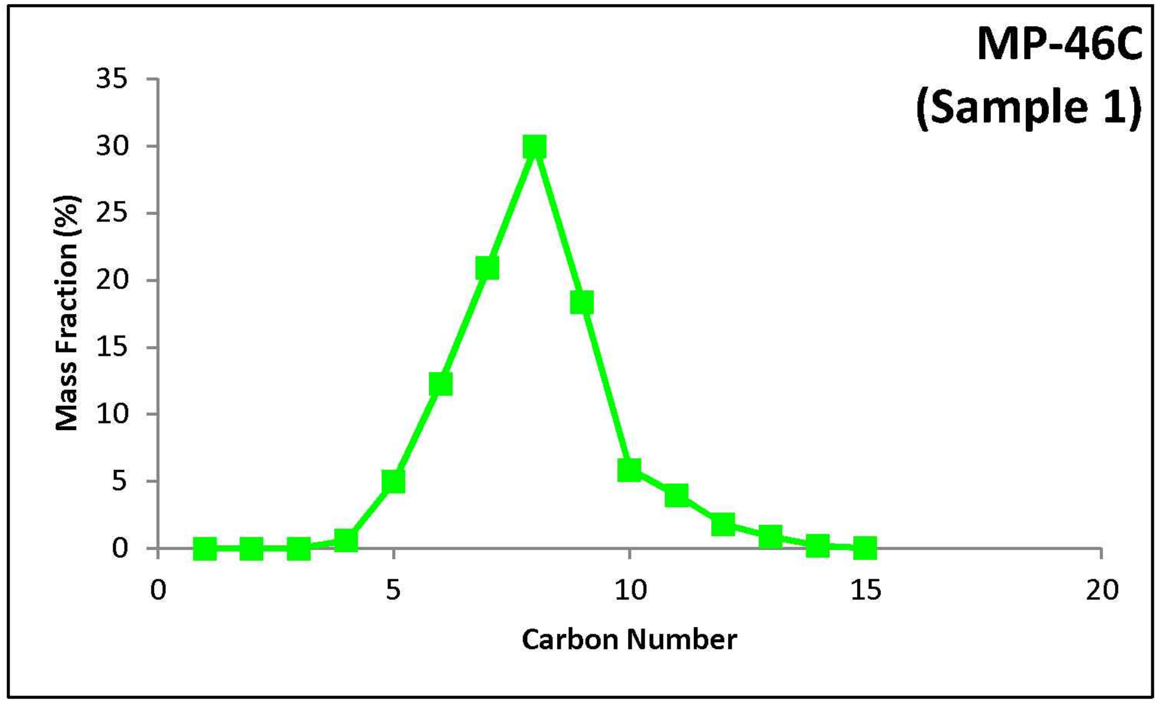
Trihydro
CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

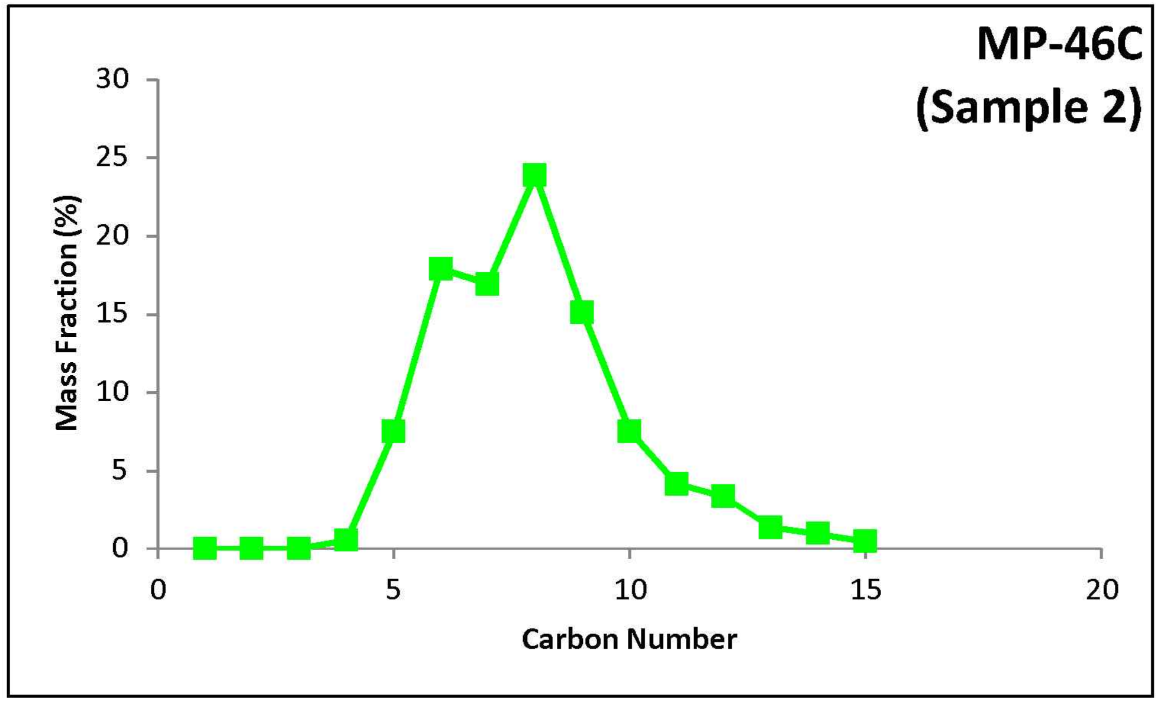
FIGURE D-3

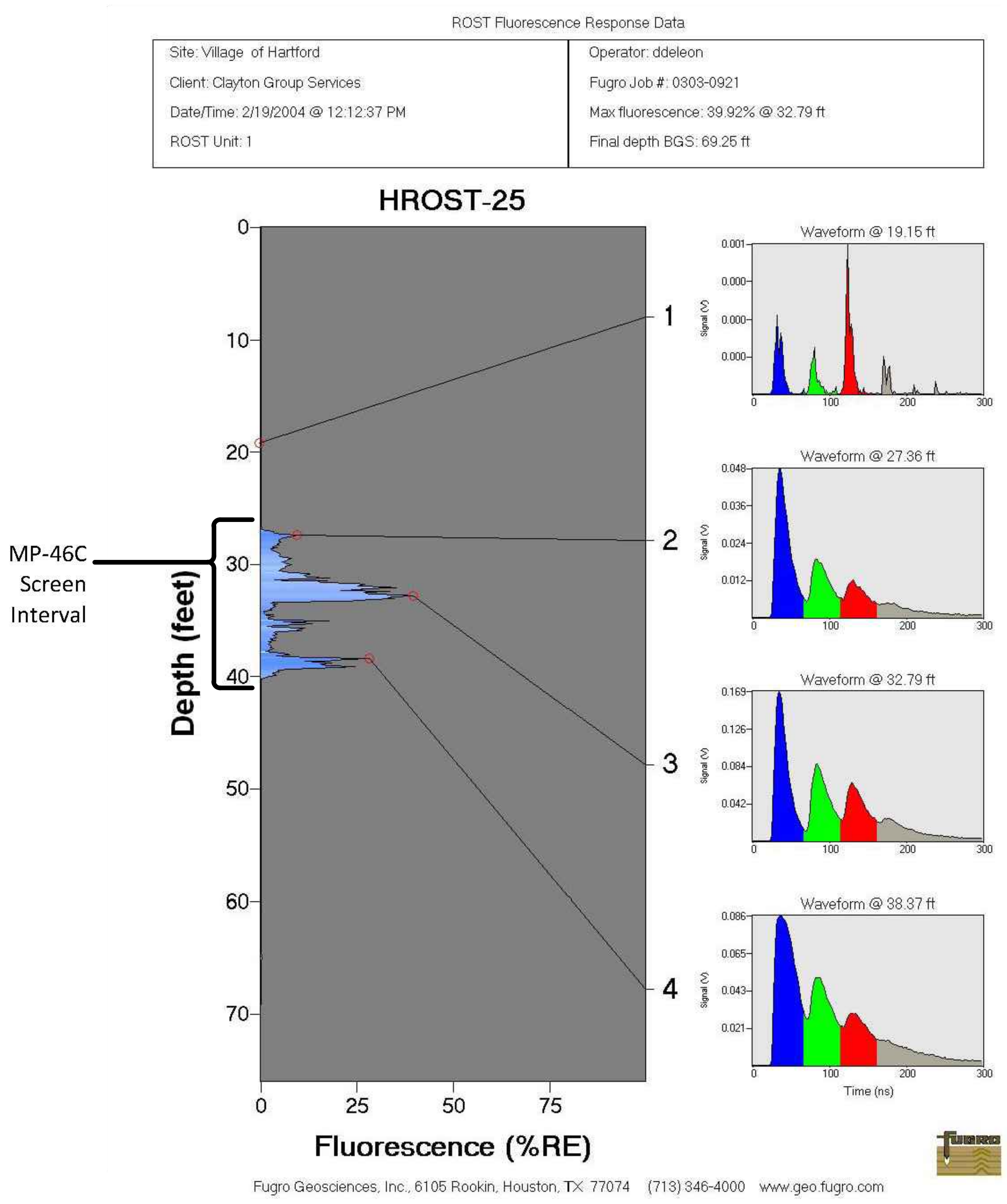
LNAPL CHEMISTRY FOR MP-039C COMPARED TO FLUORESCENCE RESPONSE IN HROST-020

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: KJW	Checked By: PM	Scale: NO SCALE	Date: 1/27/14	File: 24S_CARBONDIST20130919






ROST Fluorescence Response Data

Site: Village of Hartford
Client: Clayton Group Services
Date/Time: 2/19/2004 @ 12:12:37 PM
ROST Unit: 1

Operator: ddeleon
Fugro Job #: 0303-0921
Max fluorescence: 39.92% @ 32.79 ft
Final depth BGS: 69.25 ft

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ROST Hydrocarbon Type

🟦 Light–Range LNAPL

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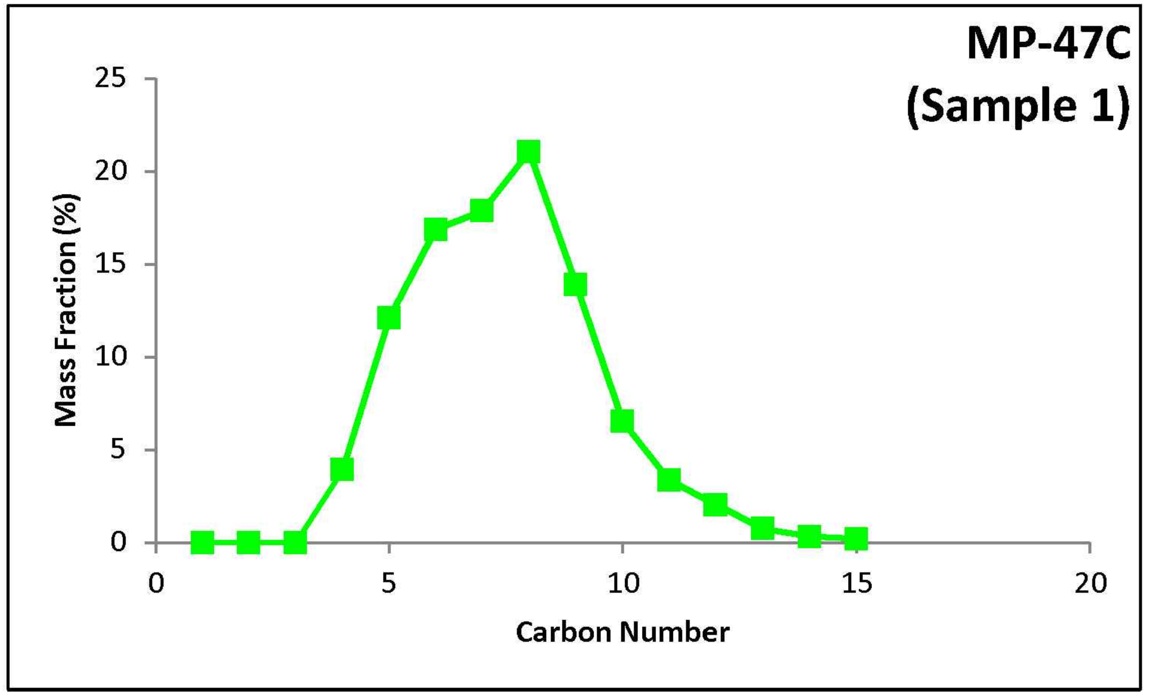
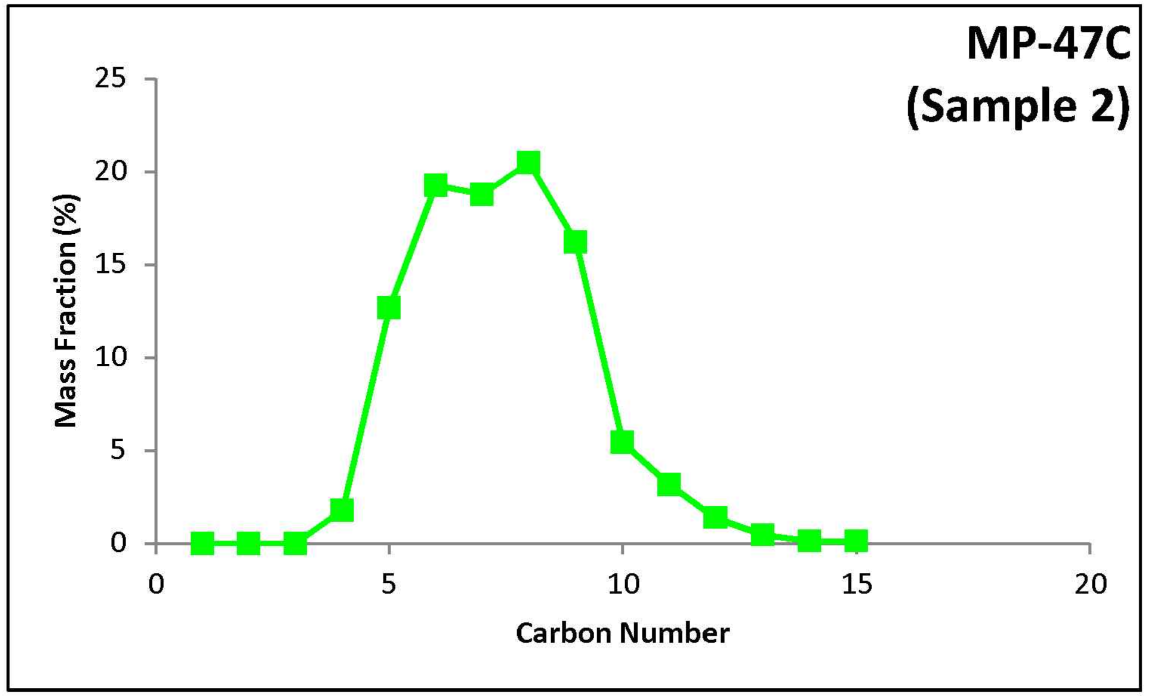
FIGURE D-4

LNAPL CHEMISTRY FOR MP-046C COMPARED TO FLUORESCENCE RESPONSE IN HROST-025

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

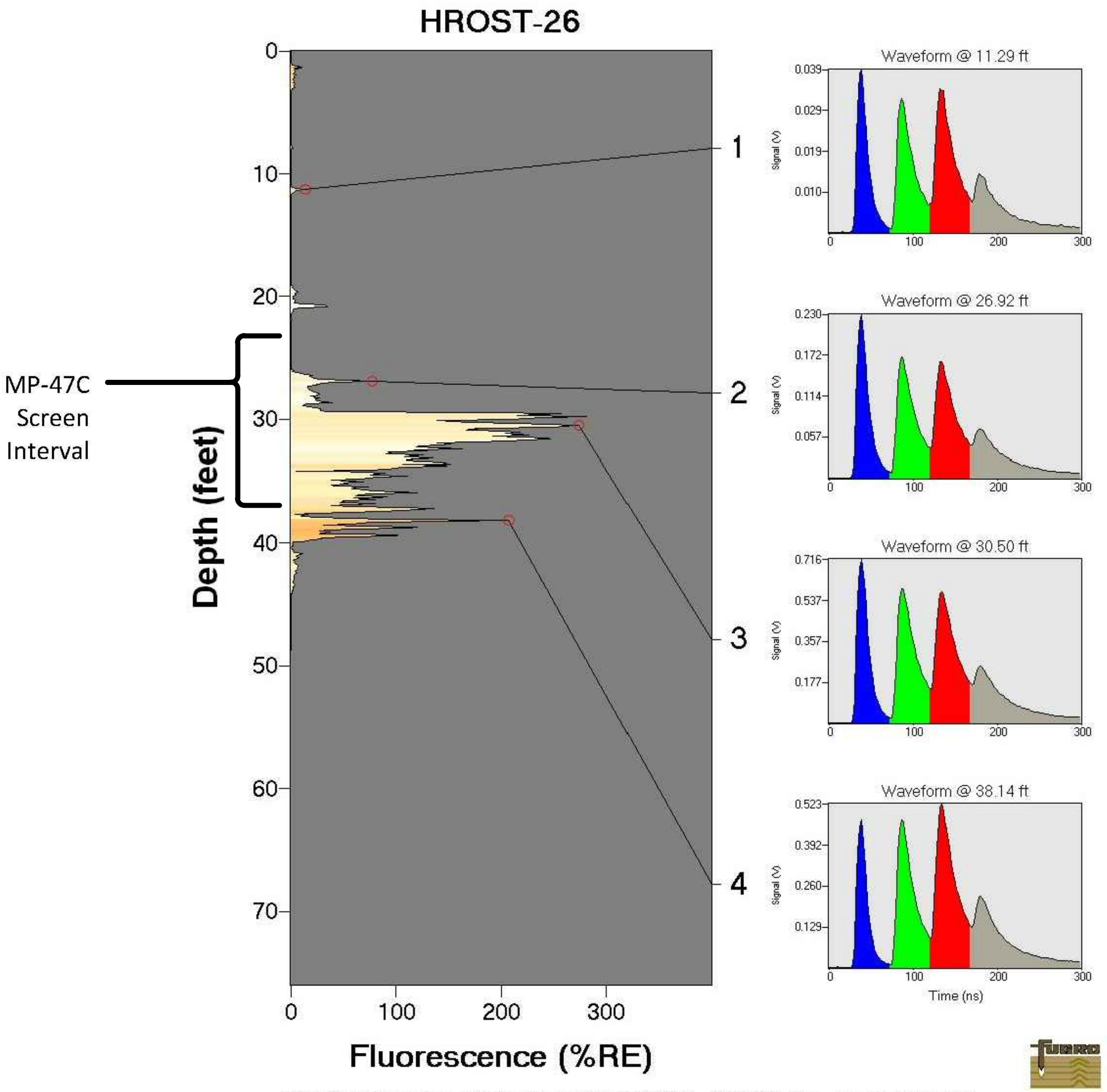
Drawn By: KJW | Checked By: PM | Scale: NO SCALE | Date: 1/27/14 | File: 24S_CARBONDIST20130919





ROST Fluorescence Response Data

Site: Village of Hartford	Operator: ddeleon
Client: Clayton Group Services	Fugro Job #: 0303-0921
Date/Time: 1/29/2004 @ 1:38:36 PM	Max fluorescence: 282.37% @ 29.74 ft
ROST Unit: 1	Final depth BGS: 48.85 ft



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ROST Hydrocarbon Type

🟧 Heavy–Range LNAPL

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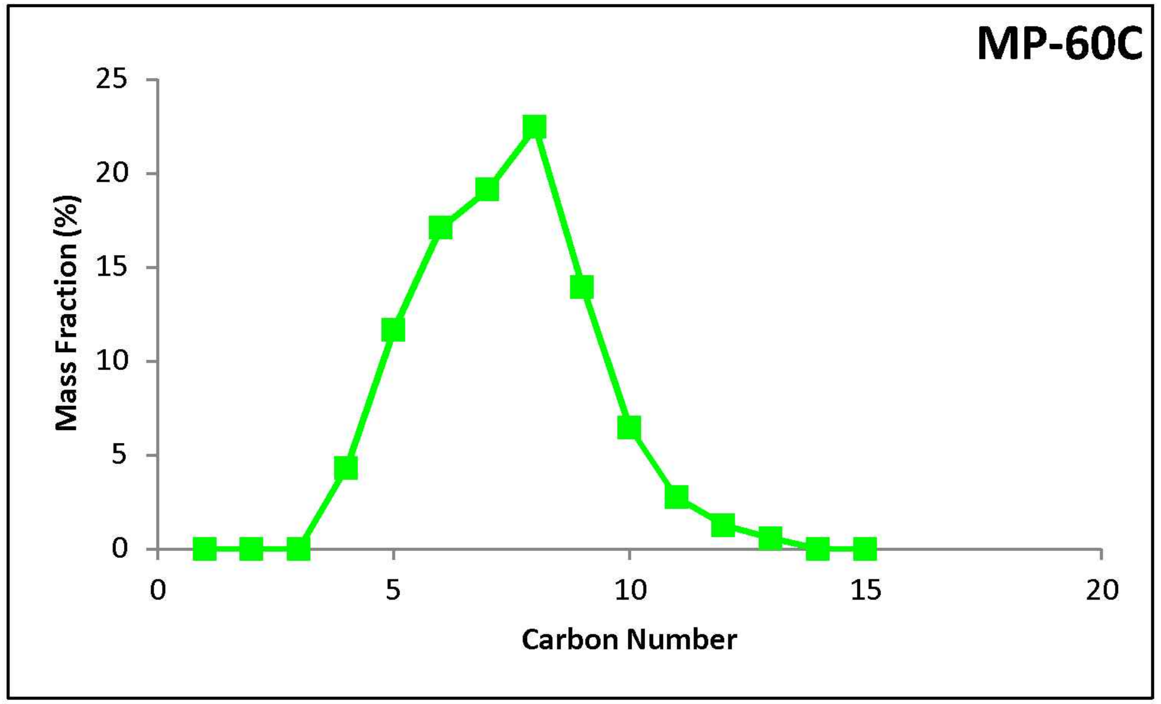
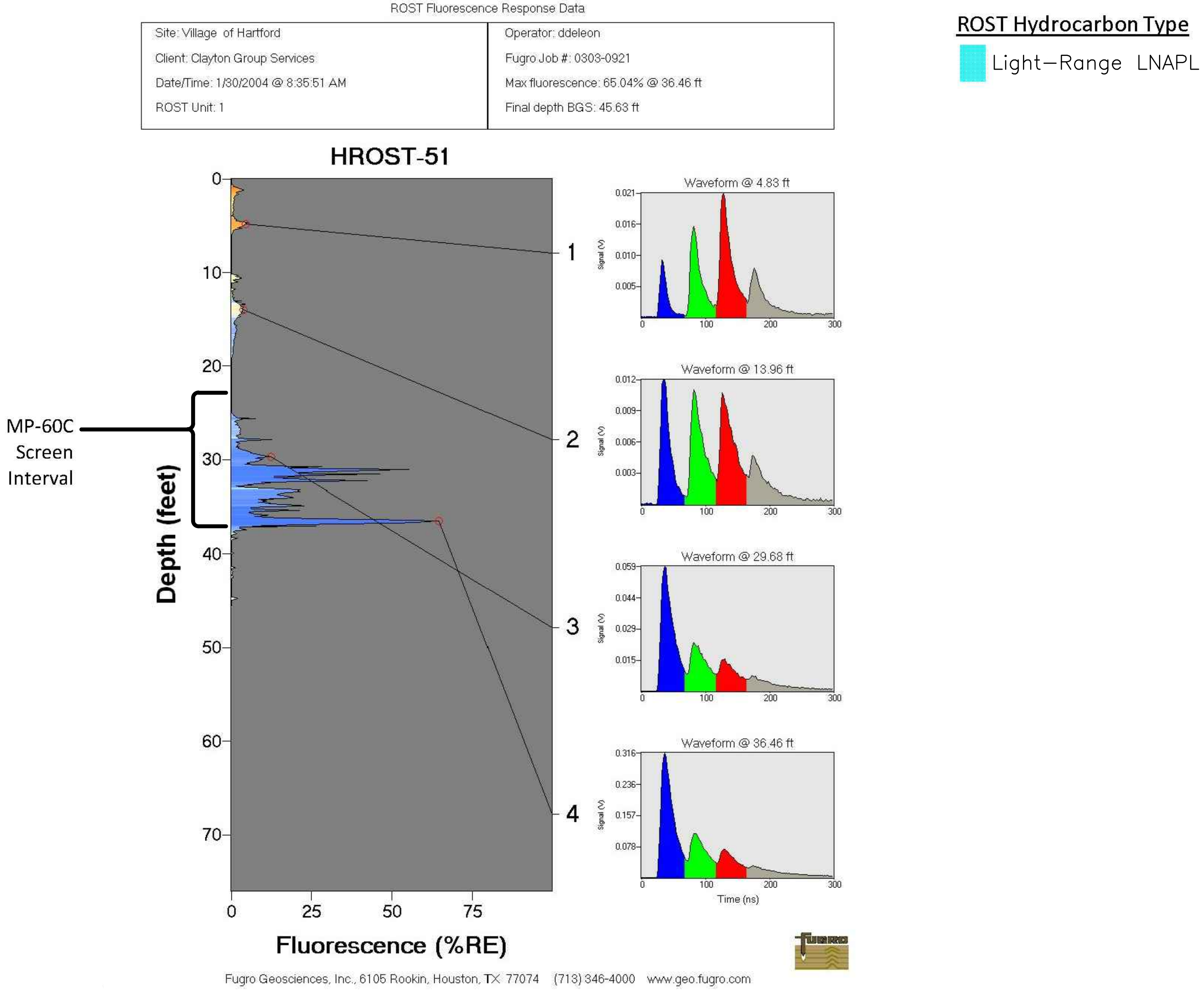
FIGURE D-5

LNAPL CHEMISTRY FOR MP-047C COMPARED TO FLUORESCENCE RESPONSE IN HROST-026

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: KJW	Checked By: PM	Scale: NO SCALE	Date: 1/27/14	File: 24S_CARBONDIST20130919




ROST Fluorescence Response Data

Site: Village of Hartford	Operator: ddeleon
Client: Clayton Group Services	Fugro Job #: 0303-0921
Date/Time: 1/30/2004 @ 8:35:51 AM	Max fluorescence: 65.04% @ 36.46 ft
ROST Unit: 1	Final depth BGS: 45.63 ft

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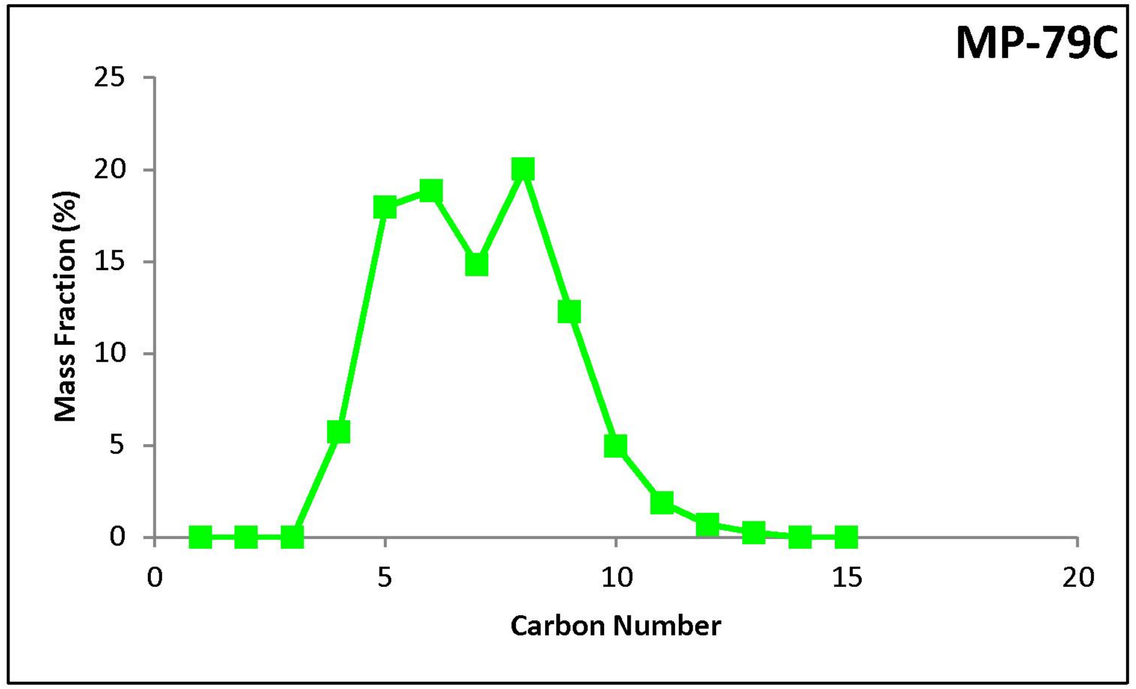
FIGURE D-6

LNAPL CHEMISTRY FOR MP-060C COMPARED TO FLUORESCENCE RESPONSE IN HROST-051

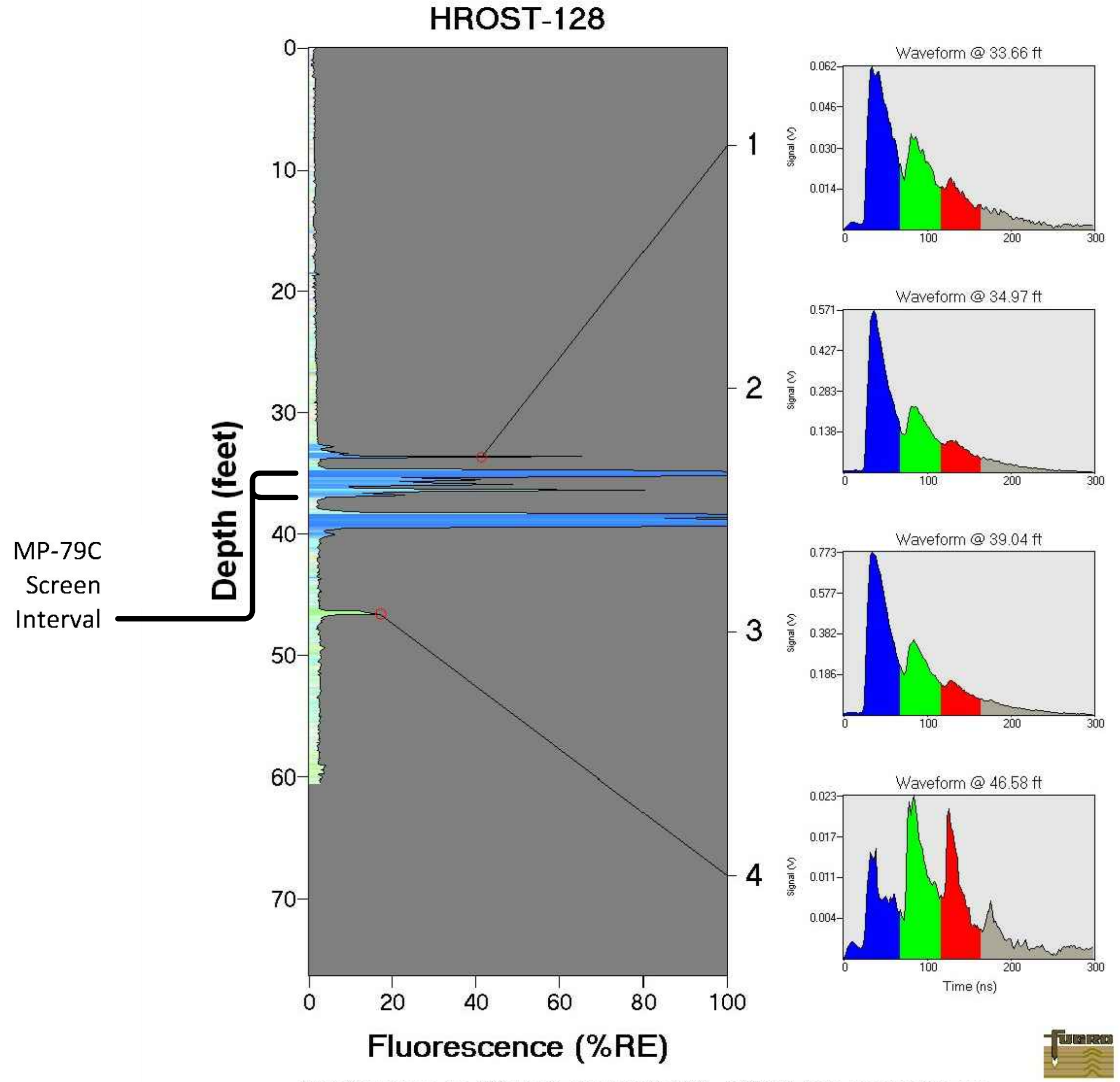
HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: KJW	Checked By: PM	Scale: NO SCALE	Date: 1/27/14	File: 24S_CARBONDIST20130919



ROST Fluorescence Response Data

Site: HARTFORD WORKIG GROUP	Operator: Robert Biehle
Client: CLAYTON GROUP	Fugro Job #: 0305-1583
Date/Time: 8/29/2005 @ 4:41:47 PM	Max fluorescence: 445.61% @ 38.58 ft
ROST Unit: III	Final depth BGS: 60.43 ft



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ROST Hydrocarbon Type

🟦 Light–Range LNAPL

Note:
LIF type for HROST–128 not reported in Clayton (2005) report. Therefore, the types reported here are based on other similar waveforms reported by Clayton (2005).

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FIGURE D-7

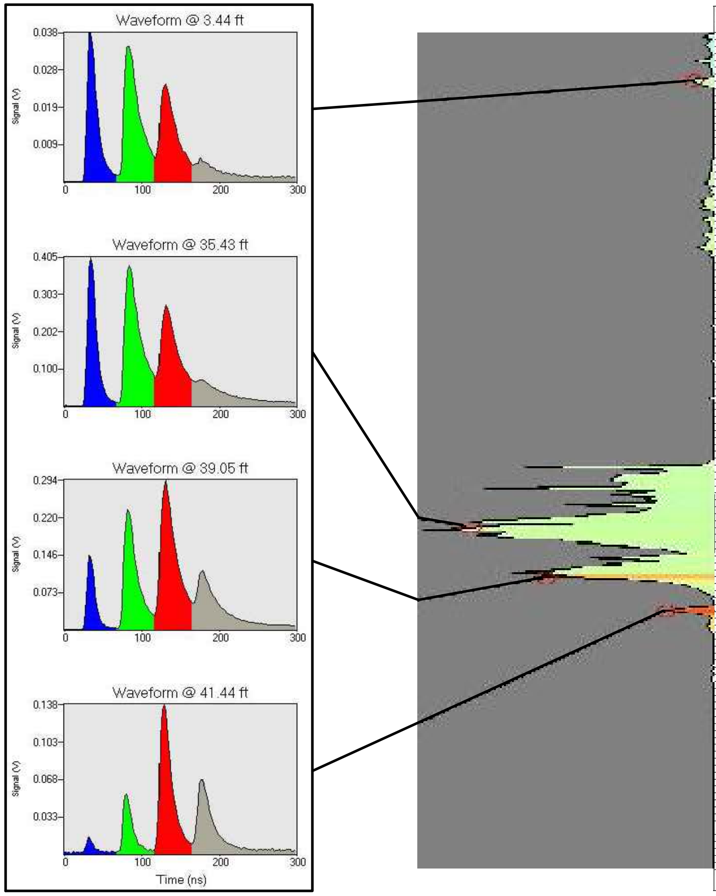
LNAPL CHEMISTRY FOR MP-079C COMPARED TO FLUORESCENCE RESPONSE IN HROST-128

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: KJW | Checked By: PM | Scale: NO SCALE | Date: 1/27/14 | File: 24S_CARBONDIST20130919

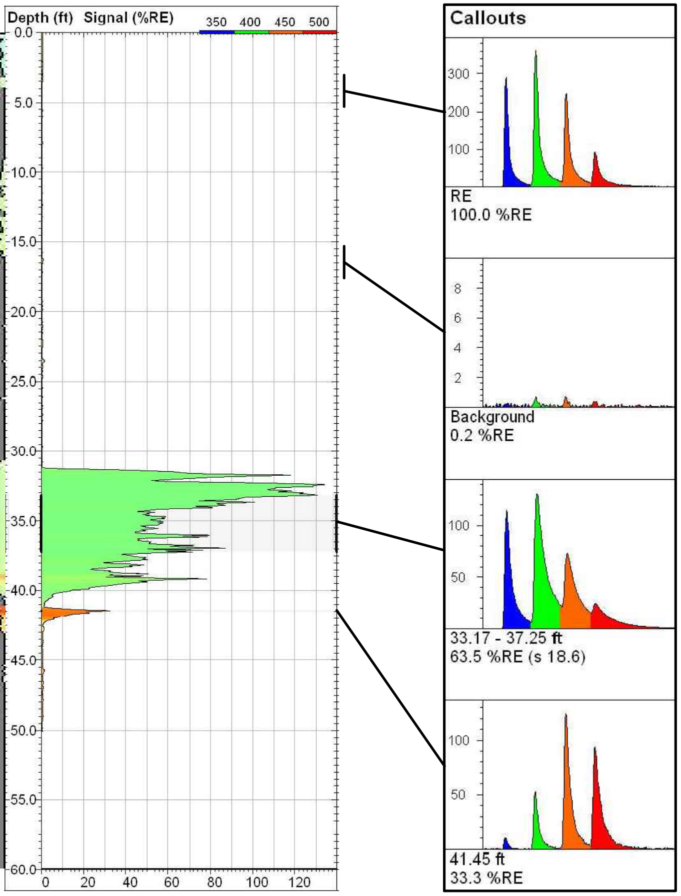
APPENDIX E

FLUORESCENCE RESPONSE COMPARISON FOR SELECTED MONITORING LOCATIONS



A **HROST-002, FEBRUARY 2004**

MIRRORED AND SCALED TO B



B **HUVOST-002, SEPTEMBER 2013**

SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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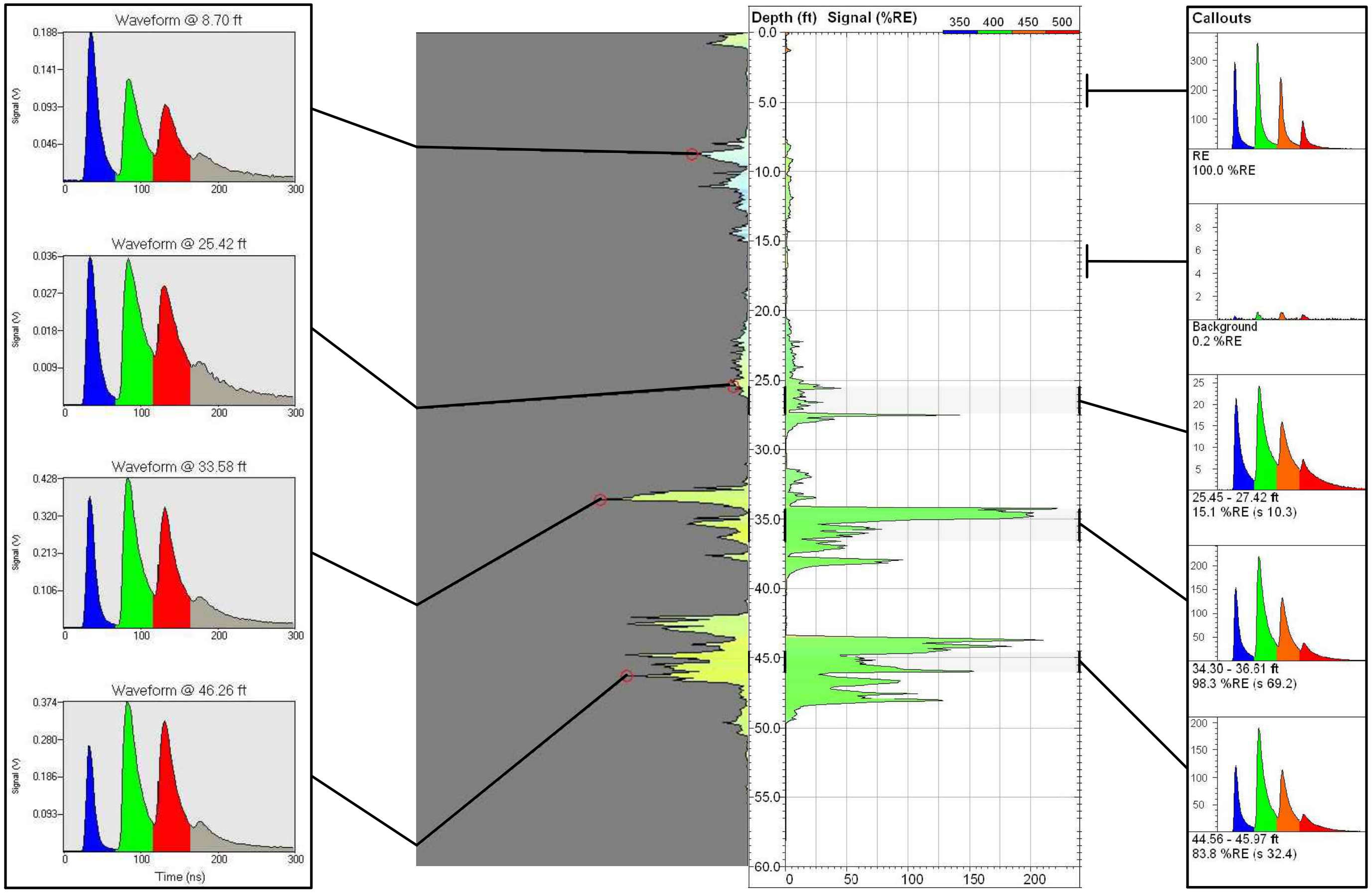
FIGURE E-1

FLUORESCENCE RESPONSE COMPARISON FOR HUVOST-002 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST002COMP



A **HROST-004, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-004, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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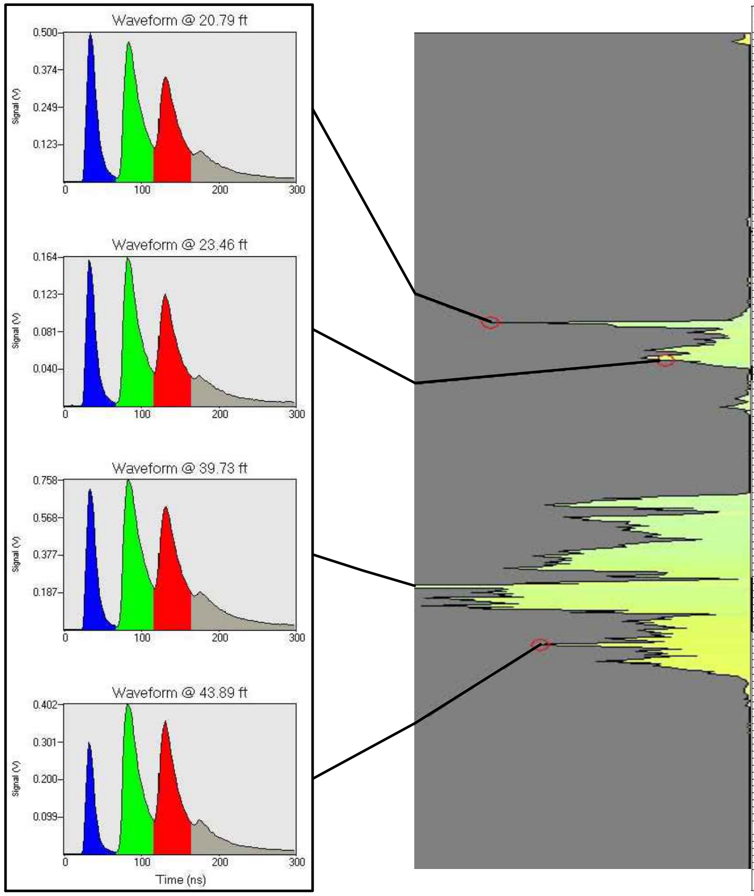
FIGURE E-2

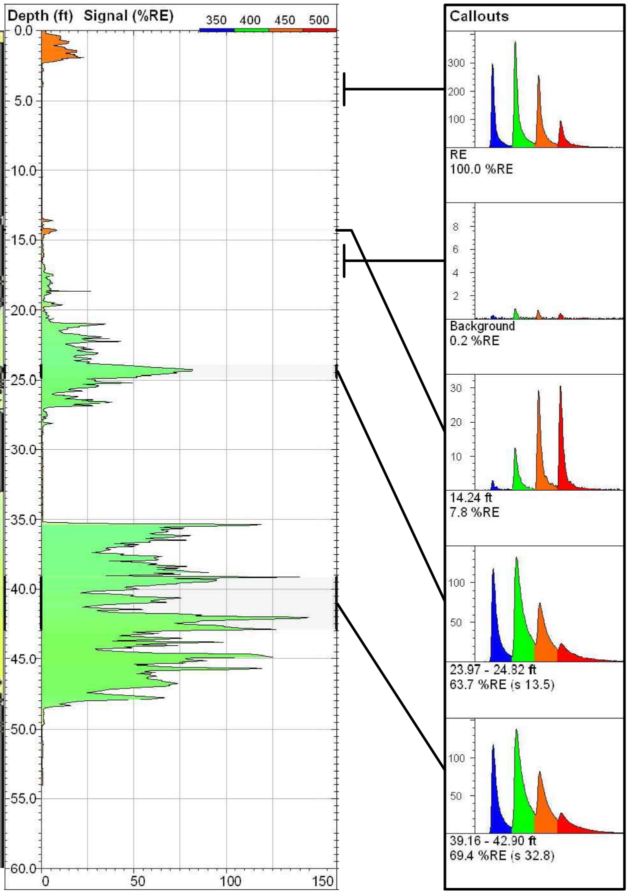
FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-004 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST004COMP



A **HROST-005, FEBRUARY 2004**
MIRRORED AND SCALED TO B



B **HUVOST-005, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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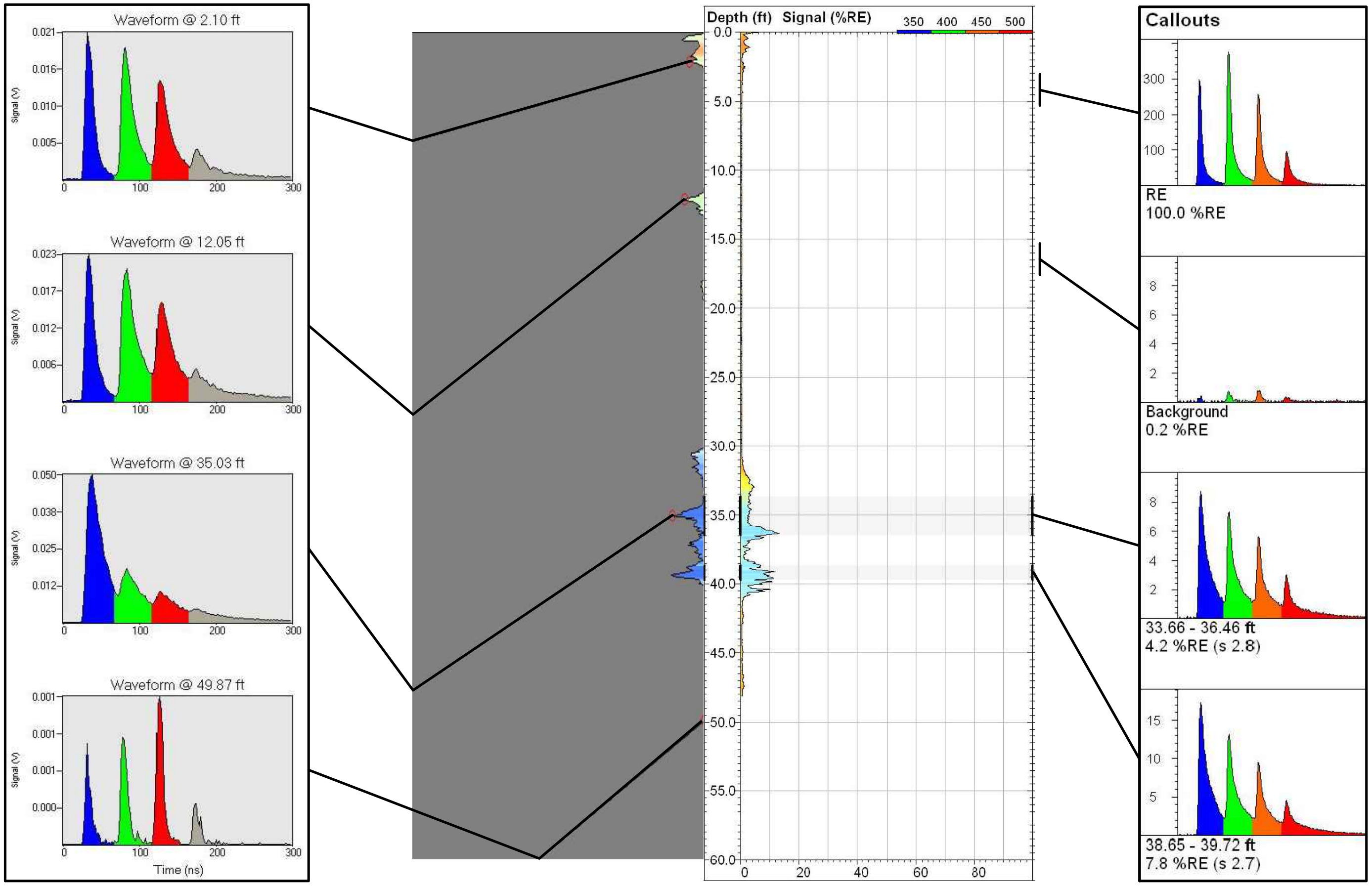
FIGURE E-3

FLUORESCENCE RESPONSE COMPARISON FOR HUVOST-005 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST005COMP



A **HROST-007, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-007, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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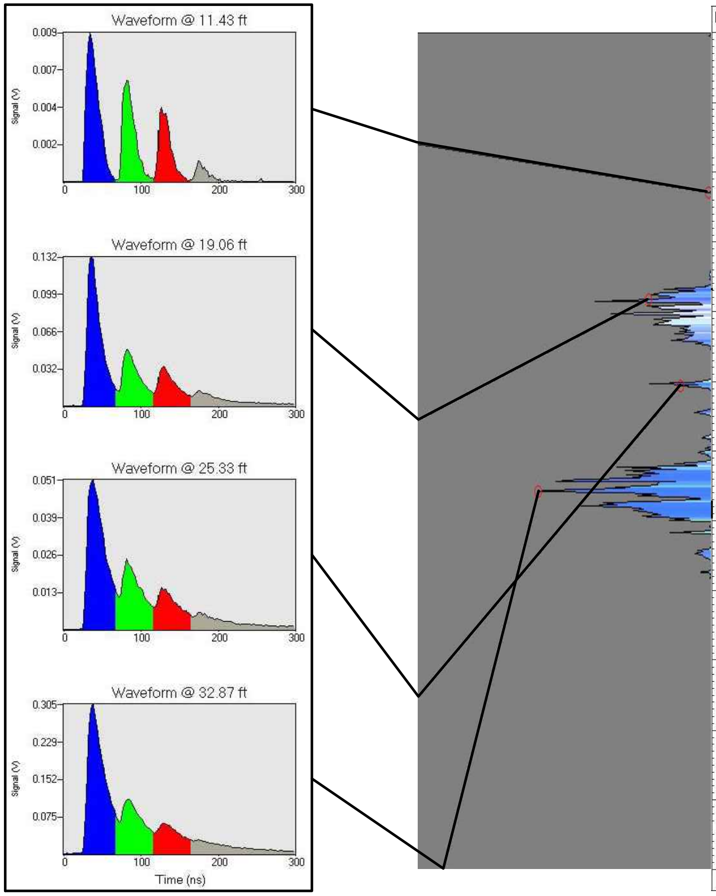
FIGURE E-4

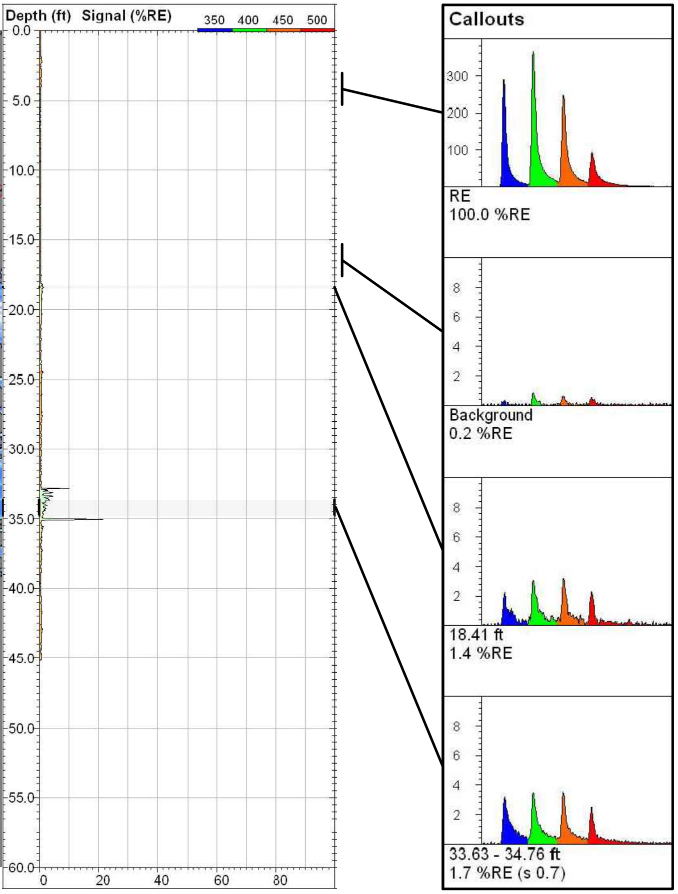
FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-007 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP | Checked By: PM | Scale: AS SHOWN | Date: 5/22/14 | File: 24SROST007COMP



A **HROST-013, FEBRUARY 2004**
MIRRORED AND SCALED TO B



B **HUVOST-013G, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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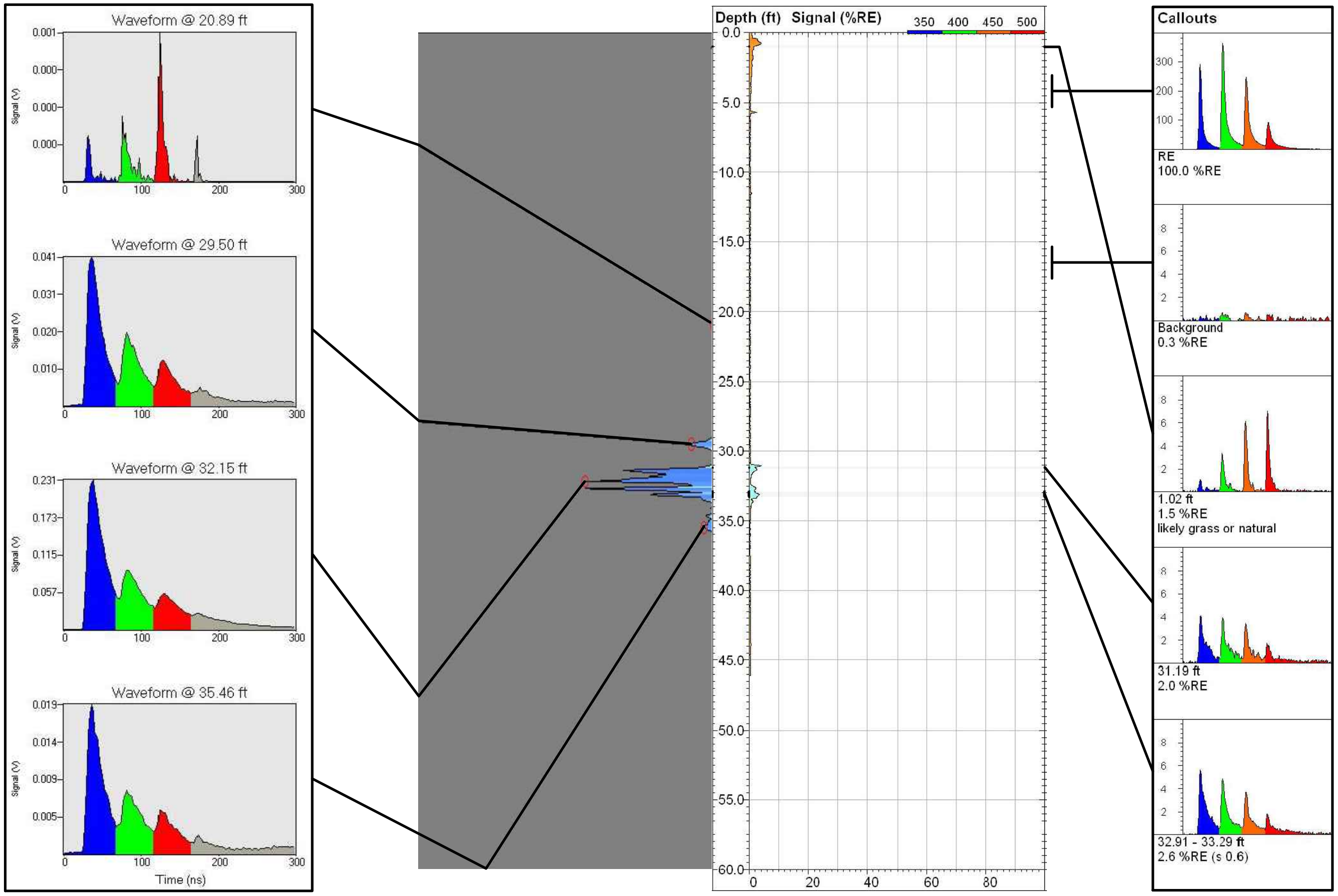
FIGURE E-5

FLUORESCENCE RESPONSE COMPARISON FOR HUVOST-013 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST013COMP



A **HROST-019, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-019, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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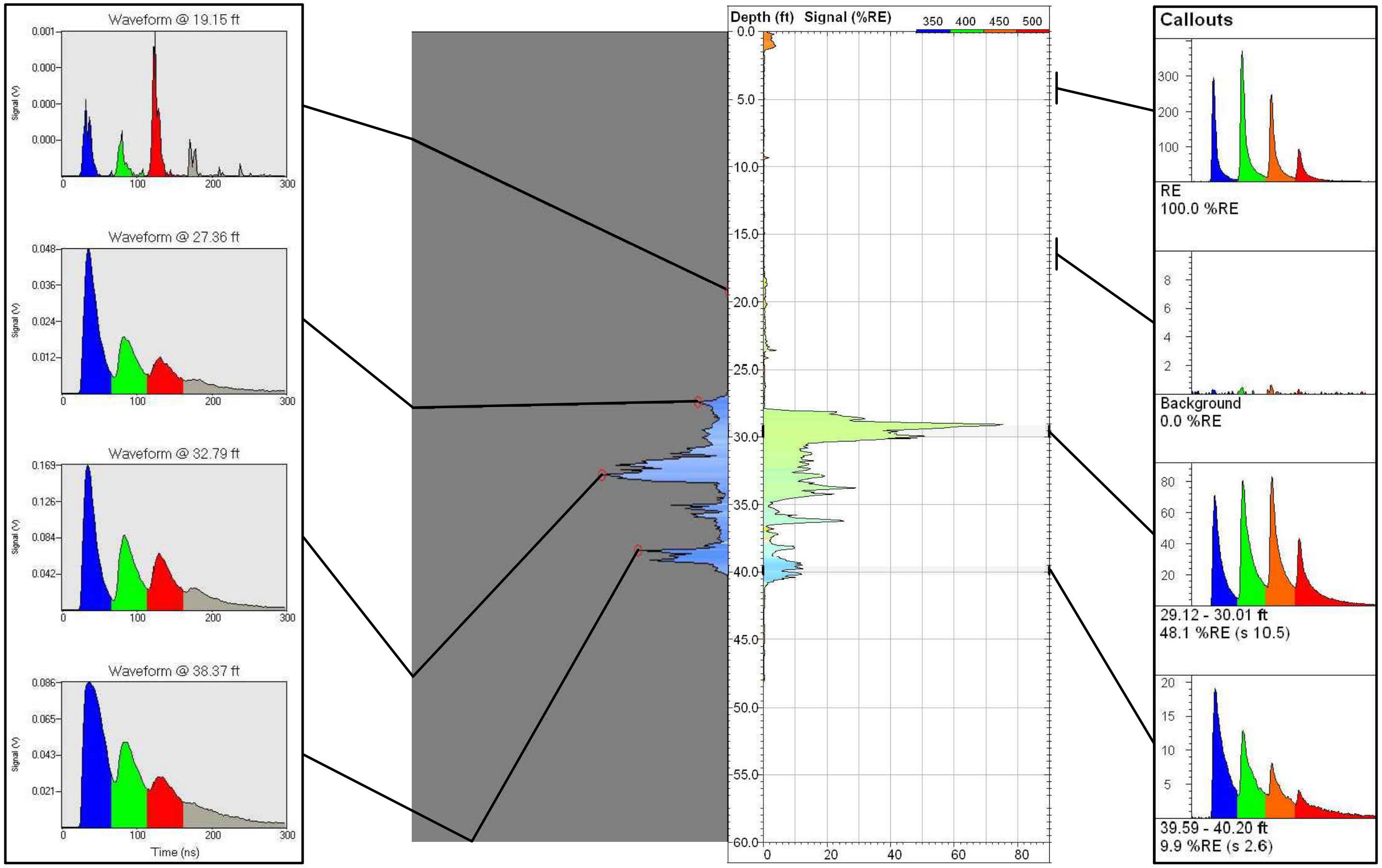
FIGURE E-6

FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-019 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST019COMP



A **HROST-025, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-025, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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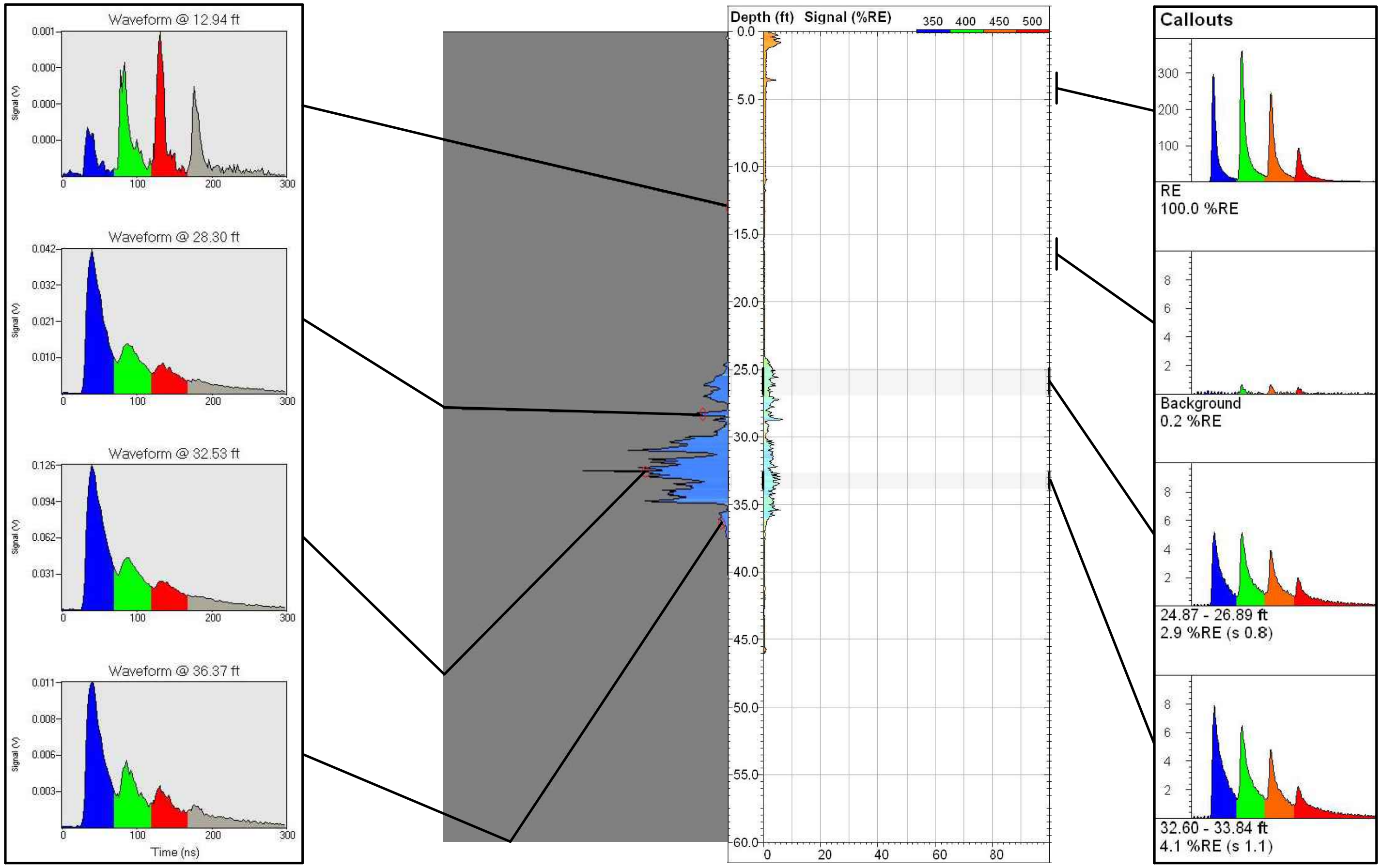
FIGURE E-7

FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-025 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST025COMP



(A) HROST-028, FEBRUARY 2004
MIRRORED AND SCALED TO B

(B) HUVOST-028, SEPTEMBER 2013
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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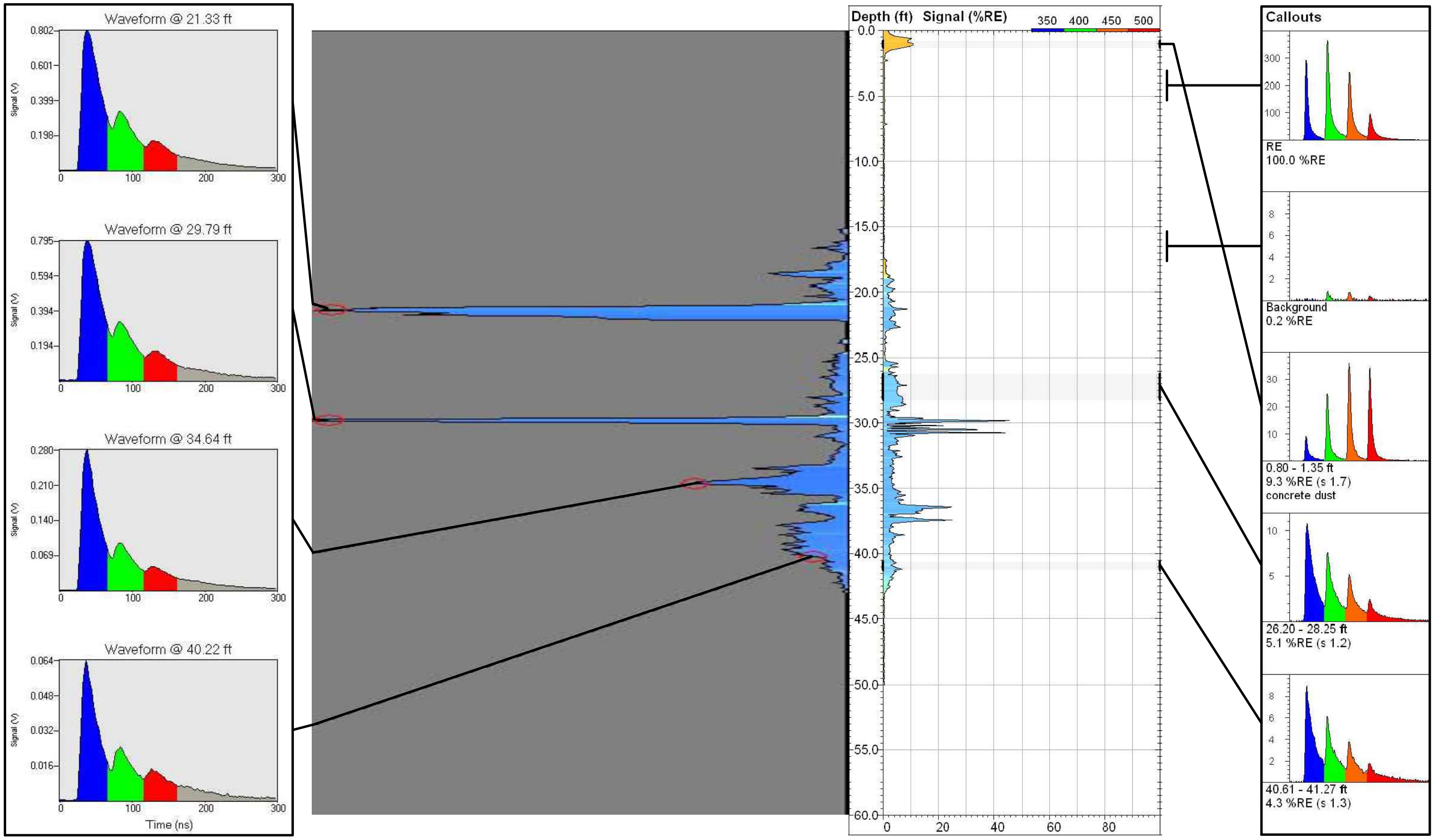
FIGURE E-8

FLUORESCENCE RESPONSE COMPARISON FOR HUVOST-028 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST028COMP



A **HROST-029, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-029, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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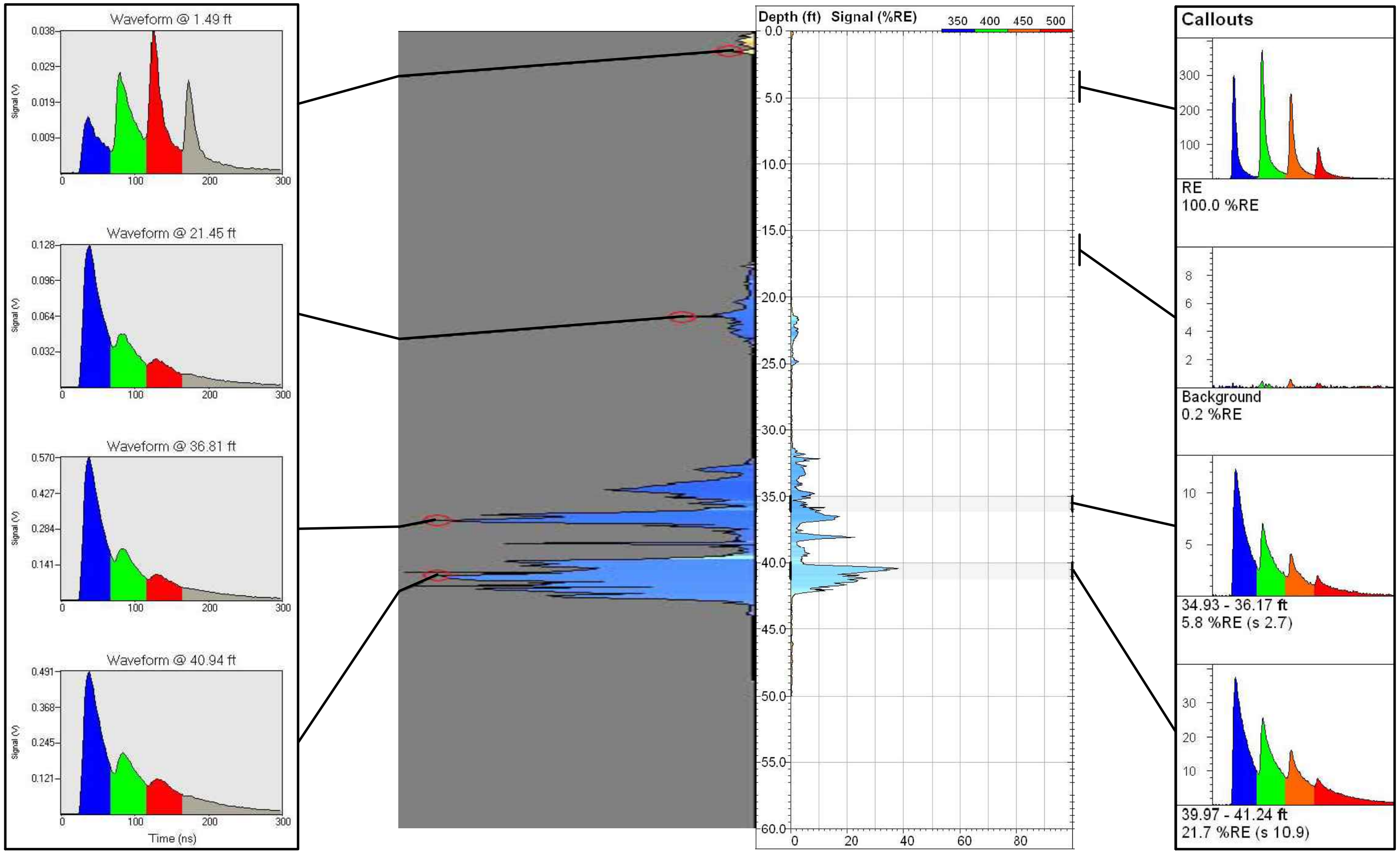
FIGURE E-9

FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-029 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST029COMP



A **HROST-030, JANUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-030, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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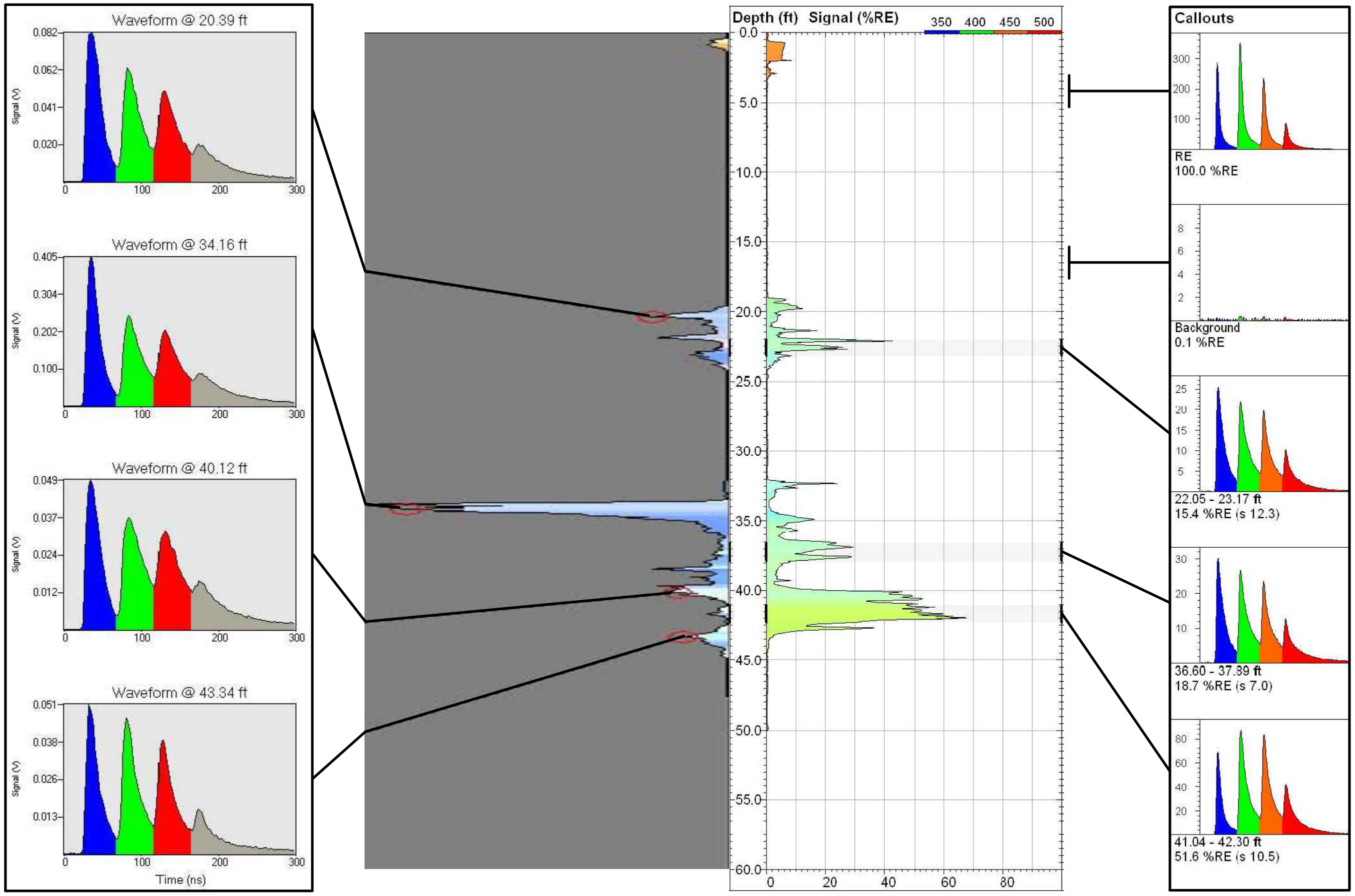
FIGURE E-10

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-030 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST030COMP



A **HROST-039, JANUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-039, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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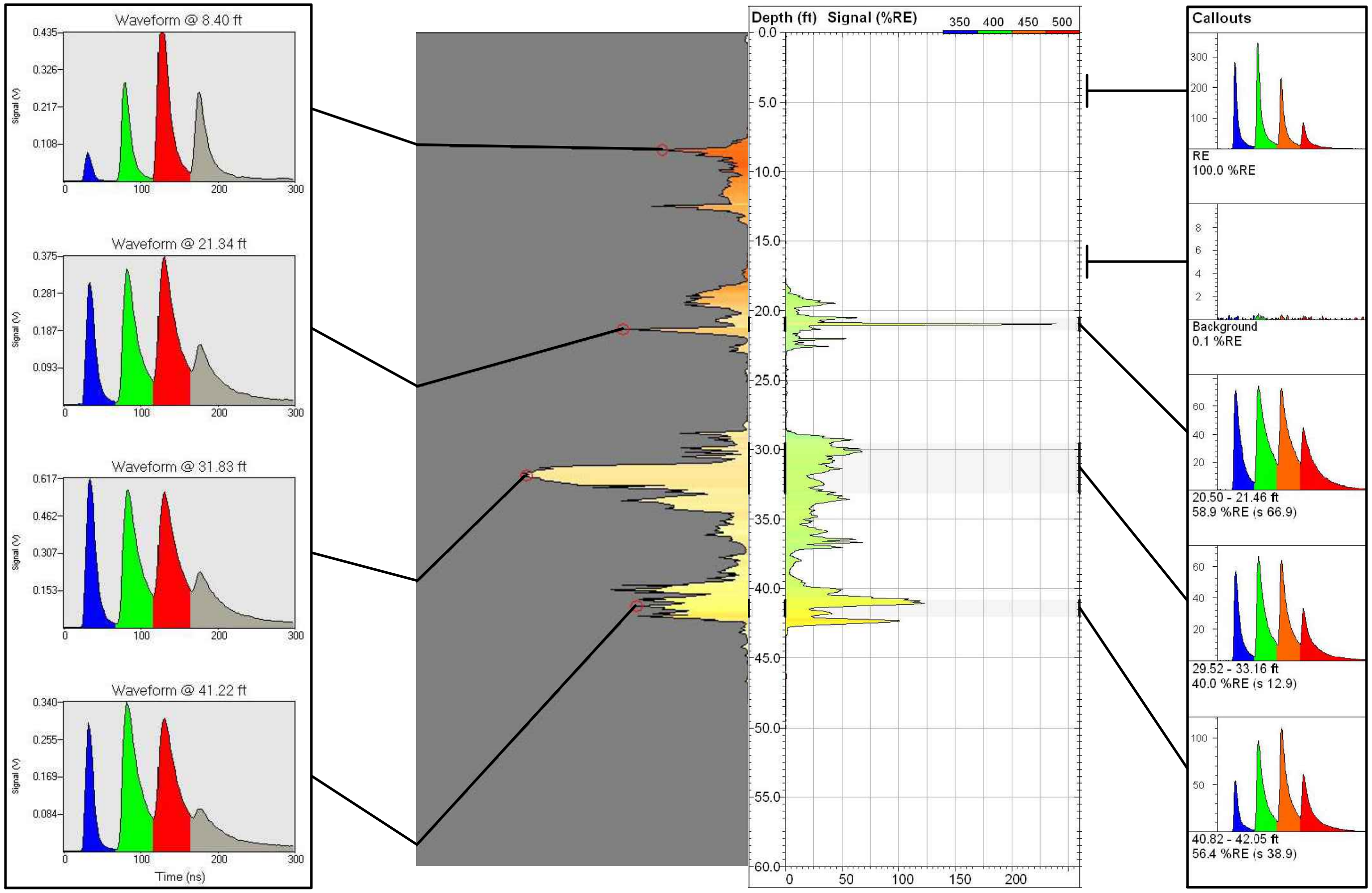
FIGURE E-11

FLUORESCENCE RESPONSE COMPARISON FOR HUVOST-039 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST039COMP



A **HROST-040, JANUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-040, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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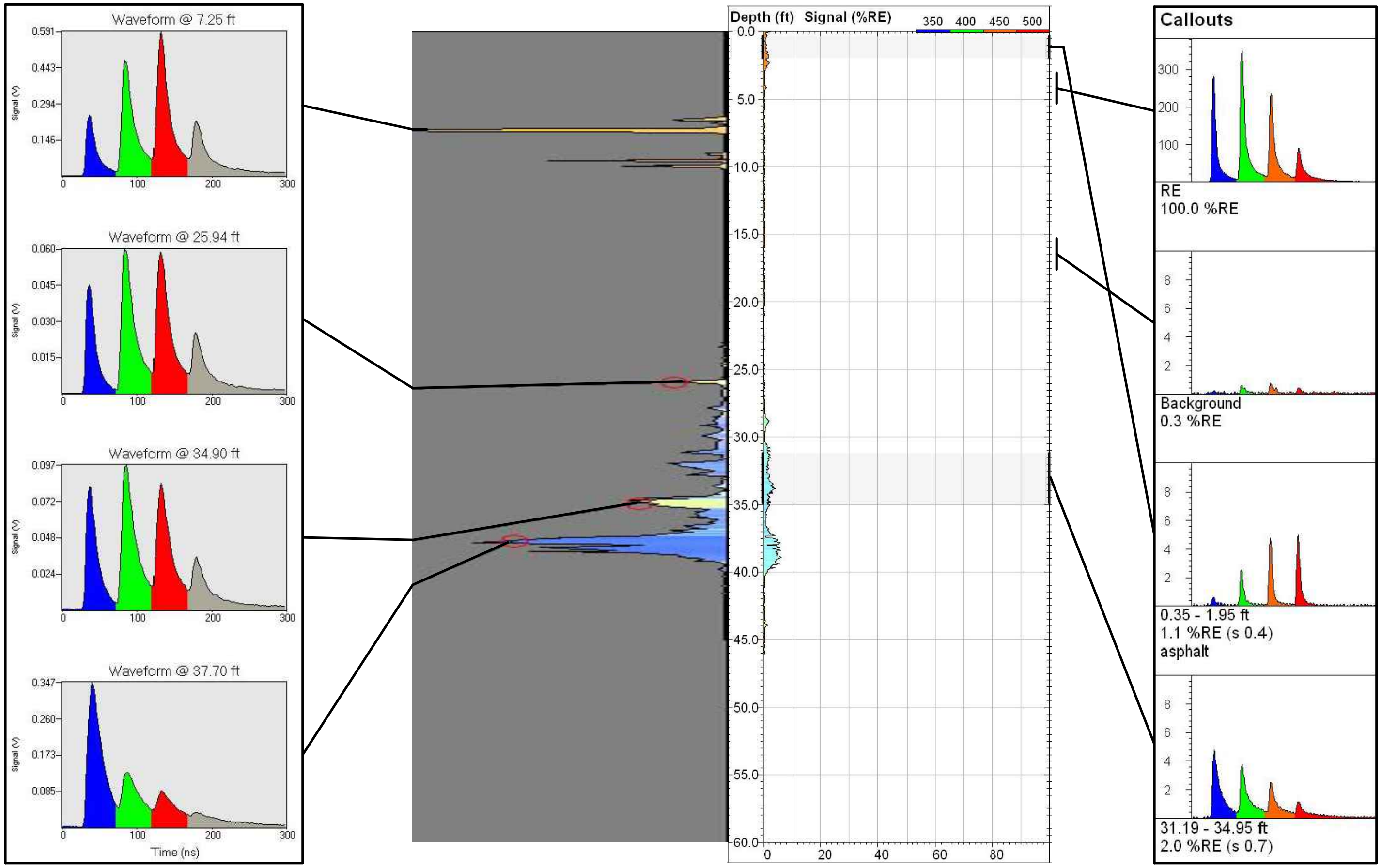
FIGURE E-12

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-040 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST040COMP



A **HROST-049, JANUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-049, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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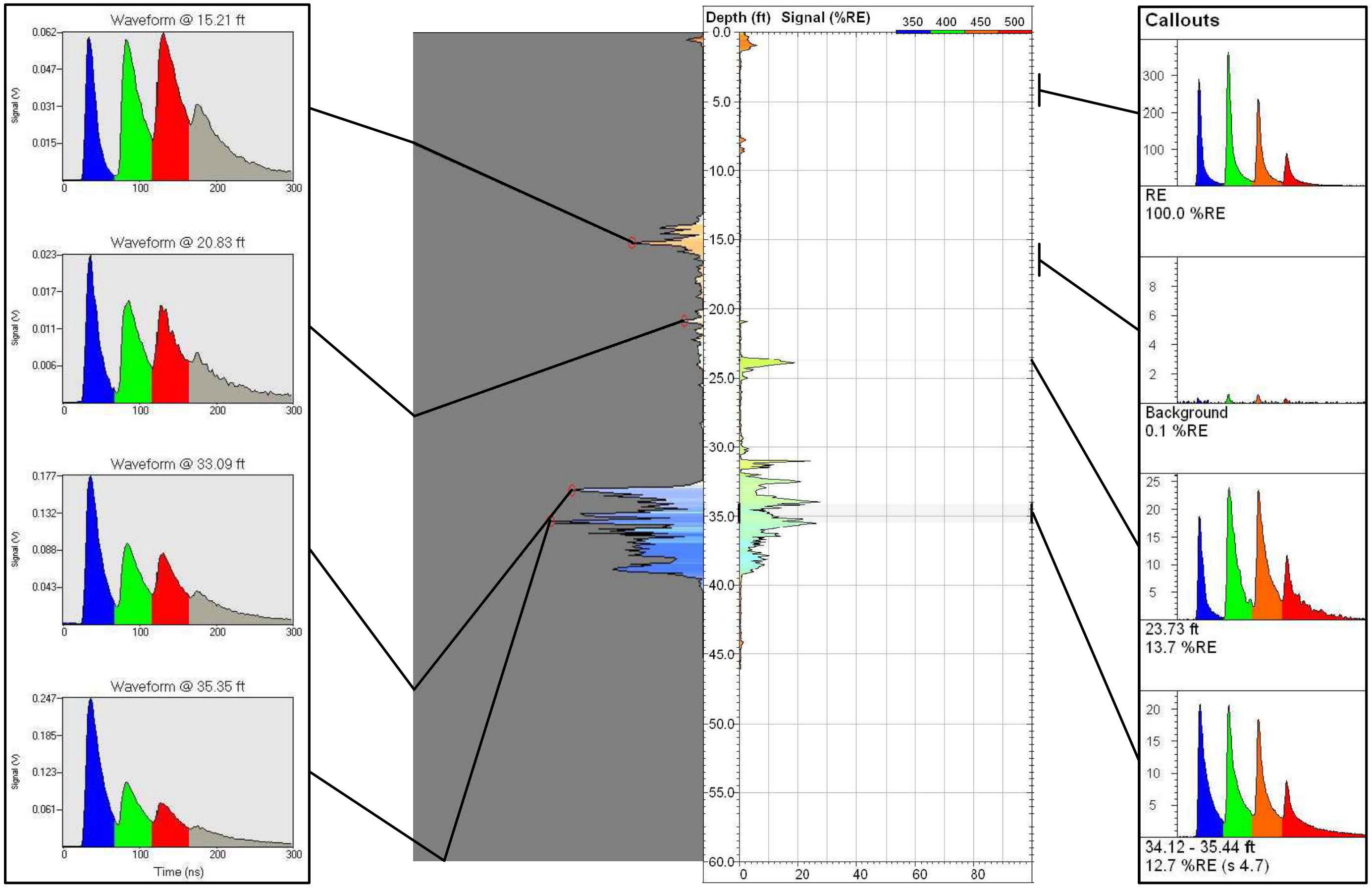
FIGURE E-13

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-049 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST049COMP



A **HROST-052, JANUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-052, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:
THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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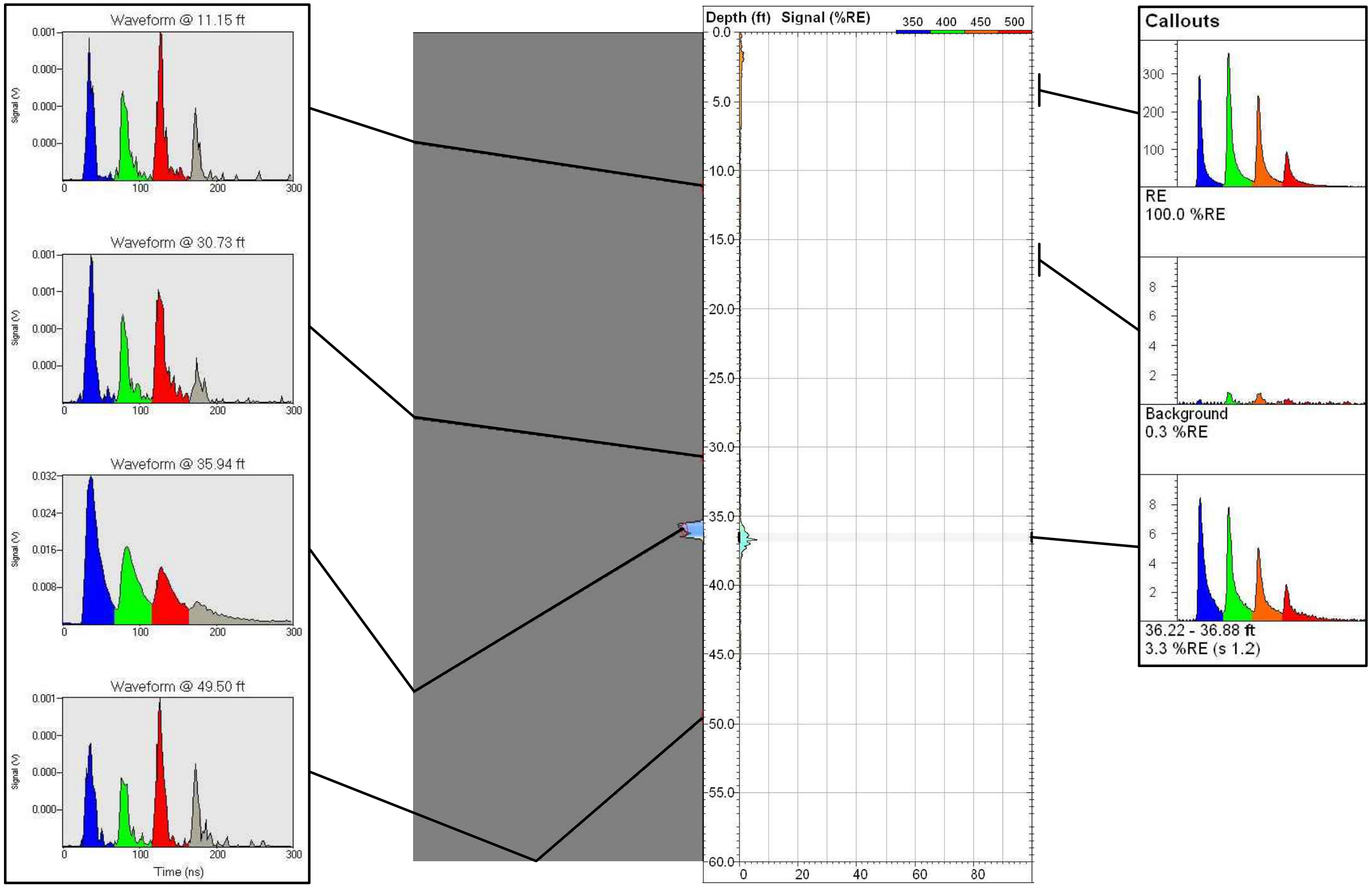
FIGURE E-14

FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-052 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST052COMP



A **HROST-066, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-066, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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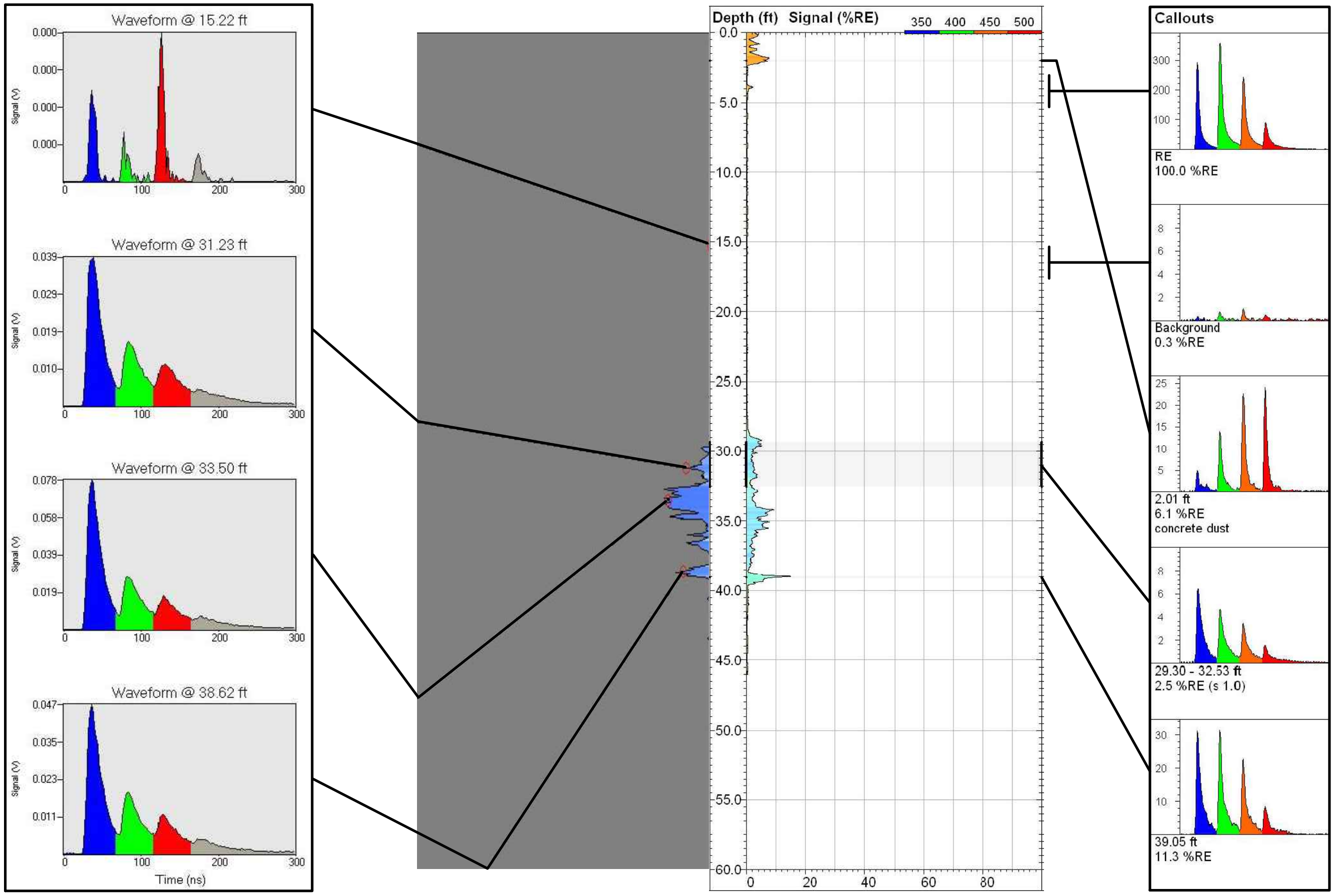
FIGURE E-15

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-066 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST066COMP



A **HROST-068, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-068, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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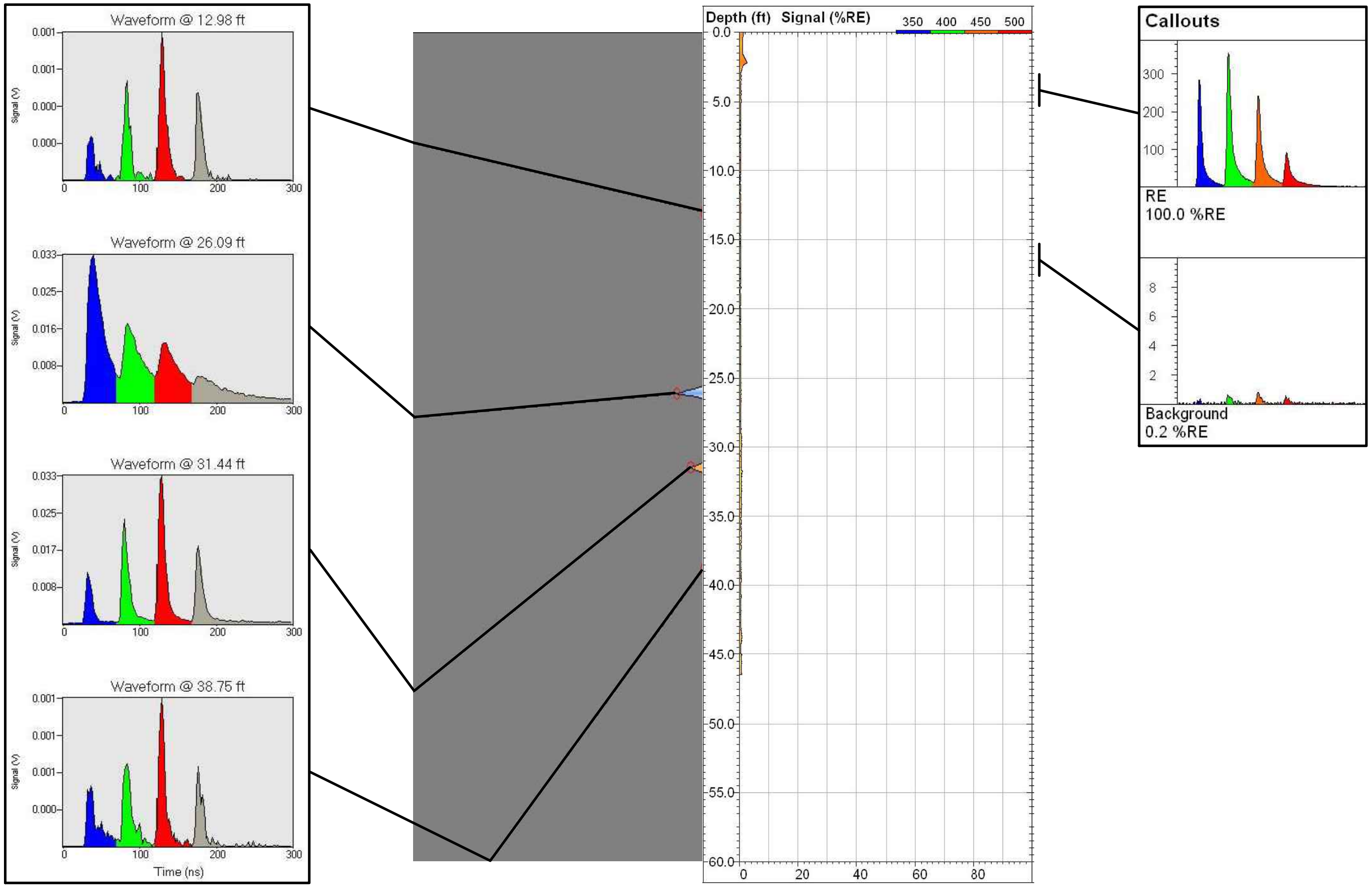
FIGURE E-16

FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-068 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST068COMP



A **HROST-072, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-072, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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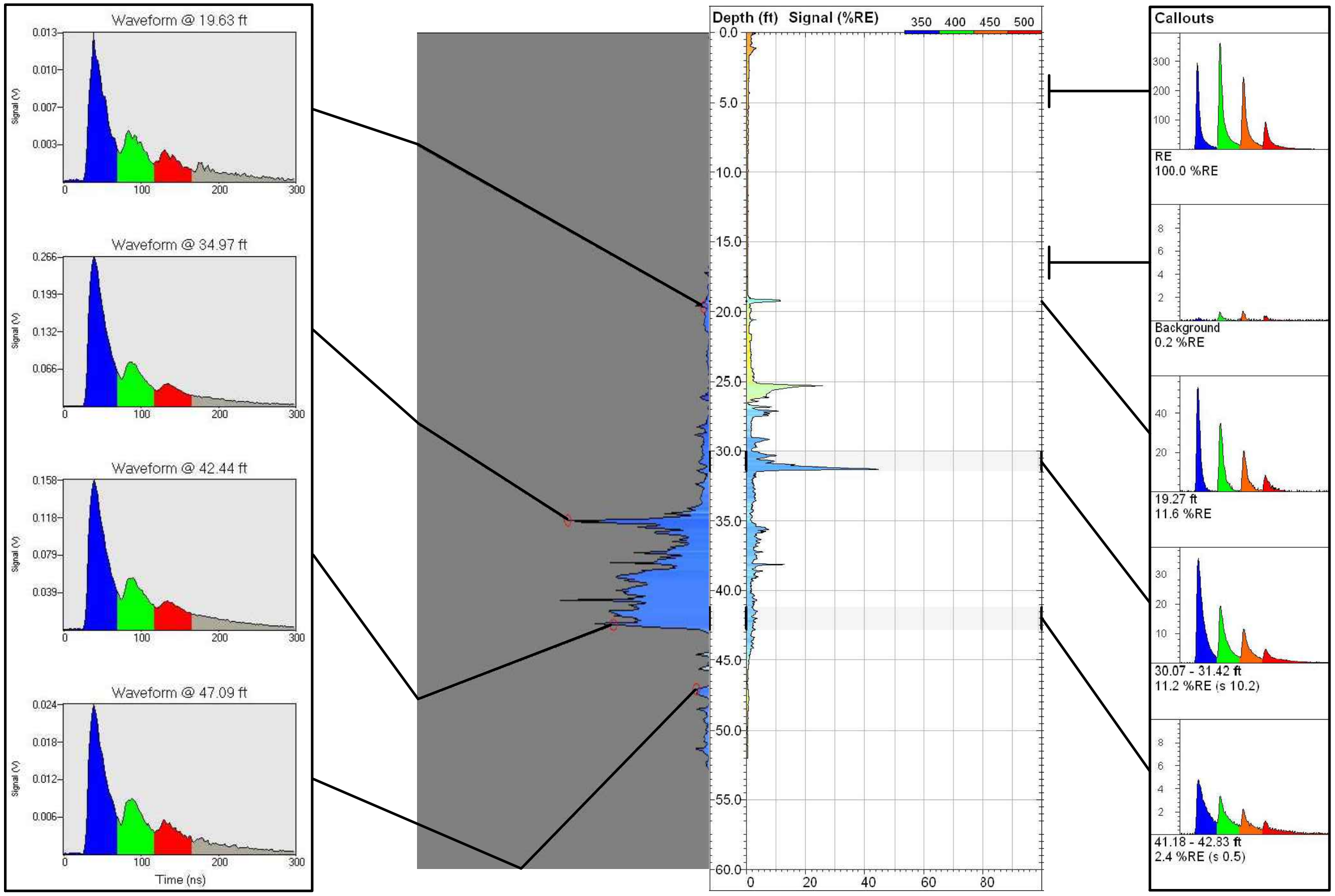
FIGURE E-17

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-072 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST072COMP



A **HROST-078, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-078A, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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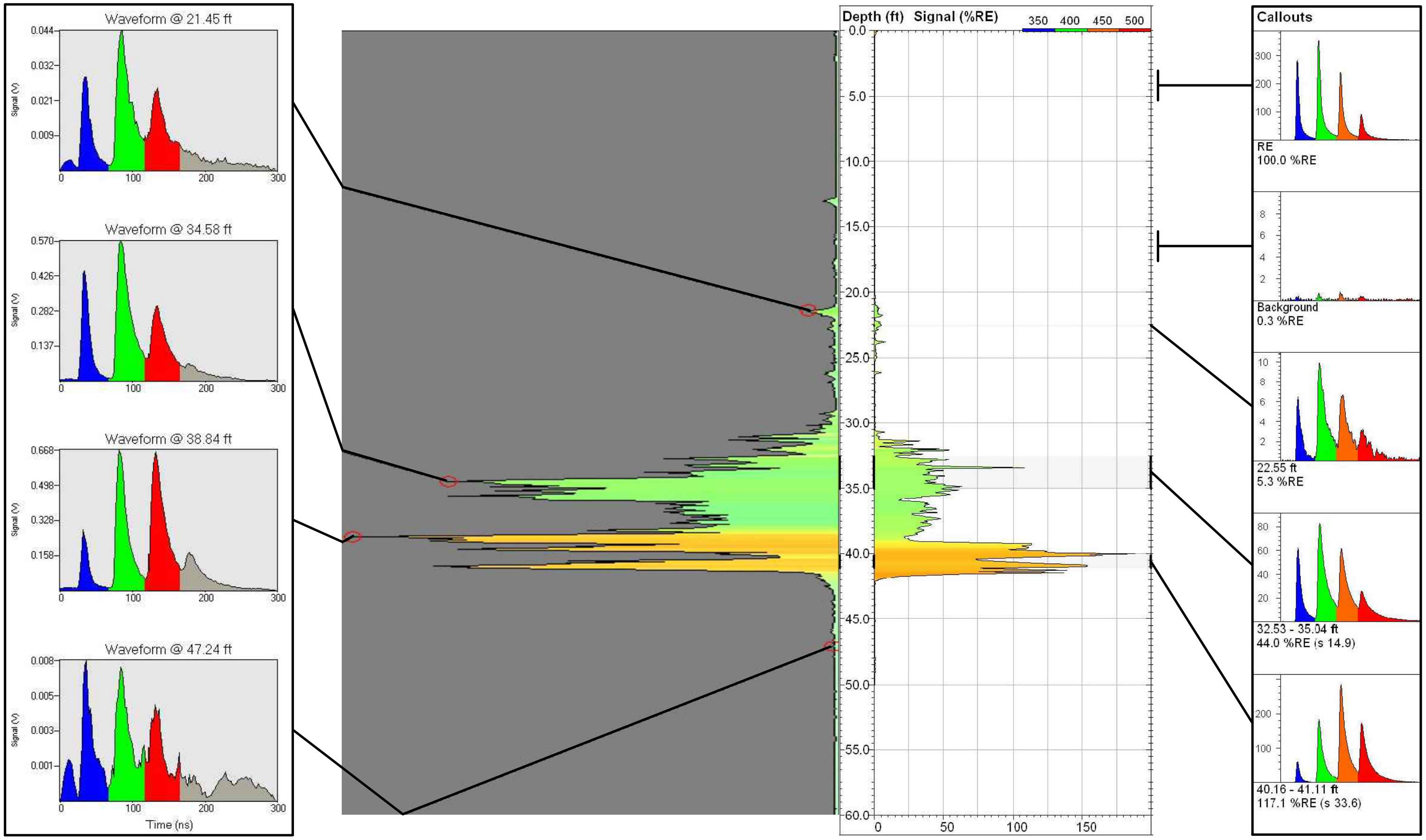
FIGURE E-18

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-078 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST078COMP



A **HROST-090, JUNE 2005**
MIRRORED AND SCALED TO B

B **HUVOST-090, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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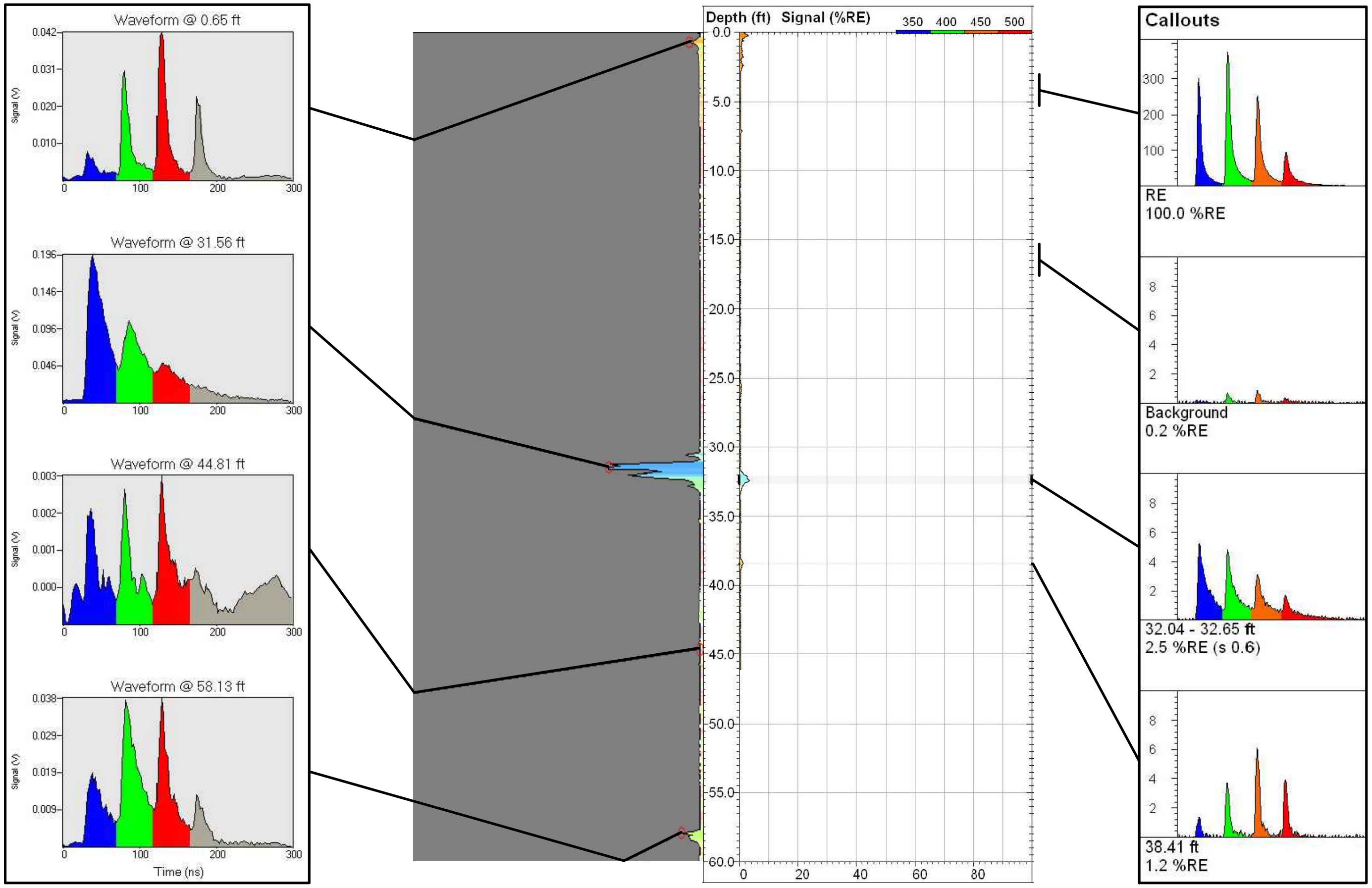
FIGURE E-19

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-090 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP | Checked By: PM | Scale: AS SHOWN | Date: 5/22/14 | File: 24SROST090COMP



A **HROST-099, JUNE 2005**
MIRRORED AND SCALED TO B

B **HUVOST-099, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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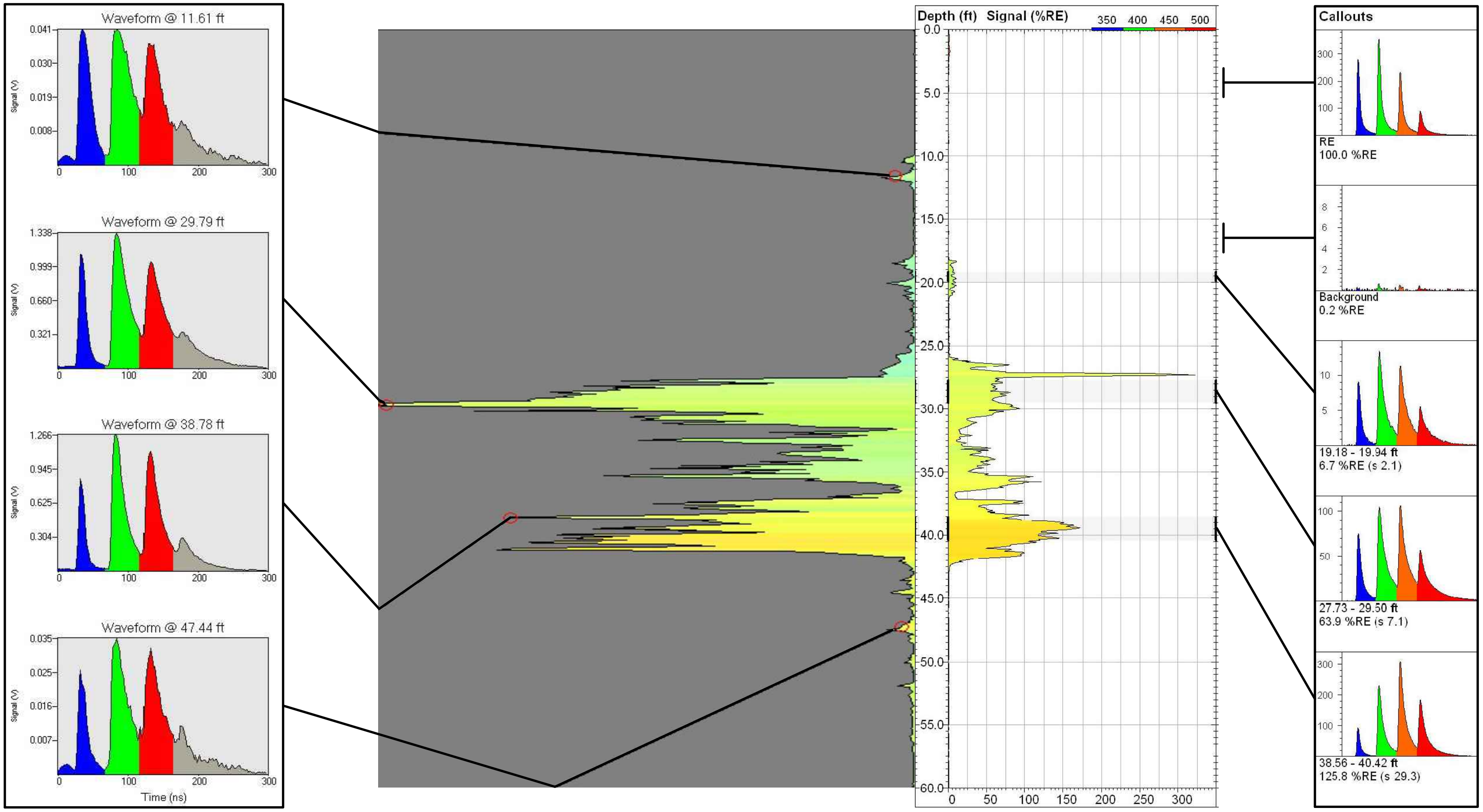
FIGURE E-20

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-099 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST099COMP



A **HROST-113, JUNE 2005**
MIRRORED AND SCALED TO B

B **HUVOST-113, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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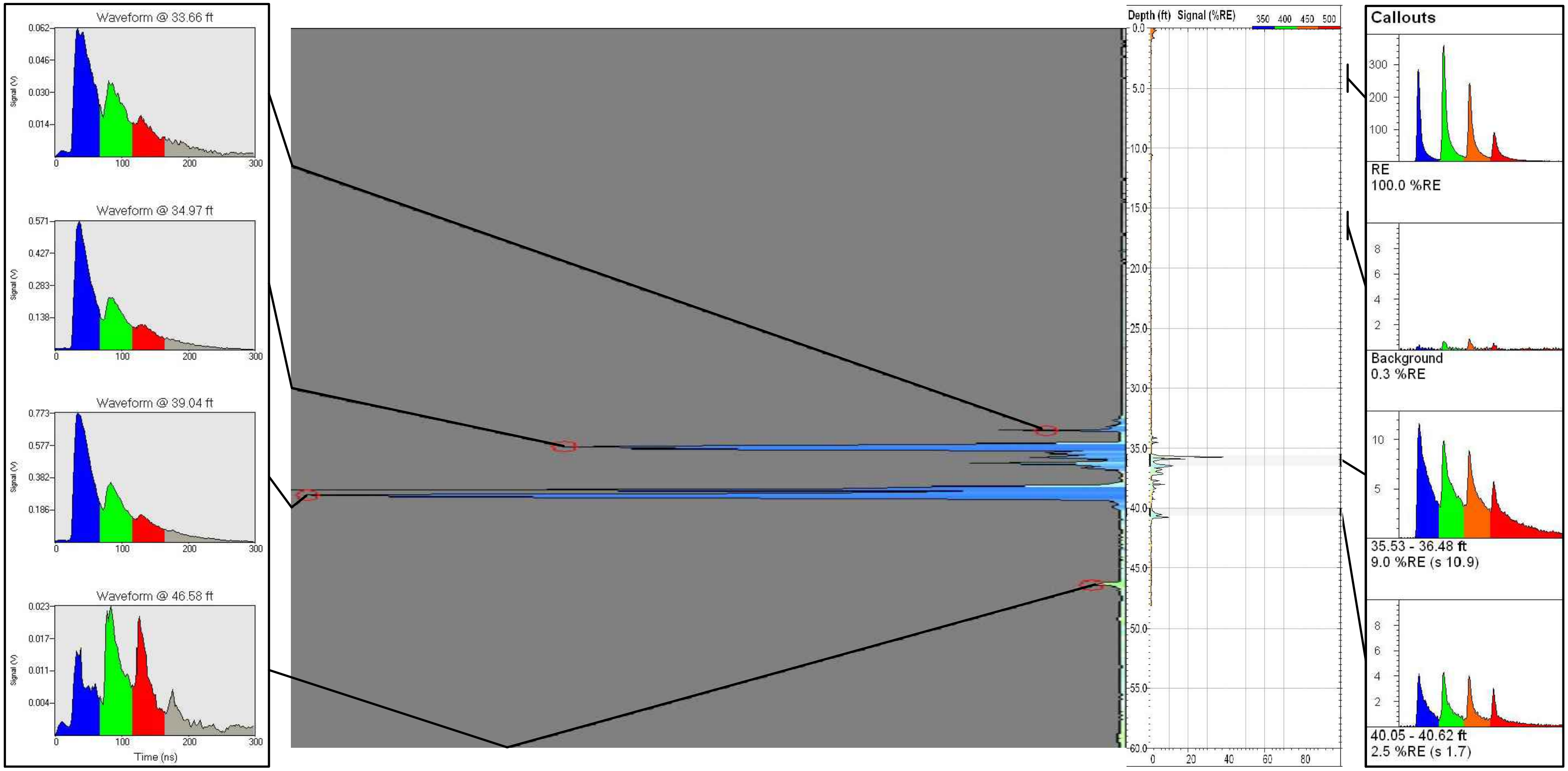
FIGURE E-21

**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-113 LOCATION**

**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP | Checked By: PM | Scale: AS SHOWN | Date: 5/22/14 | File: 24SROST113COMP



A **HROST-128, AUGUST 2005**
MIRRORED AND SCALED TO B

B **HUVOST-128, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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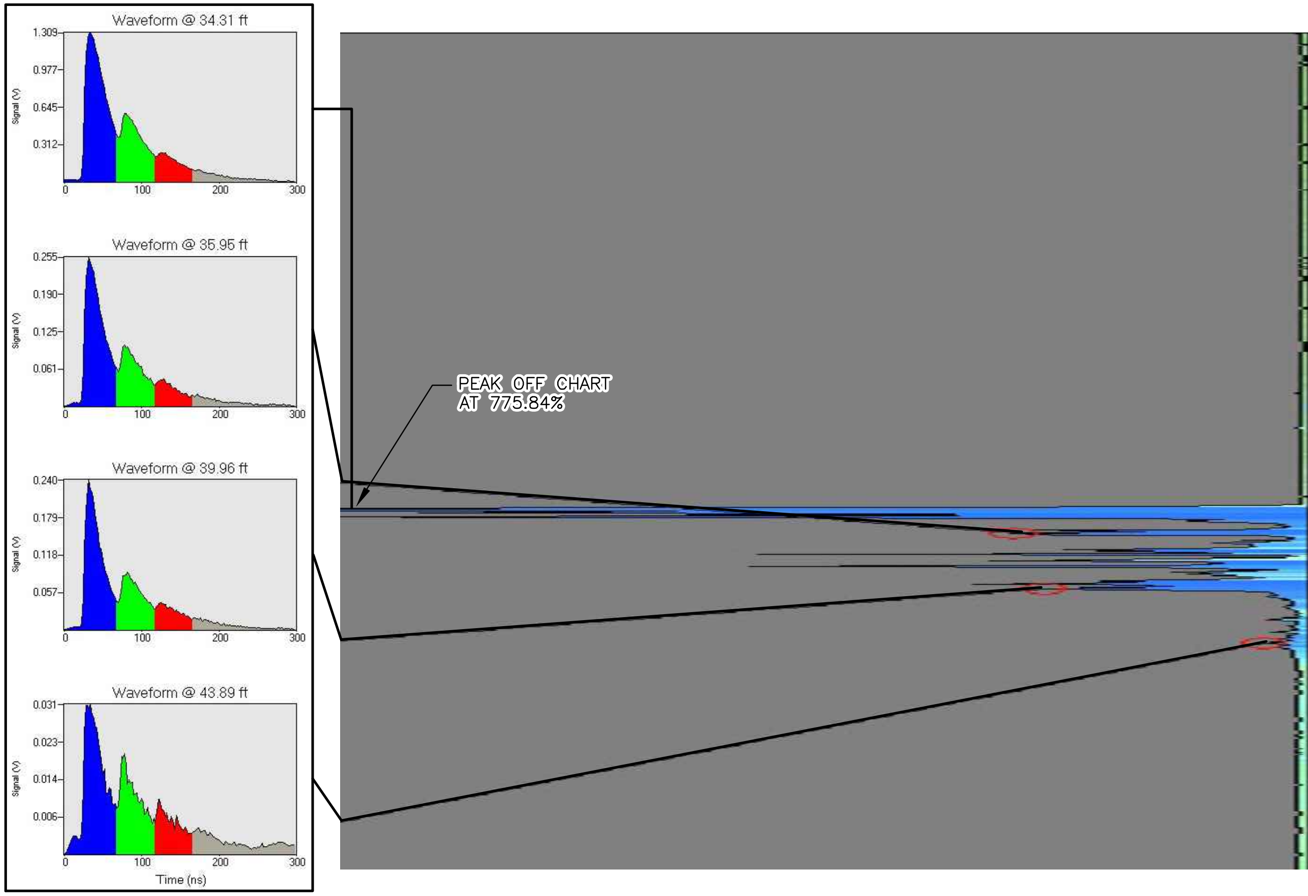
FIGURE E-22

FLUORESCENCE RESPONSE COMPARISON FOR HUVOST-128 LOCATION

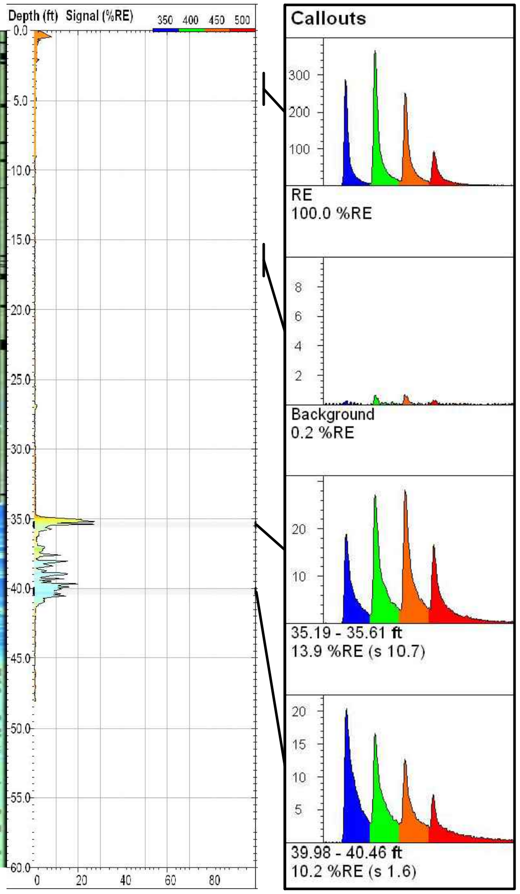
**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST128COMP



A **HROST-129, AUGUST 2005**

MIRRORED AND SCALED TO B



B **HUVOST-129, SEPTEMBER 2013**

SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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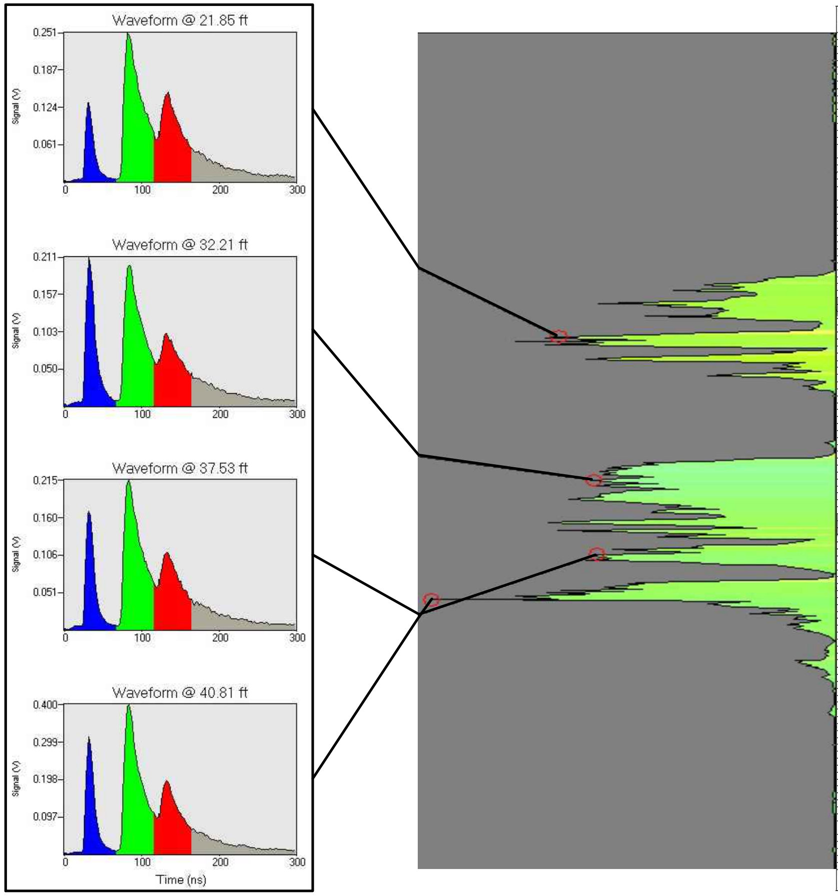
FIGURE E-23

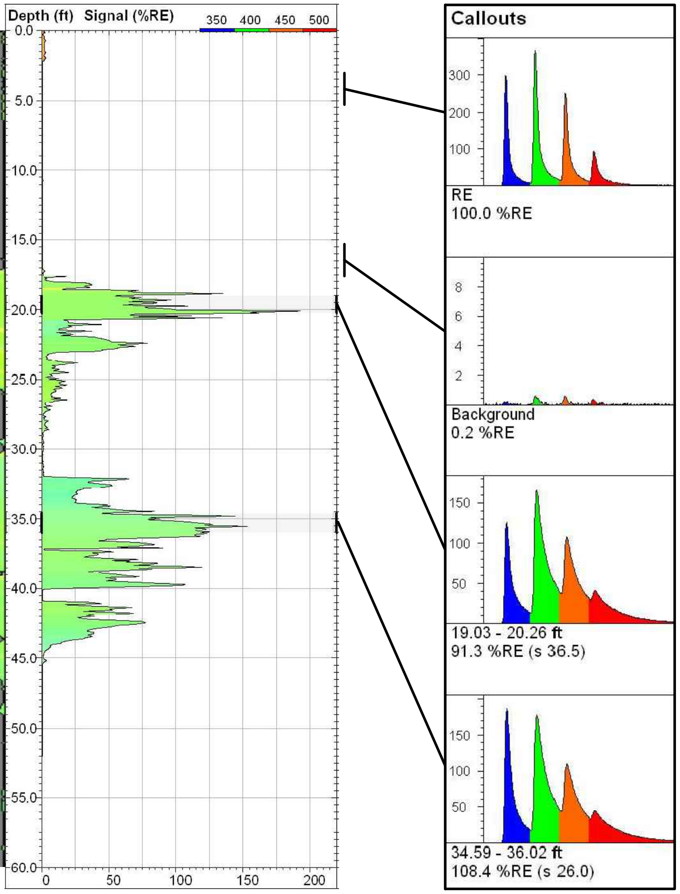
FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-129 LOCATION

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/22/14	File: 24SROST129COMP



A **HROST-130, SEPTEMBER 2005**
MIRRORED AND SCALED TO B



B **HUVOST-130, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:

THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

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FIGURE E-24

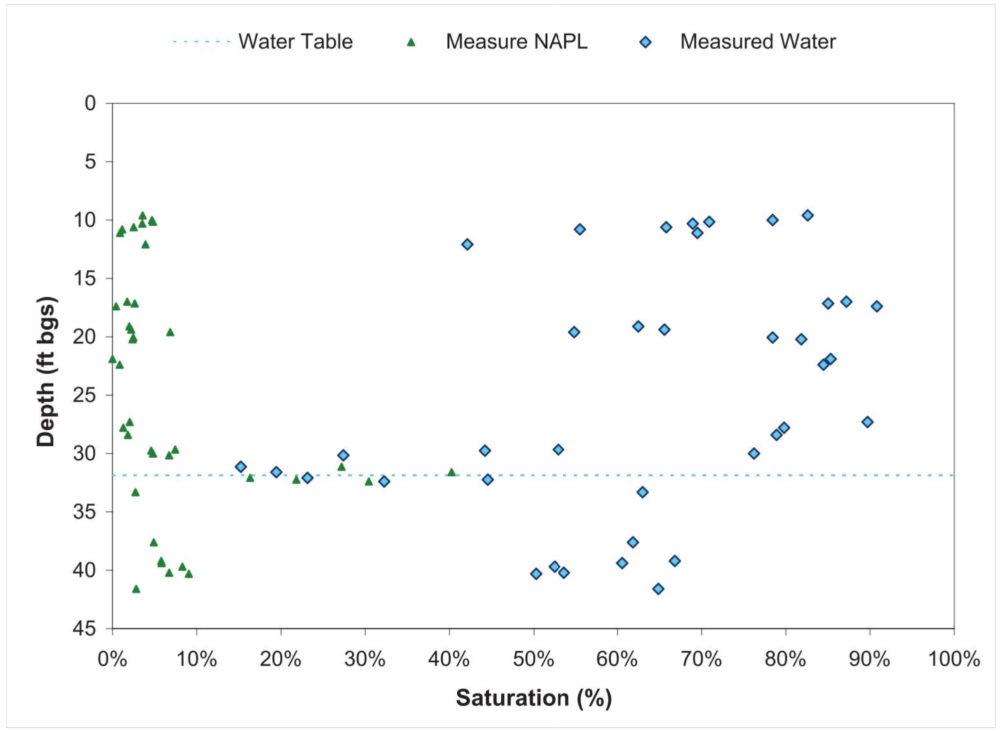
**FLUORESCENCE RESPONSE COMPARISON
FOR HUVOST-130 LOCATION**

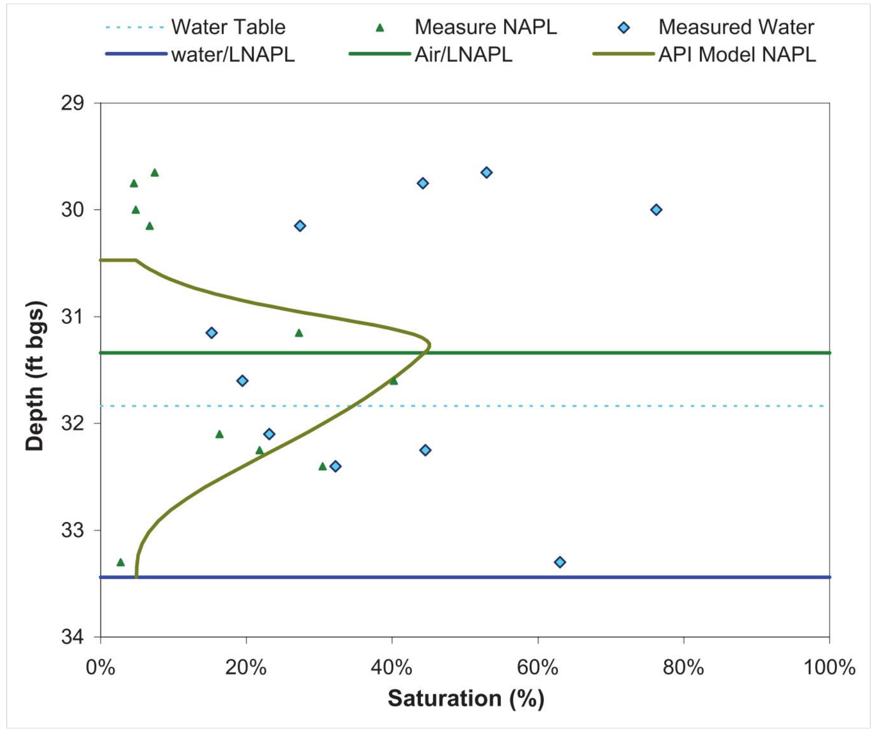
**HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS**

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24SROST130COMP

APPENDIX F

MEASURED (HCSB-1) VERSUS MODELED (HMW-044C) SATURATION PROFILE





Measured Saturation Data (Dean-Stark Method)

Depth	S_n	S_w	ϕ	Do	Do Mobile
9.6	0.036	0.826	0.47	0.0079	0.0000
10	0.047	0.784	0.49	0.0036	0.0000
10.15	0.048	0.709	0.51	0.0031	0.0000
10.3	0.035	0.689	0.49	0.0045	0.0000
10.6	0.025	0.658	0.51	0.0019	0.0000
10.8	0.011	0.556	0.52	0.0016	0.0000
11.1	0.009	0.695	0.50	0.0127	0.0000
12.1	0.039	0.421	0.53		
17	0.017	0.872	0.52	0.0018	0.0000
17.15	0.026	0.850	0.58	0.0022	0.0000
17.4	0.004	0.908	0.58	0.0110	0.0000
19.1	0.020	0.625	0.51	0.0032	0.0000
19.4	0.022	0.656	0.49	0.0046	0.0000
19.6	0.069	0.549	0.51	0.0105	0.0000
20.05	0.025	0.784	0.48	0.0018	0.0000
20.2	0.024	0.818	0.49	0.0100	0.0000

Do Sum (ft)
Smear Zone
0.60
Total Do over the Mobile Interval Where
0.30
Mobile Fraction of Do over the Mobile Interval
0.18

API Model Sn

Depth	Sn
30.47	0
30.47	0.048218
30.499	0.054075
30.528	0.060538
30.557	0.067669
30.586	0.075537
30.615	0.084217
30.644	0.093788
30.673	0.104338
30.702	0.115956
30.731	0.128733
30.76	0.142759
30.789	0.158117
30.818	0.174875
30.847	0.193079
30.876	0.212733

Gauging Data - Well HMW-44C

Ground Surface Elevation
429.78

Measuring Point Elevation
NA

Water Table Elevation
397.94

Estimated Water Table Depth
0 31.84
1 31.84

Sor
0.049

9/23/2005
DTP **Corrected LNAPL Depth**

Note: Data and figures originally presented within Appendix F of the Active LNAPL Recovery System 90% Design Report (Clayton 2006).

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FIGURE F-1

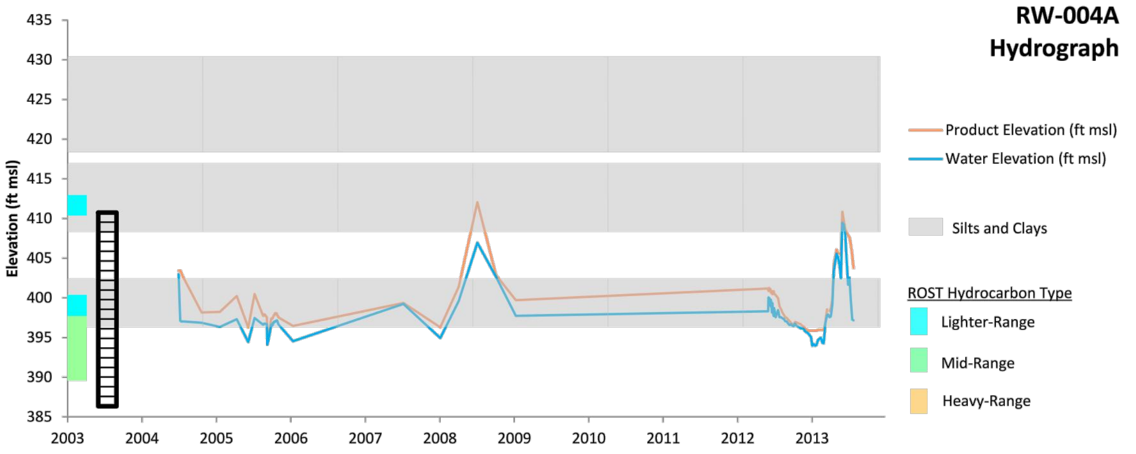
MEASURED (HCSB-1) VERSUS MODELED (HMW-044C) SATURATION PROFILE

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP | Checked By: PM | Scale: NO SCALE | Date: 5/22/14 | File: 24S_SATPROFILE_201405

APPENDIX G

HYDROGRAPHS AND LNAPL RECOVERY OVER TIME FOR SELECTED MONITORING LOCATIONS



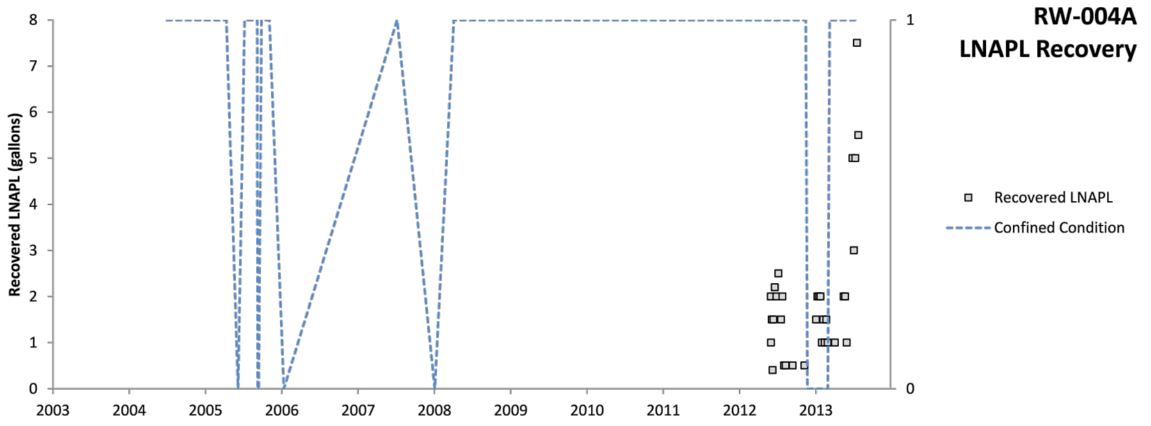


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FIGURE G-1

RW-004A HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_01_RW-004A

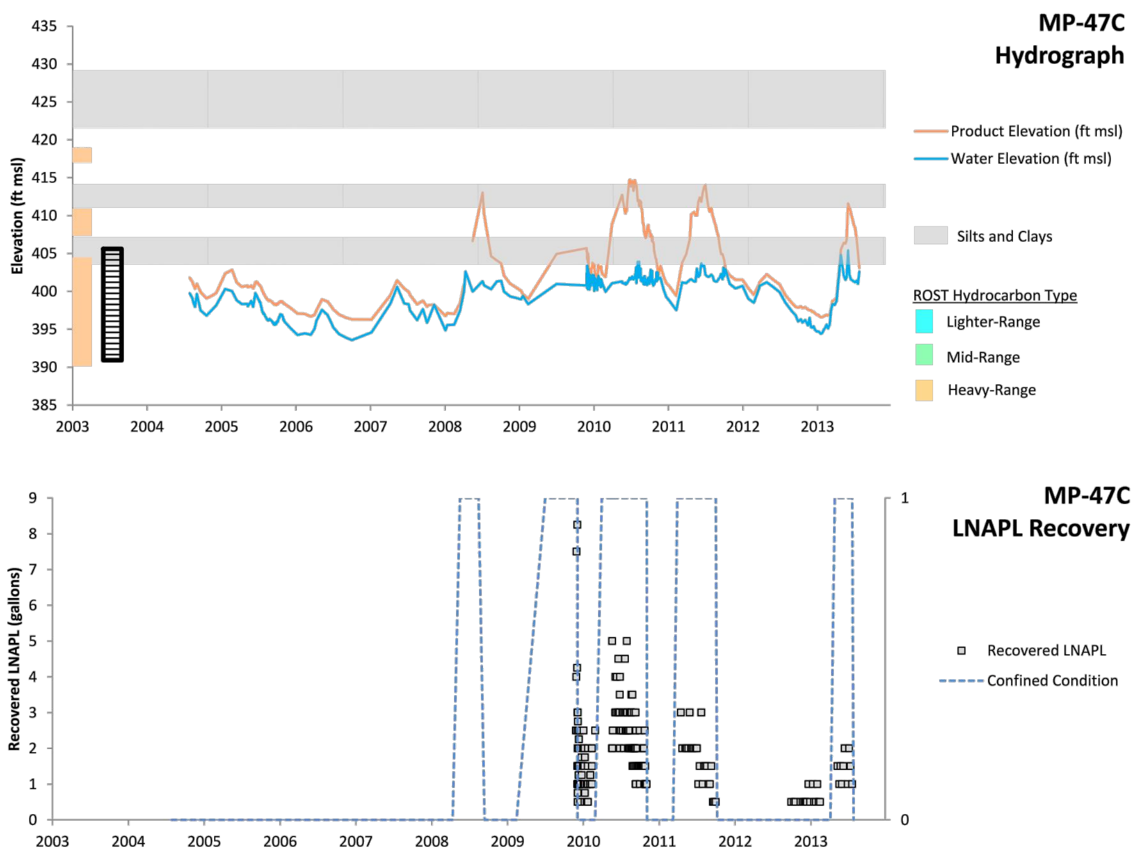

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FIGURE G-2

MP-047C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_02_MP-047C

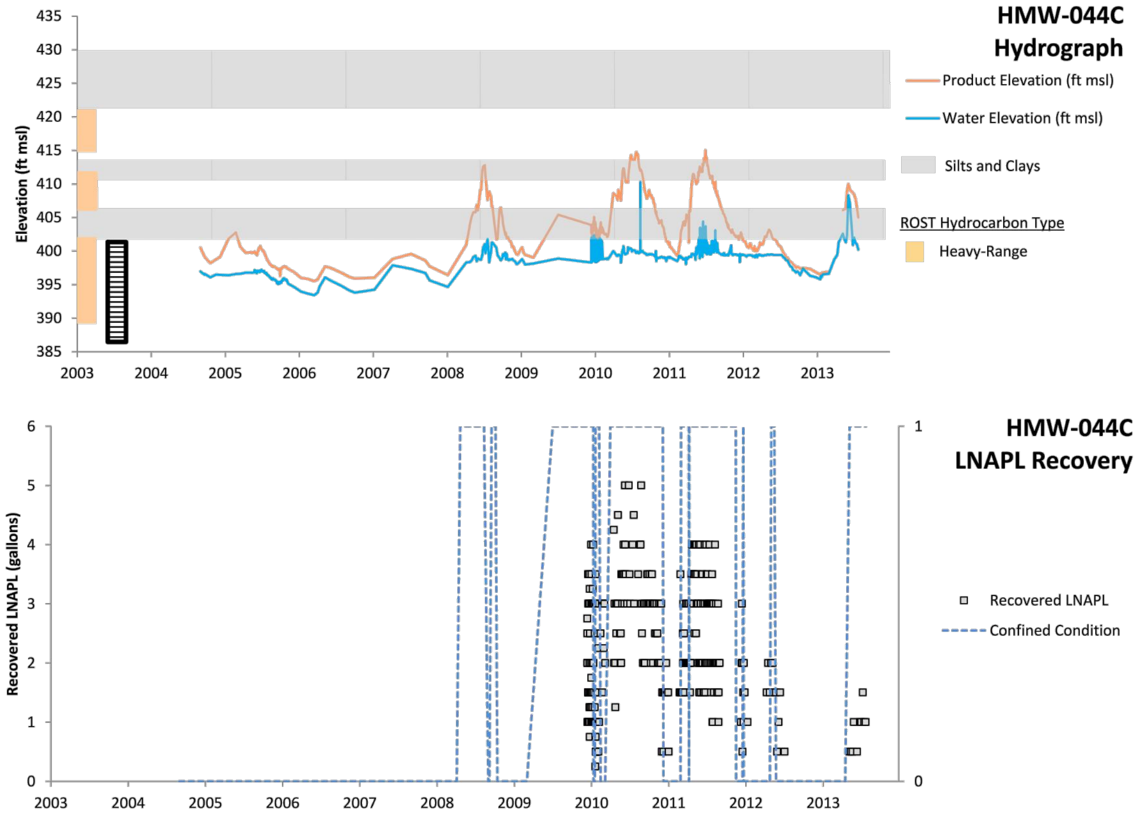

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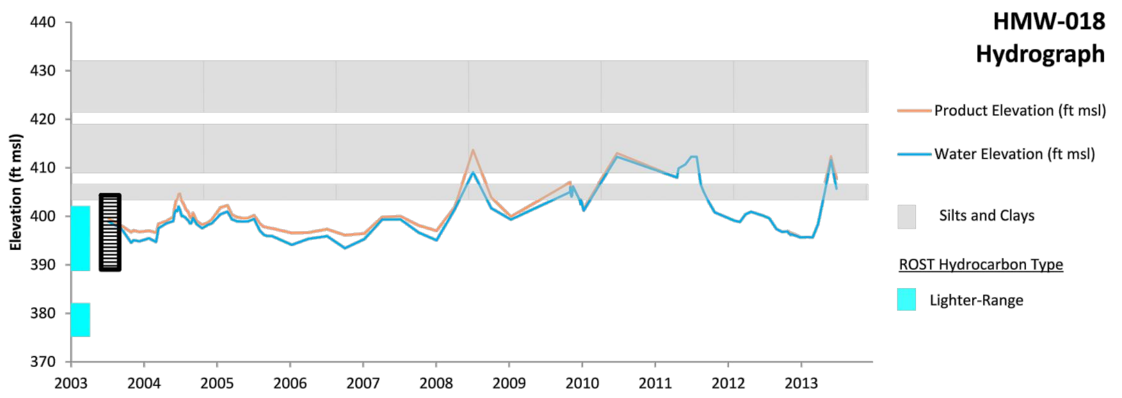
FIGURE G-3

HMW-044C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_03_HMW-044C



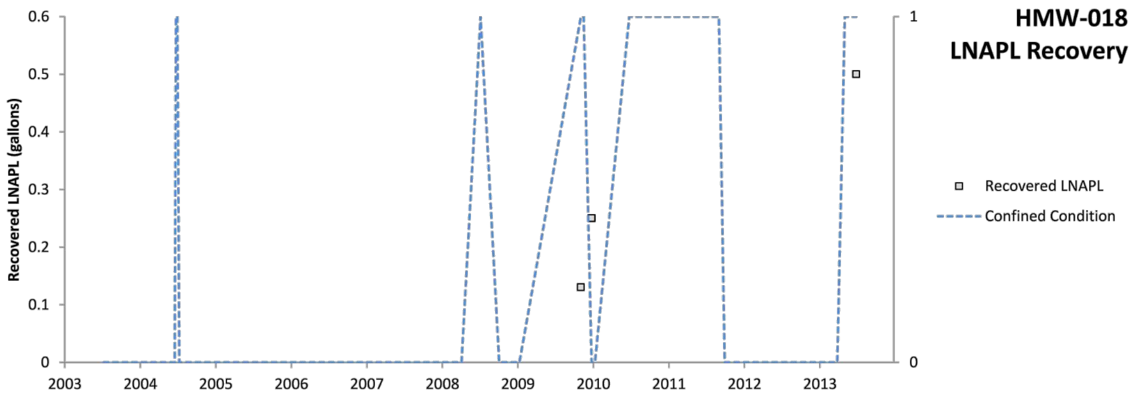


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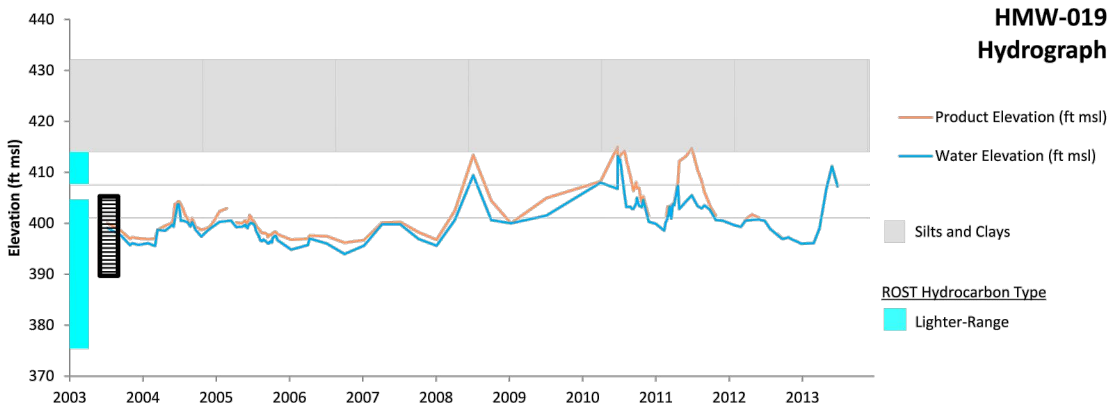
FIGURE G-4

HMW-018 HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_04_HMW-018



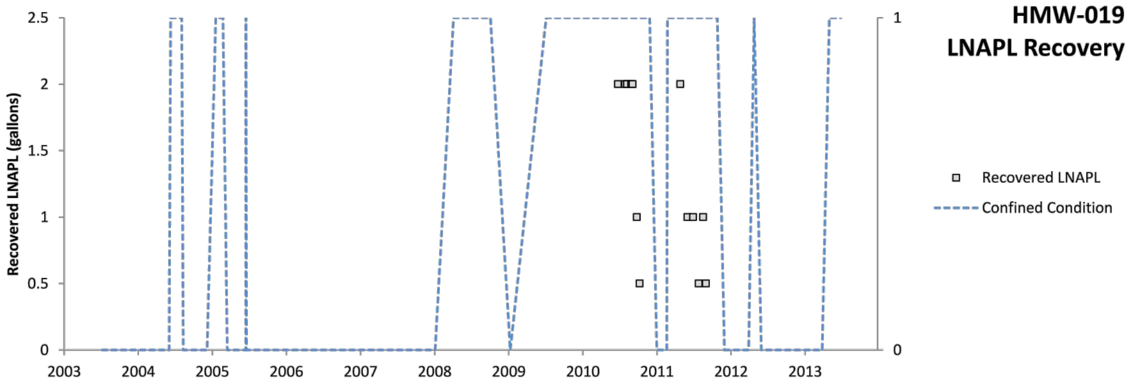


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FIGURE G-5

HMW-019 HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_05_HMW-019

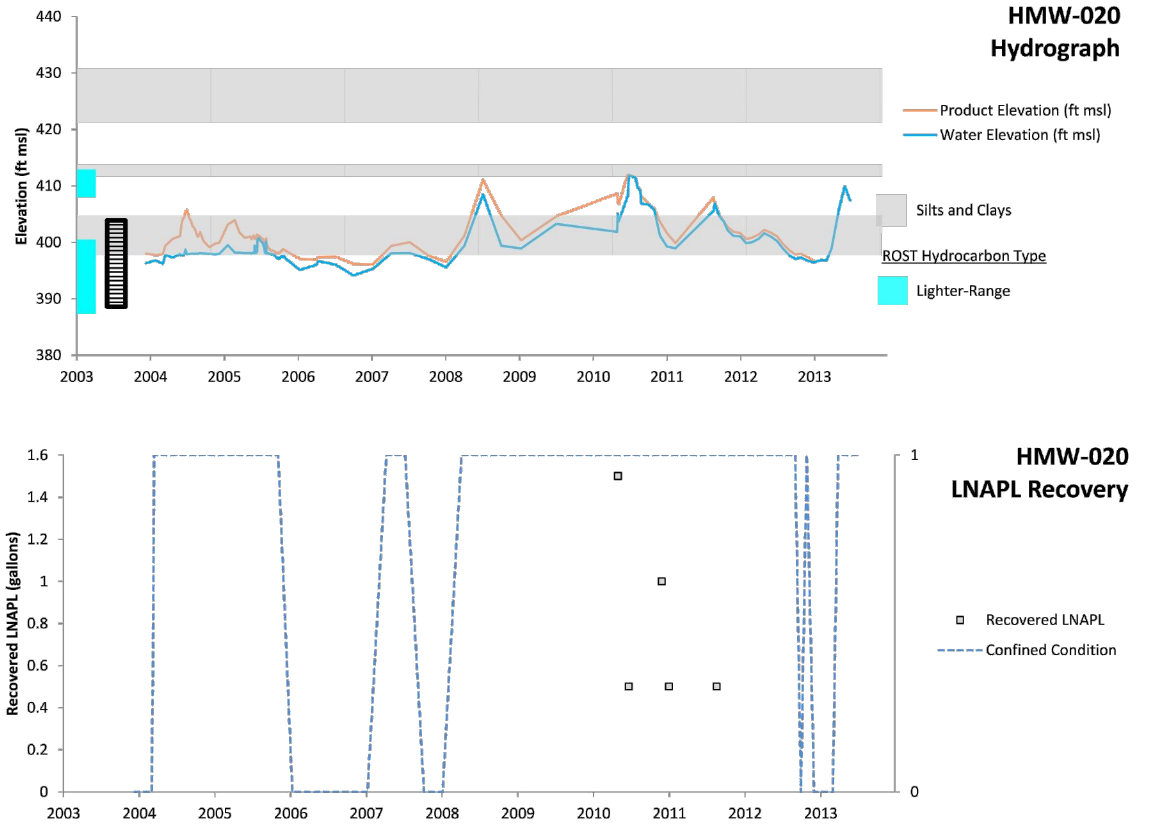

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FIGURE G-6

HMW-020 HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_06_HMW-020

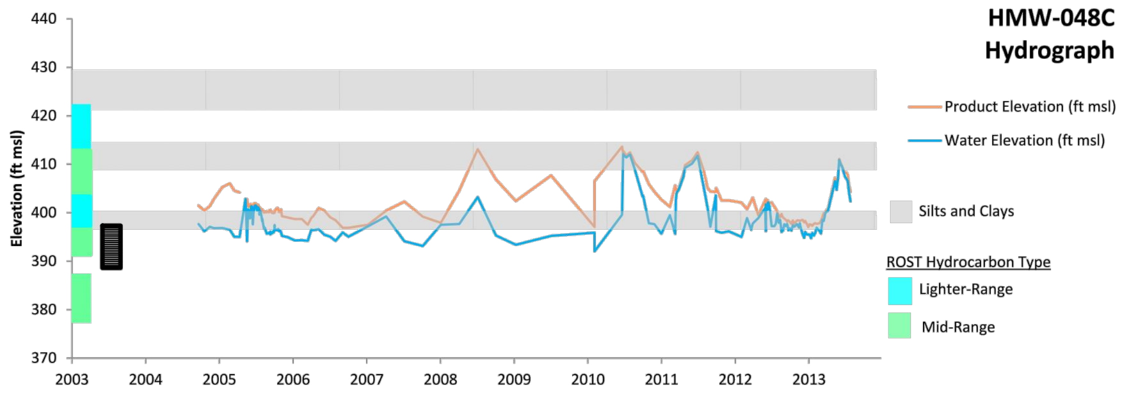

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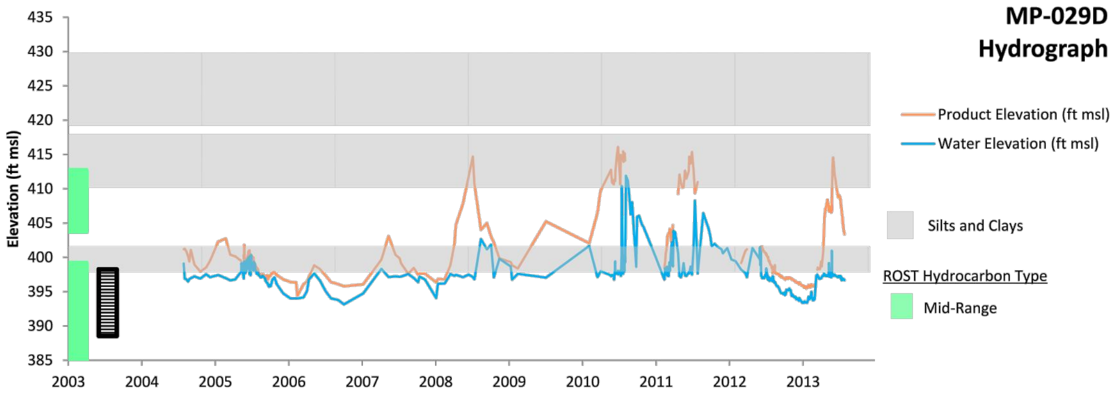
FIGURE G-7

HMW-048C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_07_HMW-048C



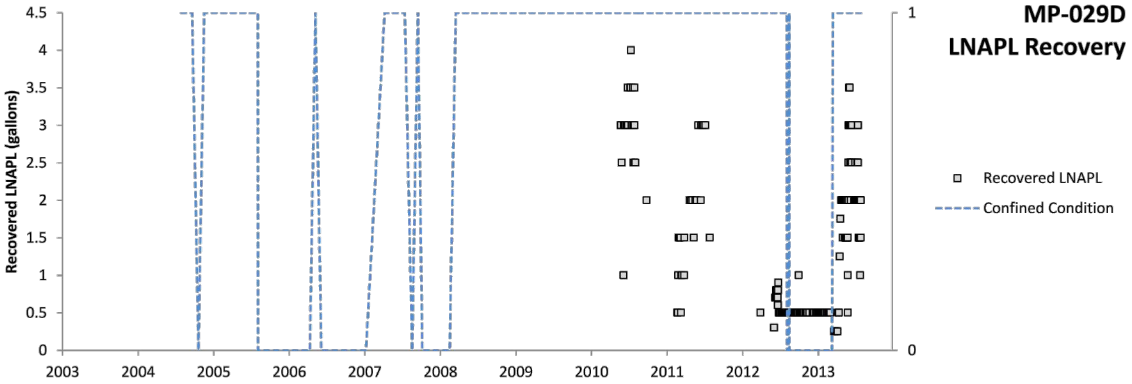


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FIGURE G-8

MP-029D HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_08_MP-029D

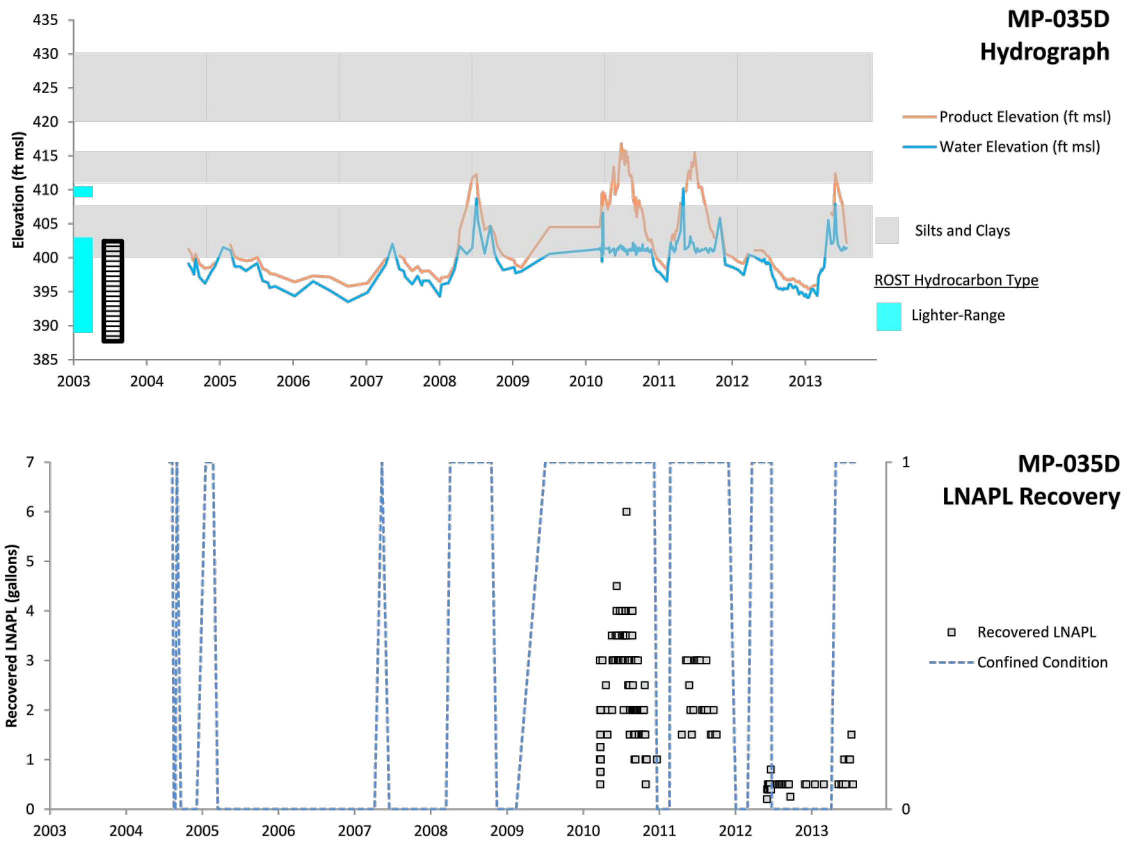

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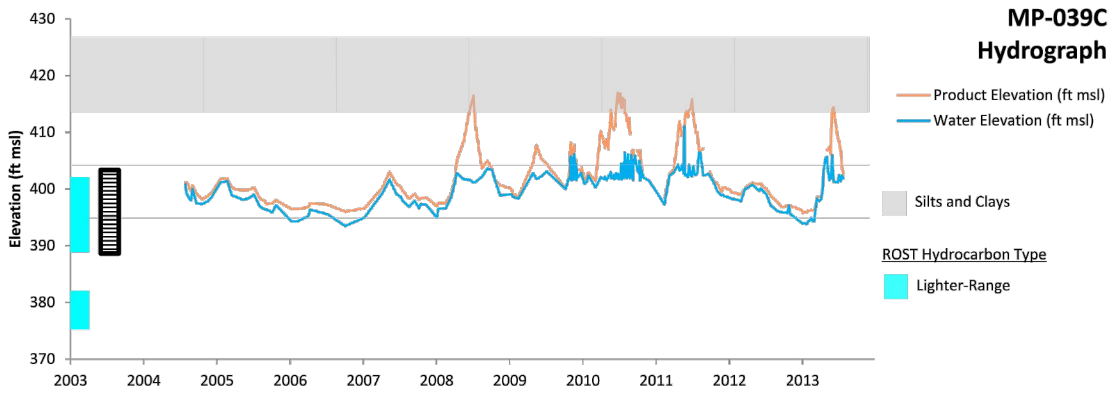
FIGURE G-9

MP-035D HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_09_MP-035D



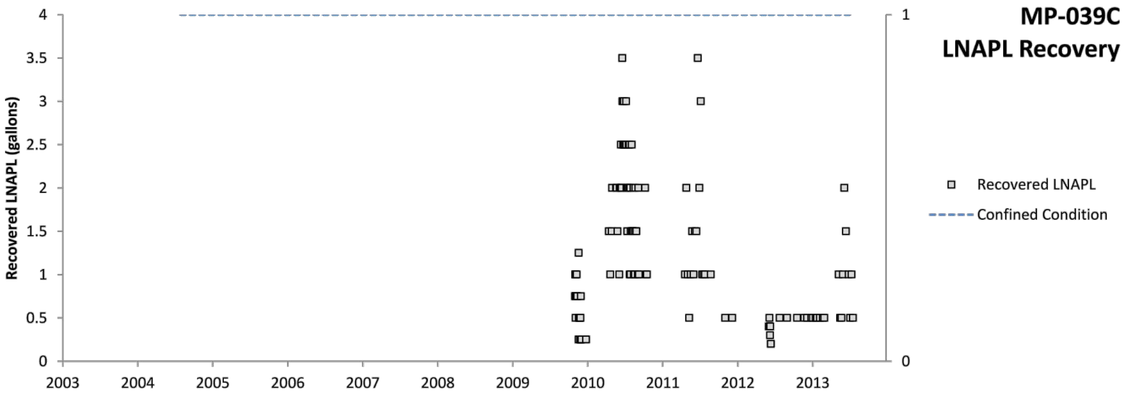


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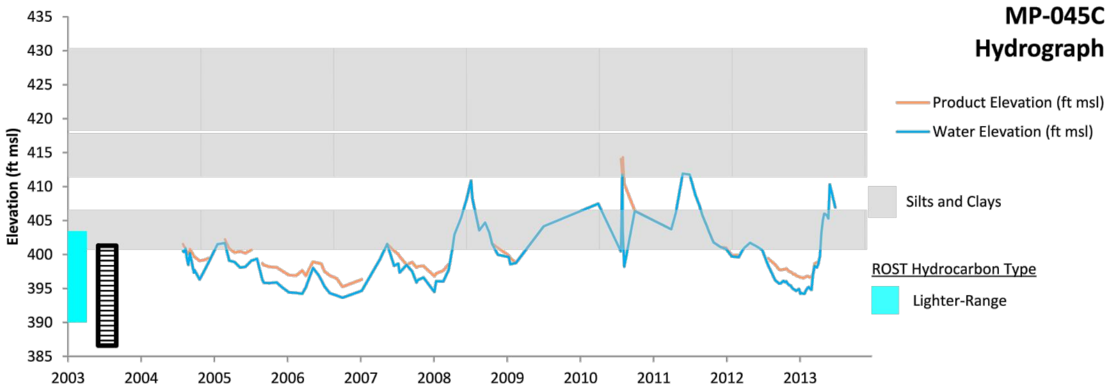
FIGURE G-10

MP-039C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_10_MP-039C



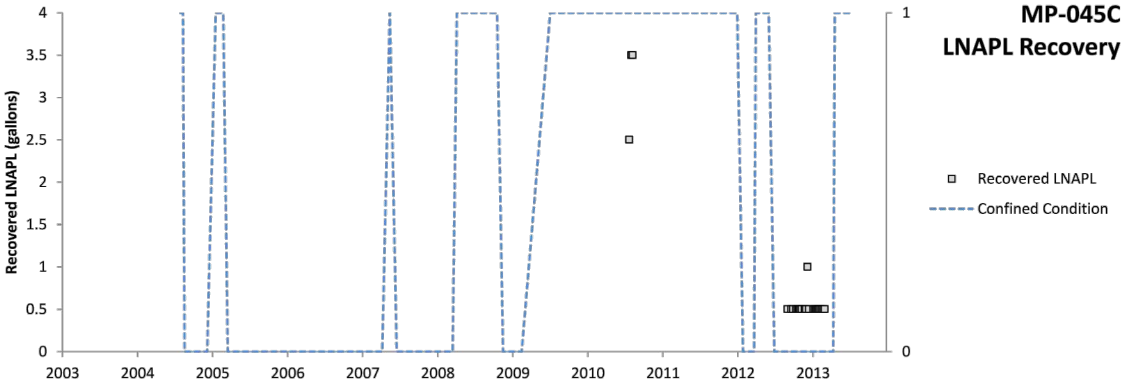


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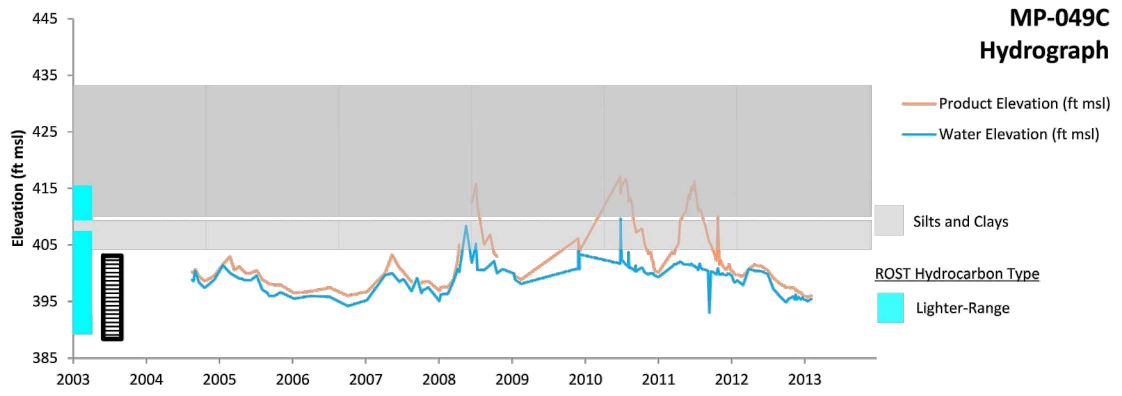
FIGURE G-11

MP-045C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_11_MP-045C



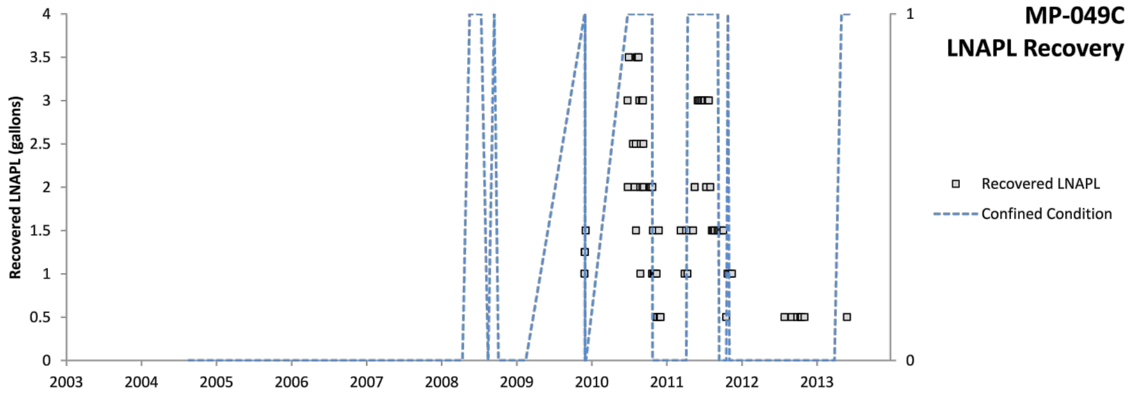


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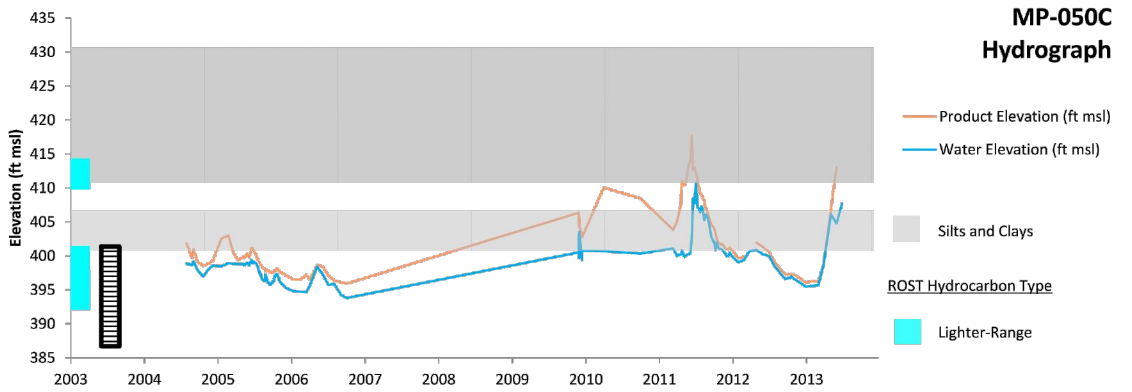
FIGURE G-12

MP-049C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_12_MP-049C



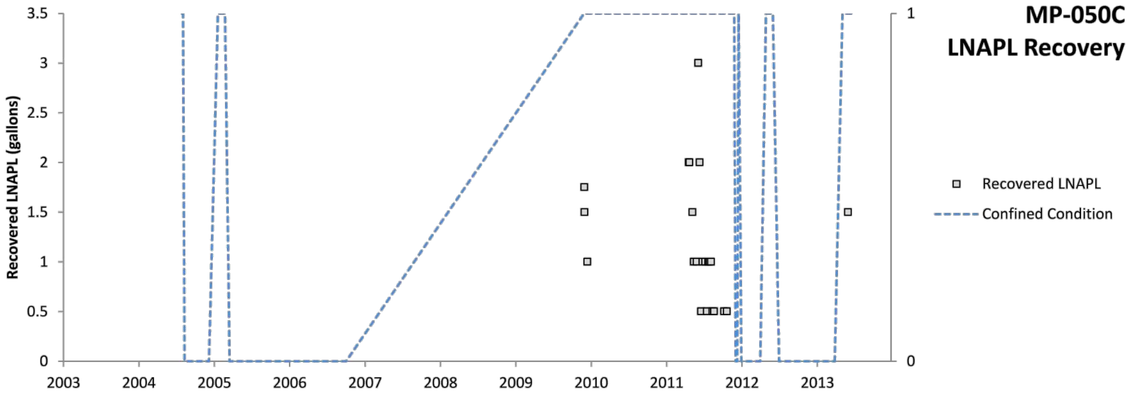


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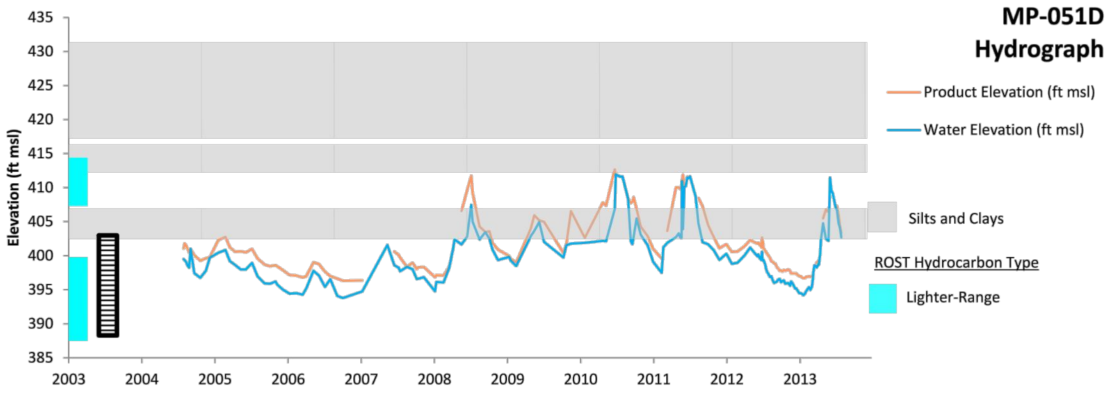
FIGURE G-13

MP-050C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_13_MP-050C



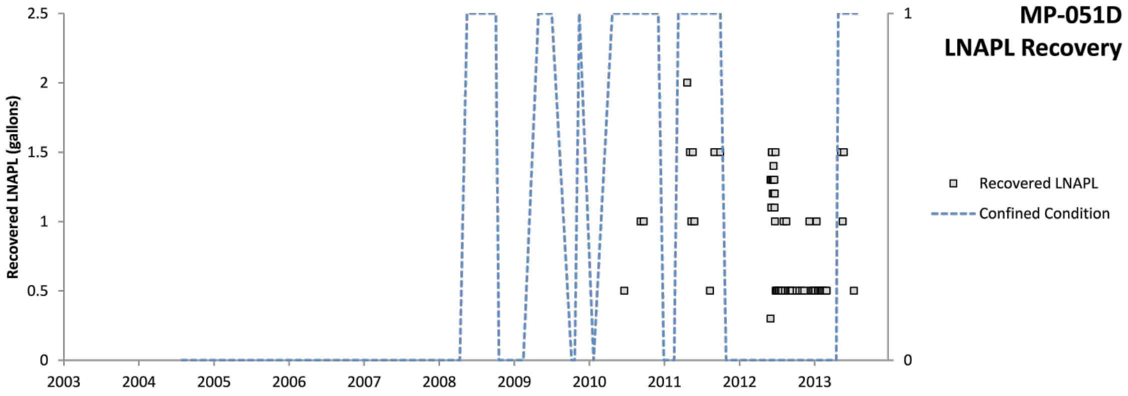


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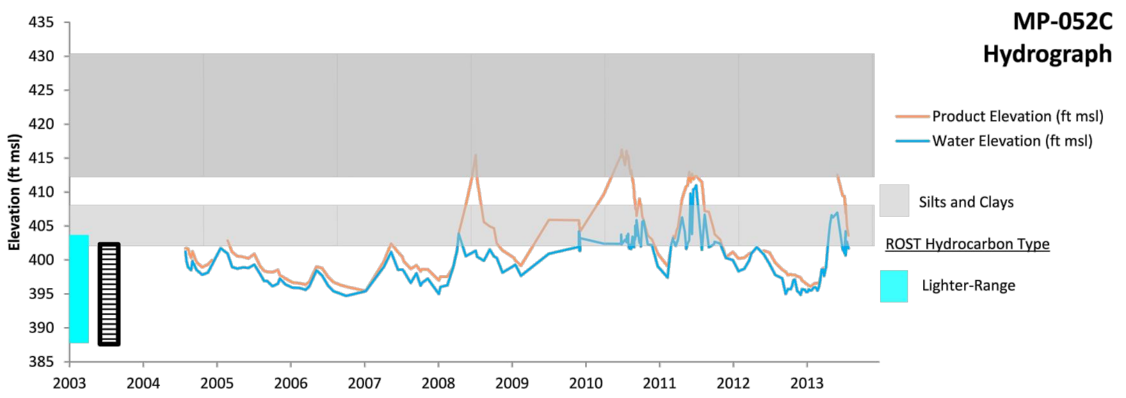
FIGURE G-14

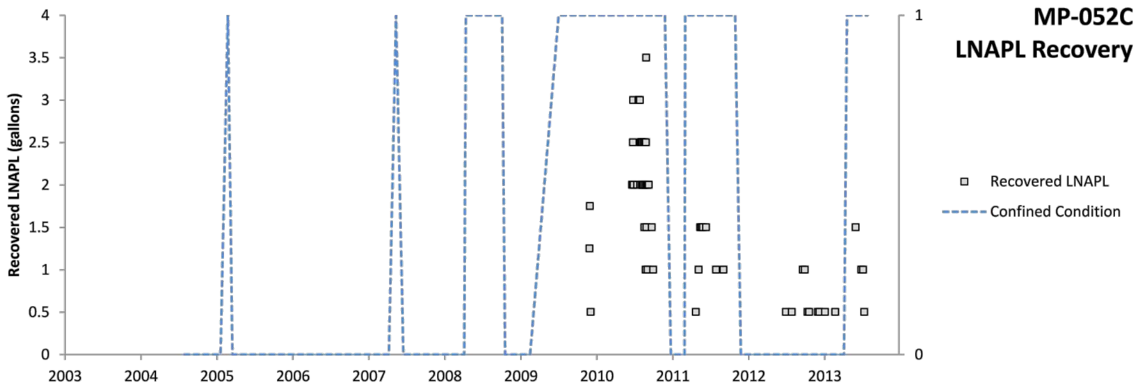
MP-051D HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_14_MP-051D



MP-052C Hydrograph



MP-052C LNAPL Recovery

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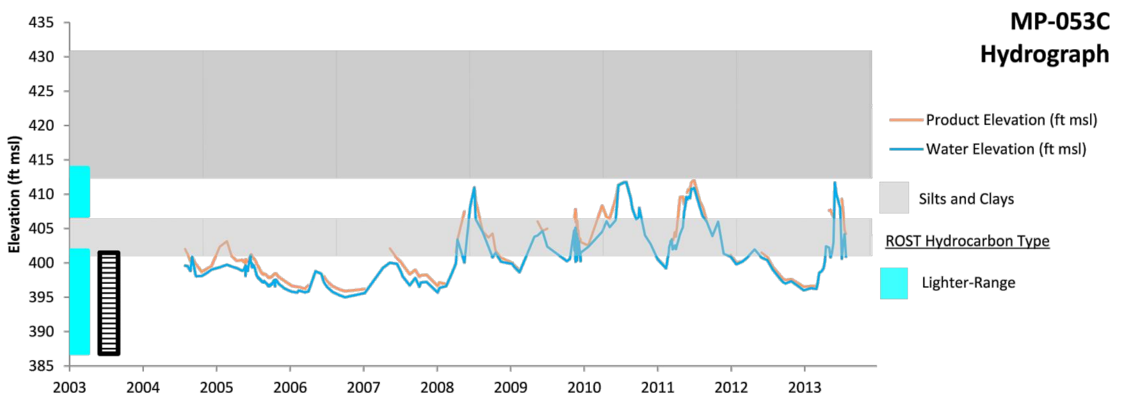
FIGURE G-15

MP-052C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_15_MP-052C



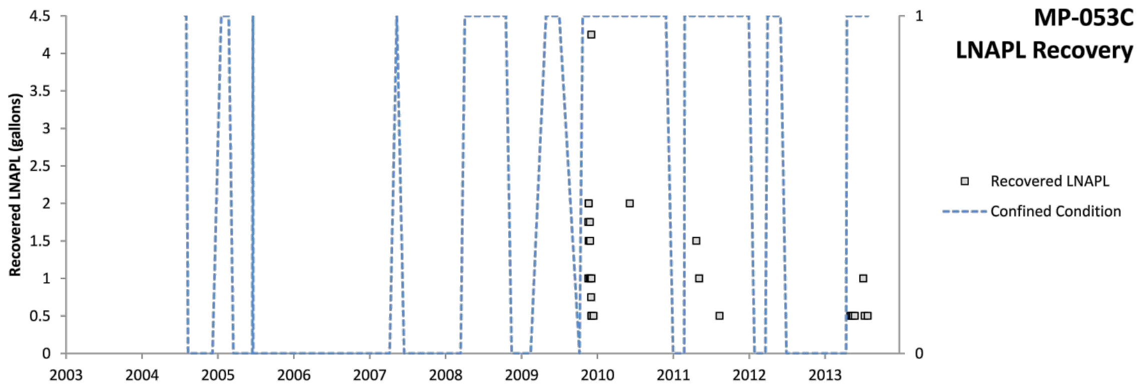


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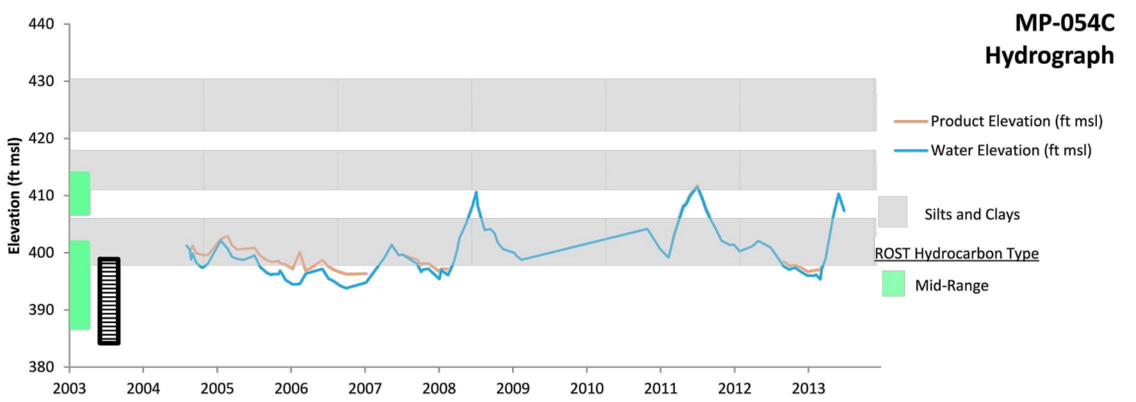
FIGURE G-16

MP-053C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 12/2/13	File: 24S_16_MP-053C



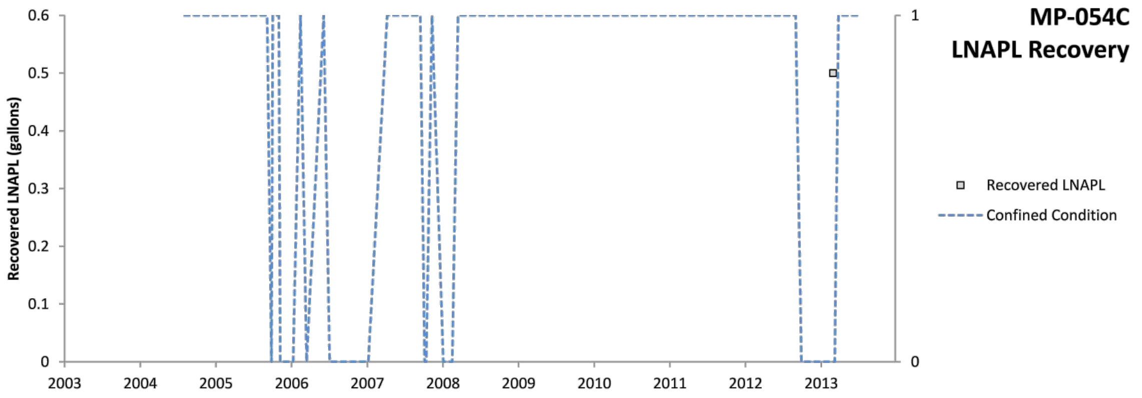


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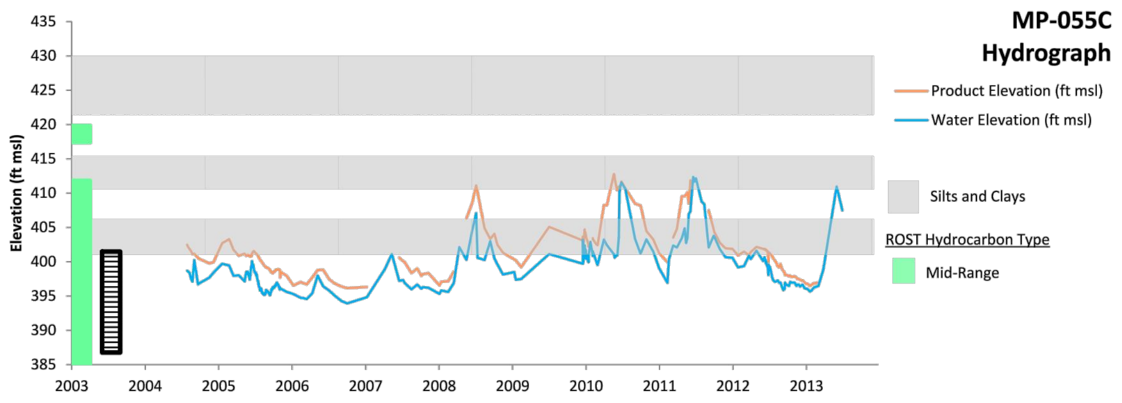
FIGURE G-17

MP-054C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_17_MP-054C



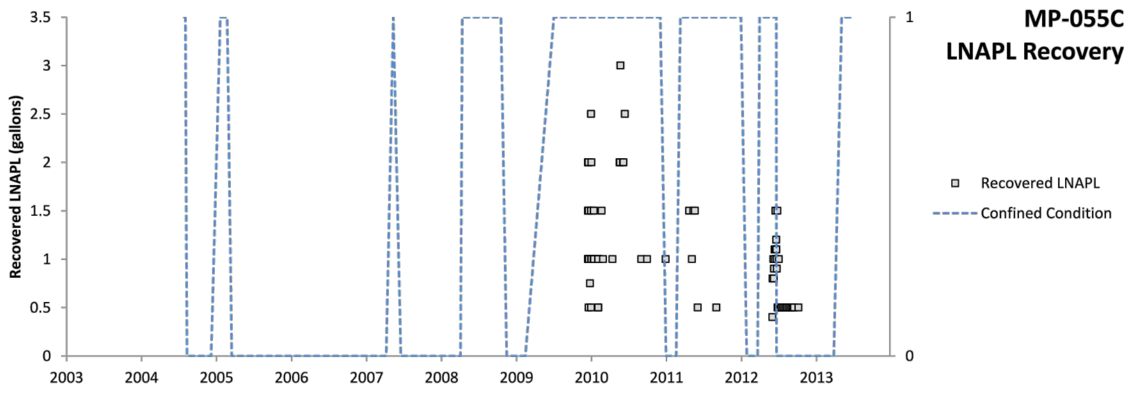


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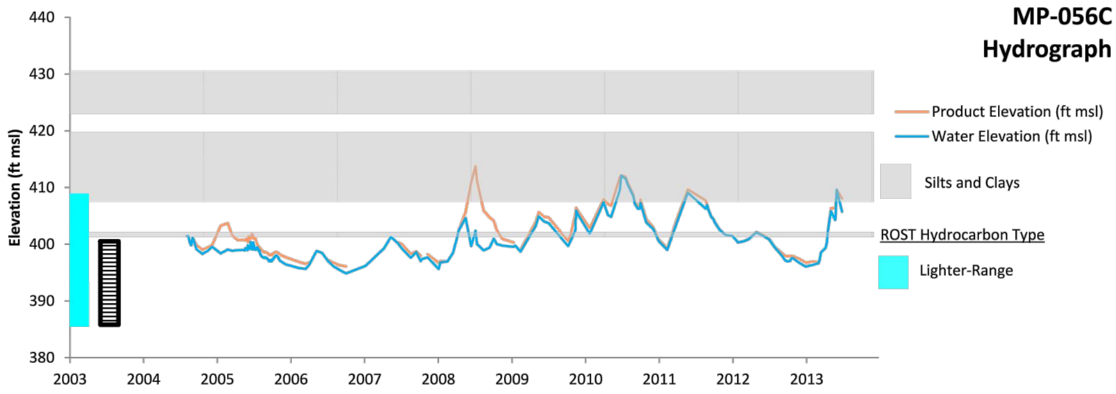
FIGURE G-18

MP-055C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 12/2/13	File: 24S_18_MP-055C



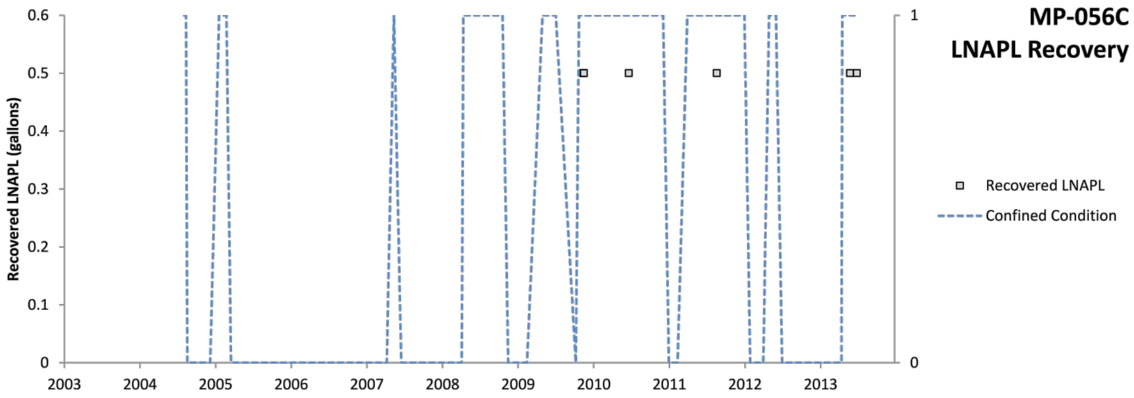


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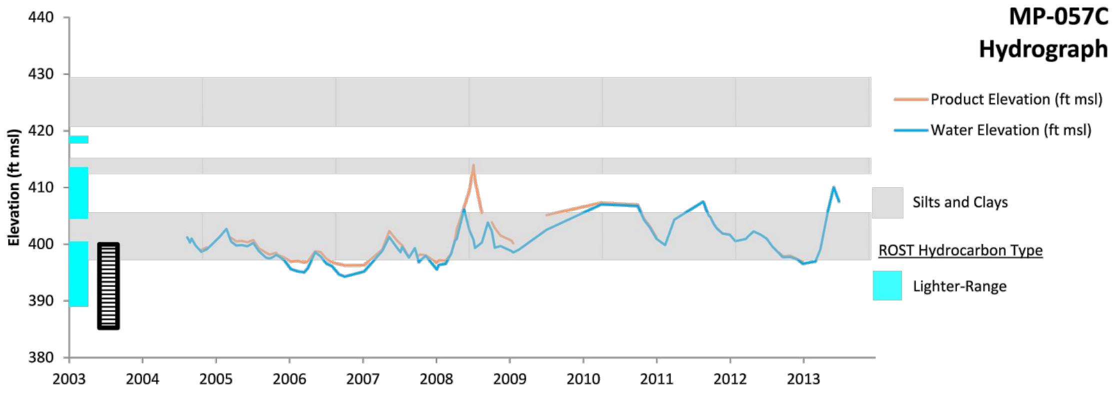
FIGURE G-19

MP-056C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_19_MP-056C



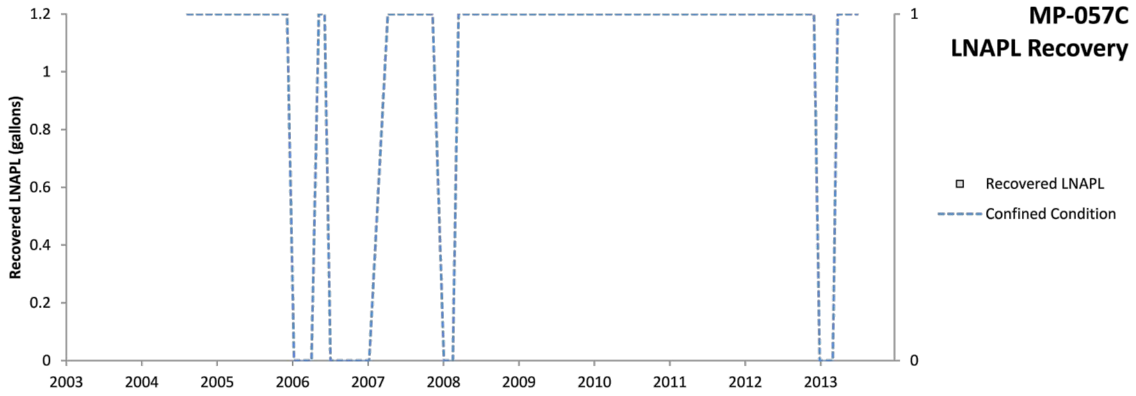


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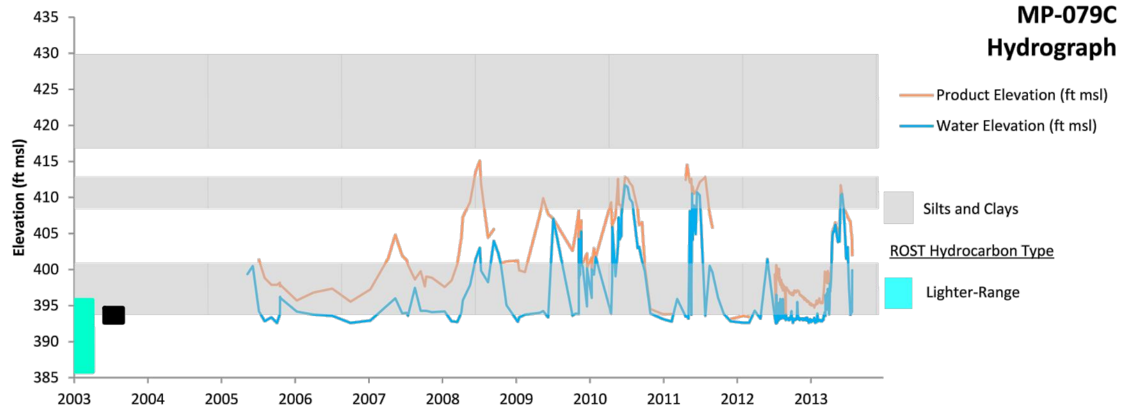
FIGURE G-20

MP-057C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_20_MP-057C



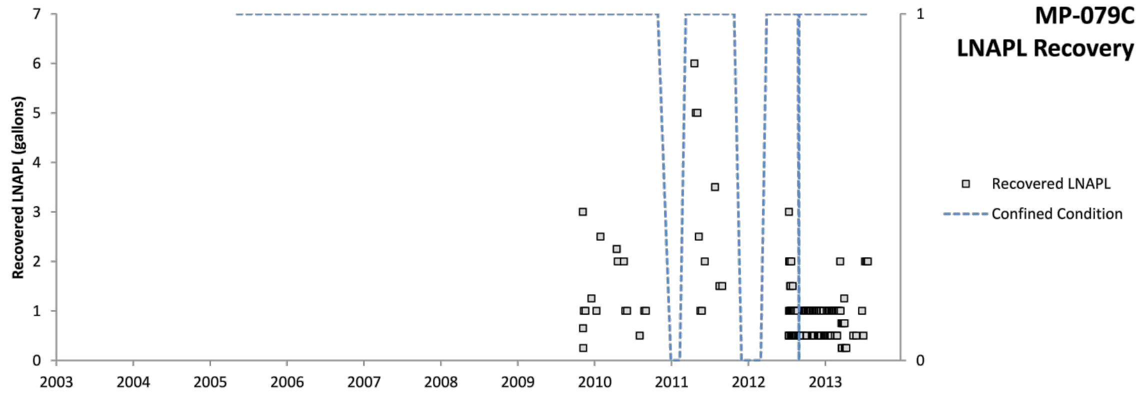


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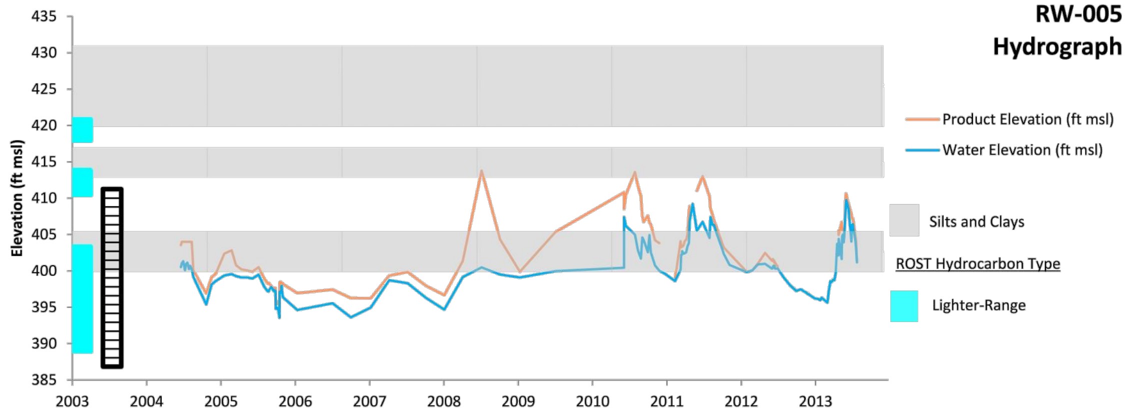
FIGURE G-21

MP-079C HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_21_MP-079C



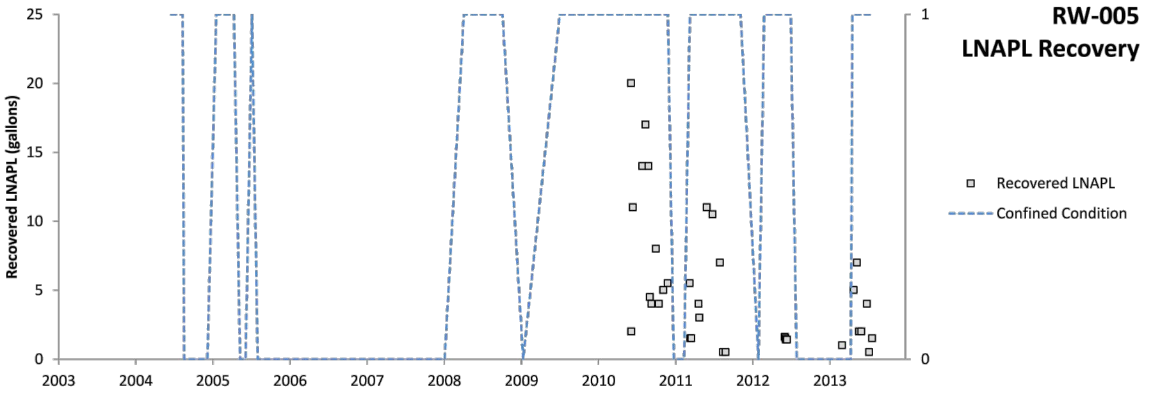


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FIGURE G-22

RW-005 HYDROGRAPH AND LNAPL RECOVERY OVER TIME

HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

Drawn By: JGP	Checked By: PM	Scale: AS SHOWN	Date: 5/21/14	File: 24S_22_RW-005